NATURE

A WEEKLY JOURNAL OF SCIENCE

CWR-Ho 6687-191- RP321

"To the solid ground
Of nature trusts the Mind that builds for aye"—WORDSWORTH

28. 2. 61.

191.

Volume 187
(JULY 2, 1960, to SEPTEMBER 24, 1960)

LONDON
MACMILLAN AND CO., LTD.
NEW YORK: ST. MARTIN'S PRESS, INC.

DATES and PAGINATION of WEEKLY ISSUES

Serial No.		*Date of Issue*		*Pagination*
4731	...	July	2	1–88
4732	...	,,	9	89–176
4733	...	,,	16	177–264
4734	...	,,	23	265–352
4735	...	,,	30	353–440
4736	...	August	6	441–534
4737	...	,,	13	535–626
4738	...	,,	20	627–718
4739	...	,,	27	719–808
4740	...	September	3	809–882
4741	...	,,	10	883–970
4742	...	,,	17	971–1054
4743	...	,,	24	1055–1140

24321

Pur… Library. …COLLEGE. 92, … Road. CALCUTTA
CHEMICAL LABORATORY … 28.2.61 … COLLEGE

INDEX

AACH, Dr. H. G.: A Difference between the Sub-Units of Tobacco Mosaic Virus Protein?, 75
Abbie, Prof. A. A.: Doctor Ruggles Gates and the Aboriginal Australian, 375
Abe, Takahiro: Interaction of Picric Acid with Sodium Hydroxide in Water, 234
Abercrombie, Dr. M. L. Johnson: The Anatomy of Judgment, *review* by Prof. O. L. Zangwill, 817
Ability to excrete Beetroot Pigment (Betanin): Race Differences in the (Dr. P. H. Saldanha, L. E. Magalhaes and Wanda A. Horta), 806
Ablation (Stepwise), and Heat Transfer in Cold-Cathode Arcs (Dr. A. von Engel and Dr. K. W. Arnold), 1101
Abnormal Crimping in Merino and Polwarth Wools (R. E. Chapman, B. F. Short and P. G. Hyland), 960
Abnormal Serum Protein in Experimental Poisoning by Cadmium and other Metals (D. J. Lawford), 946
'Abominable Snowman': Problem of the (S. V. Obruchev), 558
Aboriginal Australian: Doctor Ruggles Gates and the (Prof. A. A. Abbie), 375
Aborigine (Central Australian): Haematology of the (J. R. Casey-Smith), 903
Aboul-Ela, I. A.: Conditioning *Ostrea edulis* L. from Limfjord for Reproduction Out of Season (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 25), *review* by Dr. A. J. Southward, 360
Abramson, Harold A. (edited by): Neuropharmacology—Transactions of the Fourth Conference, Princeton, 1957, *review* by Dr. D. H. Brinton, 447
Abroad (Science): The Royal Society and the Progress of (Prof. R. J. Forbes), 100
Absence of Carbon Monoxide-sensitive Respiration in a Streptomycin-dependent Mutant of *Escherichia coli* grown in Limited Amount of Streptomycin (Hanna Engelberg and Dr. M. Artman), 801
Absence of Local Cytotoxic Change in Man from Griseofulvin (Prof. Leon Goldman, Amanda Beyer and Jan Schwarz), 335
Absorbance of Feulgen-stained Somatic Cell Nuclei (Dr. Simon Iversen), 86
Absorption of Ultra-violet and Visible Light by Ultra-thin Sections of Vitrinite from a High-volatile Bituminous Coal (Sabri Ergun, J. T. McCartney and R. E. Walline), 1014
Absorption (Atomic): Determination of Nickel and Cobalt by (J. E. Allan), 1110
Absorption (Atomic) Spectrophotometric Determination of Molybdenum and Strontium (D. J. David), 1109
Absorption (Intestinal), of Glycose, Methionine and Sodium Butyrate: Reduction of the, by the Cation Trimethylhexadecylammonium (Dr. J. A. Nissim), 308
Absorption (Pure Rotational), of Ozone in the Region 125-500 Microns (Dr. H. A. Gebbie, N. W. B. Stone and C. D. Walshaw), 765
Absorption-Elution Grouping of Dried Blood-stains on Fabrics (S. S. Kind), 789
Absorption Spectra (Electronic), and Chemical Reactivity with Mercaptalbumin: An Ortho Effect influencing Fungitoxicity, (Dr. H. P. Burchfield and Eleanor E. Storrs), 593
Absorption Spectra (Ultra-violet), of the Diazines (Prof. K. Keith Innes, James A. Merritt, Wayne C. Tincher and Shelby G. Tilford), 500
Absorption Spectra (Ultra-Violet), of the Molecules H_2O, HDO and D_2O (Dr. Jack Barrett and Dr. A. L. Mansell), 138; (R. M. Golding), 139
Absorption Spectra (Ultra-violet), of Proteins in Deuterium Oxide (Dr. Shiro Takashima), 597
Abstract Bibliography of Fruit Breeding and Genetics to 1955—*Rubus* and *Ribes*, a Survey (Dr. R. L. Knight and Elizabeth Keep), *review* by Dr. G. Haskell, 184
Abstracts: Nuclear Engineering, Vol. 1, No. 1, 993
Abundance of Marine Plankton (R. M. Cassie), 289
Accelerator Conference: Second (High Voltage Engineering Corporation), 743
Accelerators (Electron Linear): Pulse-shortening in (M. G. Kelliher and R. Beadle), 1099
Accessory Glands of Gene's Organ in Ticks (Dr. B. Feldman-Muhsam and Y. Havivi), 964
Accident (Reactor), at Windscale in October 1957. The Deposition of Strontium-89 and Strontium-90 on Agricultural Land and their Entry into Milk after the (United Kingdom Atomic Energy Authority and the Agricultural Research Council joint Report on), 1077
Accidents in Mines and Quarries, 1076
Accidents (Road), during Christmas 1959 (Road Research Laboratory, Technical Paper No. 49), 1000
Acetabularia mediterranea: Influence of Localized Ultra-violet Irradiation on the Incorporation of Adenine-8-^{14}C and D,L-Methionine-^{35}S in (Prof. J. Brachet and Dr. J. M. Olszewska), 954
Acetate into Protein: Incorporation of, by Obligately Parasitic and Saprophytic Fungi (Dr. Richard C. Staples and Dr. H. P. Burchfield), 1040
Acetates (Trinuclear Basic): Structure of the (Dr. L. E. Orgel), 504
Acetobacter acetigenum: Biosynthesis of Cellulose by (Dr. A. M. Brown and Dr. J. A. Gascoigne), 1010
  Syntheses of Glucose, Cellobiose and other Saccharides by, in a Lactate-buffered Glycerol Medium (Dr. C. P. Jackson and K. Ramamurti), 942
Acetone Fixation for the Cytochemical Demonstration of Dehydrogenases in Blood and Bone Marrow Cells (Dennis Quaglino and Dr. F. G. J. Hayhoe), 85
Acetylcholine with Physiological Stimulus: Summative Action of, on the Generator Potential in the Lateral Eye of the Horseshoe Crab (R. Kikuchi, K. Naito and S. Minagawa), 1118
Acetylcholine Concentration in the Brain of the Rat: Strain Differences in (Edward L. Bennett, James Crossland, David Krech and Mark R. Rosenzweig), 787
Acetyl-chymotrypsin: Structures of some Acetyl-serine Peptides from (Leo Benoiton, Prof. H. N. Rydon, R. A. Oosterbaan, M. E. Van Adrichem and Prof. J. A. Cohen), 596
Acetyl-serine Peptides: Structures of some, from Acetyl-chymotrypsin (Leo Benoiton, Prof. H. N. Rydon, R. A. Oosterbaan, M. E. Van Adrichem and Prof. J. A. Cohen), 596
Achievement—some Contributions of Animal Experiment to the Conquest of Disease (Dr. Geoffrey Lapage), *review* by Dr. W. Lane-Petter, 977
Acid Phosphatase: A Simple Azo-Dye Method for Histochemical Demonstration of (Dr. Tibor Barka), 248
Acid Phosphatase (Rat Serum): Total and *l*(+) Tartaric Acid Inhibited (Dr. Z. Laron and B. Epstein Halberstadt), 67
Acid-etched Glass Rods: Strengths of (B. A. Proctor), 492
Acid-tolerant and Non-sporulating Yeast from Passion Fruit Juice (B. A. S. Rao and J. S. Pruthi), 342
Acridine Orange: Effect of, on Living Bull Spermatozoa (C. van Duijn, jun.), 1006
  Induced Fluorescence with, after Osmium Fixation (W. J. Randles), 964
Acrylate (Methyl): Generation of Aerosols by Vapour-Phase Polymerization of (R. Pearson and G. Langer), 235
Actinomycin: Action of Nucleic Acids on the Inhibition of Growth by, of *Neurospora crassa* (Dr. W. Kersten, Dr. H. Kersten and Prof. H. M. Rauen), 60
  Interaction of, with Deoxyribonucleic Acid (Prof. J. Kawamata and M. Imanishi), 1112
Action of Micrococcal Phosphodiesterase: Mode of (Dr. K. K. Reddi), 74
Action of Nucleic Acids on the Inhibition of Growth by Actinomycin of *Neurospora crassa* (Dr. W. Kersten, Dr. H. Kersten and Prof. H. M. Rauen), 60
Action of Soluble Matrix Antifouling Compositions: Mode of (A. Partington), 1105
Action of some Surface-Active Compounds on the Gastro-intestinal Mucosa (Dr. J. A. Nissim), 305
Action of Tetrakis (Hydroxymethyl) Phosphonium Chloride on Wool (L. S. Bajpai, Prof. C. S. Whewell and J. M. Woodhouse), 602
Action (Anti-Fertility), of a Monoamine Oxidase Inhibitor (W. G. Spector), 514
Action (Direct), on Metabolism: Polypeptides of the Human Pituitary with (Dr. J. Bornstein and Deirdre Hyde), 125
Action (Lipaemic Clearing), of Artificial Anticoagulants (Dr. E. P. George, Dr. G. V. Hall and Dr. G. S. Farkas), 782
Action (Physiological), of Rotenone: Mechanism of the (Prof. P. E. Lindahl and K. E. Öberg), 784
Action (Summative), of Acetylcholine with Physiological Stimulus on the Generator Potential in the Lateral Eye of the Horseshoe Crab (R. Kikuchi, K. Naito and S. Minagawa), 1118
Action (Sustained), of Injected Chelating Agents (Dr. A. Lindenbaum and Dr. J. Schubert), 575
Action (Synergetic), of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia (Dr. E. Fischer, J. L. J. Szabó and M. Stamburgo), *erratum*, 559
Activation: Energies of, for Self-diffusion of Alkali Metal Ions in Analcite (Prof. R. M. Barrer and L. V. C. Rees), 768
Activation of One Plant Virus by Another (B. Kassanis and H. L. Nixon), 713
Activation (Enzymatic), of a Hormone-like Response in *Hydra* by Proteases (Dr. Howard M. Lenhoff and John Bovaird), 671
Activation (Neutron): Non-destructive Analysis of Selenium by, followed by Gamma-Ray Spectrometry (Dr. Minoru Okada), 594
Active against Gram-positive Bacteria: An Antibiotic Complex derived from a *Streptomyces* and (B. Sgarzi, A. M. Lugli and G. Giolitti), 1029
Active Adsorbents: Solid-Solid Interactions on (Dr. Phillip Anthony and Prof. Harry Zeitlin), 936
Active Cellular Fractions: Homotransplant Antigens—Preparation of (L. T. Mann, jun., J. M. Corson and Prof. G. J. Dammin), 774
Active Forms (Optically), of a Derivative of Tetra-substituted Sulphur (M. Baresh), 591
Active Fragments (Immunologically); Presence of, after Proteolytic Degradation of Human γ-Globulin (L. A. Hanson and B. G. Johansson), 599
Active Substance (Pharmacologically): An Unidentified, extracted from Cerebral Hemispheres (P. F. L. Andrews, Shirley A. P. Price and Dr. G. B. West), 420
Activities (Scientific), at Halley Bay: Recent—International Geophysical Co-operation, 1959 (M. J. Blackwell), 982
Activity: Plant Hormone—Stilboestrol applied to the Wheat Seedling (Dr. J. J. C. Hinton and Dr. T. Moran), 258
Activity of Bovine Pancreatic Ribonuclease A in Mixed Solvent Systems (Dorothy Findlay, Dr. A. P. Mathias and Dr. B. R. Rabin), 601
Activity (Alpha), of certain Botanical Materials (Prof. W. V. Mayneord, R. C. Turner and J. M. Radley), 208
Activity (Anti-Inflammatory), of Salicylate (Dr. V. Marks and Dr. M. J. H. Smith), 610
Activity (Antileukaemic), of Glycyrrhetinic Acid (Dr. W. Logemann, F. Lauria, G. Cudkowicz and J. Franceschini), 607
Activity (Anti-neoplastic), of Tetrahydro-1,3-oxazine Derivatives (Prof. T. Urbański, D. Gurne, S. Slopek, H. Mordarska and M. Mordarski), 426
Activity (Anti-Pneumococcus Type XIV), of Precipitins from *Ricinus communis* Seeds (Lieut.-Col. G. W. G. Bird), 415
Activity (Catalase-like), in Lactic Acid Bacteria: Two Types of (R. Whittenbury), 433, *erratum*, 466
Activity (Depressing), of Meprobamate on the Reticulo-Endothelial System (Prof. A. Del Vecchio and L. Bolis), 513

Activity (Diuretic), of 2-Amino-4-metachloro-anilino-1,3,5,triazine (*R*-37), (D. J. Mehta, Prof. U. K. Sheth and Dr. C. V. Delwala), 1034
Activity (Esterase), during Intracellular Digestion in a Histophagous Ciliate : Increase of (Dr. Miklós Muller, József Tóth and Prof Imre Toro), 65
Activity (The β-D-Fucosidase), of Mammalian Tissues and its relation to other Glycosidases (Dr. G. A. Levvy), 1027
Activity (Mutagenic), of Formaldehyde : Mechanism of Formaldehyde-induced Mutagenesis—the Uniqueness of Adenylic Acid in the Mediation of the (Dr. Thomas Alderson), 485
Activity (Nerve) : Chemical and Molecular Basis of (David Nachmansohn), *review* by Dr D. H Brinton, 447
Activity (Phagocytic), of the Reticulo-Endothelial System : Effect of some Aromatic Hydroxy Compounds on the (Prof. T. Nicol, C. Druce and C. C Ware), 422
  Effect of Three Compounds related by Diethylstilboestrol on the (Prof T. Nicol, G. Brownlee, C. Druce and C. C. Ware), 1032
Activity (Plant-Growth), of α-Alkylphenylacetic Acids and 1,2-Benzo-1-*cyclo*-alkene-3-carboxylic Acids (Kazuyoshi Kawazu, Toshio Fujita, Tetsuo Mitsui, Juro Kato and Masayuki Katsumi), 694
Activity (Polyphenol Oxidase), of *Nicotiana glutinosa* Leaves infected with Tobacco Mosaic Virus (Dr. Masatake Kikuchi and Akira Yamaguchi), 1048
Activity (Proactivator) : Isolation of Material with, from Human Serum (H B. W. Greig and Elsie M. Cornelius), 1125
Acuity (Visual) Effect of Size of Pupil on (Dr. F. W. Campbell and Dr. A. H. Gregory), 1121
Acute Leukaemia Cells . Proliferative Capacity of (Dr. Felice Gavosto, Giovanni Maraini and Alessandro Pileri), 611
β-Acylacrylic Acids . Structure of (Prof. Nils Hellstrom), 146, *erratum*, 650
Adams, F. R., and others : Preliminary Psychomotor Stress Studies with Subnormal Psychopathic Subjects, 172
Adams, J B. . Awarded the Roentgen Prize of the Justus Liebig University of Giessen, 201
Adaptive Chain in the Conversion of Antimetabolites into Metabolites (Dr. K. I. Markov, Dr. G. K. Saev and Dr. E. V. Golovinsky), 1041
1:1-Adducts of Cupric β-Diketone Chelates with Heterocyclic Bases · Structure of the (Dr. D. P. Graddon and E C. Watton), 1021
Adenine-8-^{14}C and D,L-Methionine-^{35}S in *Acetabularia mediterranea* : Influence of Localized Ultra-violet Irradiation on the Incorporation of (Prof. J. Brachet and Dr. J. M. Olszewska), 954
Adenosine Diphosphate : Synthesis of, by the Oxidation of Quinol Phosphates (Oxidative Phosphorylation) (Dr. V. M. Clark, D. W. Hutchinson and Sir Alexander Todd), 59
Adenosine Triphosphate and Maintenance of Shape of the Human Red Cells (Makoto Nakao, Toshiko Nakao and Saburo Yamazoe), 945
Adenovirus Nucleic Acid : Site and Nature of (Dr. M. A. Epstein and Dr. S. J. Holt), 1050
Adenylic Acid in the Mediation of the Mutagenic Activity of Formaldehyde : Mechanism of Formaldehyde-induced Mutagenesis—the Uniqueness of (Dr Thomas Alderson), 485
Administration · Scientist and Technologist in, 353
Administration of Materials Research and Development for National Security : More Effective Organization and (United States National Academy of Sciences—National Research Council, Publication No. 718), 470
Adrenal Cortex : Specific Inhibitors of the (Prof. J. H U. Brown), 985
Adrenal Glands of Litter-mate Cats : Proportion of Noradrenaline to Adrenaline in the (Dr. K. R. Butterworth and Dr. Monica Mann), 785
Adrenal Medulla (Denervated), of the Rat : Effect of Reserpine on the Nucleotide and Catecholamine Content of the (Prof. Nils-Åke Hillarp), 1032
Adrenaline : Proportion of Noradrenaline to, in the Adrenal Glands of Litter-mate Cats (Dr. K. R. Butterworth and Dr. Monica Mann), 785
Adrenergic Mechanisms : Parallelism of Changes produced by Cooling and by Drugs known to affect (Prof Eleanor Zaimis), 213
Adsorbents (Active) : Solid–Solid Interactions on (Dr. Philip Anthony and Prof. Harry Zeitlin), 936
Adsorption and Electrodekinetic Parameters at Metal Surfaces : Simultaneous Measurement of (A. M. Peers), 503 ; (Dr. E. A. Blomgren and Dr. J O'M. Bockris), 504
Adult Education, Universities Council for : Report on the Year 1958-1959, 906
Adult Spleen Cells (Homologous), injected into New-born Mice : Fate of (A. J. S. Davies and Sheila M. A. Doak), 610
Advanced Technology, Northampton College of (London) : Advanced Course on Direction and Supervision of Scientific and Engineering Personnel, 905
Advances in Chemical Physics (edited by Prof. I. Prigogine), Vols. 1 and 2, *review* by Prof. C. A. Coulson, 812
Advances in Clinical Chemistry (edited by Harry Sobotka and C. P. Stewart), Vol. 2, *review* by Dr. R. Consden, 890
Advances in Geophysics (edited by H. E. Landsberg and Prof. J. van Mieghem), Vols. 4 and 5, *review* by Dr. S. H. Hall, 1060
Advances in Steroid Chemistry : Recent (Kingston Technical College Postgraduate Course on), 905
Advances in Veterinary Science (edited by C. A. Brandly and E. L. Jungherr), Vol. 5, *review* by Prof. H Burrow, 448
Adventures with the Missing Link (Prof. Raymond A. Dart, with Dennis Craig), *review* by Sonia Cole, 888
Advisory Committee on Nuclear Safety : Appointment of an, 113
Advisory Council for Education (Central)—England : Report, Vol. 2, Surveys, 883
Advisory Council for Research and Development in Fuel and Power, 286
Advisory Group for Aeronautical Research and Development—*see under* AGARD
Advisory Water Committee, Central · Second Report of the Sub-Committee on Growing Demand for Water, 198
Aedes aegypti (L), the Yellow Fever Mosquito—its Life History, Bionomics and Structure (Sir S. Rickard Christophers), *review* by Prof. V. B Wigglesworth, 813
Aerobic Glycolysis : Inhibition of, in Yoshida Ascites Hepatoma by Tartronic Acid (Dr. L. Fiume), 792
Aeronautical Research and Development, Advisory Group for—*see under* AGARD
Aerosols : Generation of, by Vapour-Phase Polymerization of Methyl Acrylate (R. Pearson and G. Langer), 235
  The Physical Chemistry of (Faraday Society General Discussion on), 201
Africa South of the Sahara : Science and Technology in, 198
Africa's Place in the Emergence of Civilization (Prof. Raymond A Dart), *review* by M. C. Burkitt, 891
Africa (East) : Scientific Research in, 206
Africa (East) High Commission . Annual Report for 1959, 206
  Annual Report for 1959 of the East African Fisheries Research Organization, 469
Africa (Northern) : The Stone Age in (Dr. C. B. M. McBurney), *review* by M. C. Burkitt, 1062
Africa (South) . Polychaete Fauna of (Prof. J. H. Day), Part 5, 199
African (East) Fisheries Research Organization : Annual Report 1959 (East Africa High Commission), 469
African (East) Virus Research Institute : Report for 1958-59 (J. D. Gillett), 565
African (North) Prehistory, *review* by M. C. Burkitt, 1062
African (South) Animal Life—Results of the Lund University Expedition in 1950-1951, Vol. 6 (edited by Bertil Hanstrom, Per Brinck and Gustav Rudebeck), *review* by H. Oldroyd, 1063
African (South) Bantu The Rh Factor C in (Dr. A. Zoutendyk and Dr. H. Teodorczuk), 790
African (South) Broadcasting Corporation : Van Riebeeck Lectures, Africa's Place in the Emergence of Civilization (Prof. Raymond A. Dart), *review* by M C Burkitt, 891
African (South) Museum : *Annals of the*, Vol. 45, Part 3, 199
African (South) University Students : Daily Food Consumption by (Sonia E. Walker), 381
African (West) Religion : Oedipus and Job in (Prof. Meyer Fortes), *review* by Michael Argyle, 96
AGARD : Fourth Colloquium on Combustion and Propulsion (High Mach Number Air-breathing Engines), 18
  Meetings for the second half of 1960, 116
  Sixteenth Meeting of the Aero Space Medical Panel, 994
  Avionics Panel Symposium on Radio Navigation, 1079
Age : Chemical Physics Comes of, *review* by Prof. C. A. Coulson, 812
Age of the Base of the Cambrian (Dr. G. W. Wetherill), 34 ; (Prof. Arthur Holmes), 35
Age of the Cambrian System (Prof. C. F. Davidson), 1020
Age (Known) : Marked Humpback Whale of (Dr. R. G. Chittleborough), 164
Age (Scientific) : The Spiritual Crisis of the (G. D. Yarnold), *review* by R. Brightman, 818
Age (The Stone), in Northern Africa (Dr. C. B. M. McBurney), *review* by M. C Burkitt, 1062
Age Determination of Seals (H. R. Hewer), 959
Ageing Bloodstains : Use of Reflectance Measurements in assessing the Colour Changes of (Dr. D. Patterson), 688
Ageing of Mitochondria (Dr C. H. Gallagher), 162
Ageing and Radiation (Dr. G. J. Neary), 10
Agents (Surface-active) : Treatment of *Leishmania donovani* Infections with (Dr. J. D. Fulton), 1129
Ager, Dr D. V. : Appointed reader in geology at the Imperial College of Science and Technology, London, 117
Ageron, Paul (Alami, Richard, etc) . Évacuation et Récupération de la Chaleur des Réacteurs Nucléaires, *review* by R. J. Syme, 636
Ages (Potassium–Argon), of some Rocks from the South Atlantic (John A. Miller), 1019
Aggregate : Dependence of Cement-Aggregate Bond-Strength on Size of (K. M Alexander and J. Wardlaw), 230
Aggregate (Cement-) Bond-Strength : Dependence of, on Size of Aggregate (K. M. Alexander and J. Wardlaw), 230
Agricultural Advisory Service (National) : Appointment of V. Cory as county advisory officer for Yorkshire (West Riding), 1079
Agricultural Land : The Deposition of Strontium-89 and Strontium-90 on, and their Entry into Milk after the Reactor Accident at Windscale in October 1957 (United Kingdom Atomic Energy Authority and the Agricultural Research Council joint Report on), 1077
Agricultural Pests : Chemical Control of, and Conservation of America's Wild-Life (United States National Academy of Sciences—National Research Council Committee on), 114
Agricultural Policy (British) : Principles for—a Study sponsored by the Nuffield Foundation (edited by H. T. Williams), *review* by Sir John Russell, 721
Agricultural Research Council : Appointment of Prof. Alexander Robertson as a member, 290
Agricultural Research Council (United Kingdom Atomic Energy Authority and the) : Joint Report on the Deposition of Strontium-89 and Strontium-90 on Agricultural Land and their Entry into Milk after the Reactor Accident at Windscale in October 1957, 1077
Agricultural Science : Proceedings of the University of Nottingham Sixth Easter School in (1959)—The Measurement of Grassland Productivity (edited by Prof. J. D Ivins), *review* by Dr. G. W. Cooke, 544
Agricultural University : India's First, 556
Agricultural and Food Attaché (United Kingdom), in Argentina, 1075
Agricultural and Scientific Research Overseas, 556
Agriculture . Weather Problems in (Royal Meteorological Society Summer Meeting), 995
Agriculture, United States Department of : Supplements 9 and 10 to the Index-Catalogue of Medical and Veterinary Zoology, 559
Agriculture (British) : Future of, *review* by Sir John Russell, 721
Agriculture, Fisheries and Food, Ministry of : Technical Bulletin No. 10, Control of Rats in Sewers (Dr. E. W. Bentley), 288
  Fishery Investigations, Series 2, Vol. 22, No. 9, Echo Sounding Experiments in the Barents Sea (I. D. Richardson, D. H. Cushing, F. R. Harden Jones, R. J. H. Beverton and R. W. Blacker), 855
  Bulletin No. 34, Mushroom Growing, seventh edition, 902
Agriculture and Food Storage : Use of Toxic Chemicals in (Request from the Research Study Group for evidence), 290
Agriculture (Tropical), Imperial College of : To be merged into the University College of the West Indies, 374
Agrobacterium tumefaciens : A Vacuolar System in Cells of, as shown by Electron Microscopy of Ultra-thin Sections (Miguel Rubio-Huertos and Paul R. Desjardins), 1043

Ahrens, Jun., Dr. Edward H. : Promoted to a professor and member of the Rockefeller Institute, 290
Ahrens, Prof. L. H., and others (edited by) : Physics and Chemistry of the Earth, Vol. 3, *review* by B. E. Leake, 544
Aid when Operating on Marine Gastropoda : 'Water Rigour' as an (Prof. B. J. Krijgsman and A. C. Brown), 69
Aigrain, Prof. P., et Englert, F. : Les Conducteurs, *review* by Dr. J. R. Tillman, 1058
Ainsworth, Dr. G. C. : Microbial Systematics, 191
  Plant Pathology in the British Commonwealth, 834
Air : Average Water Vapour Content of the (J. K. Bannon and L. P. Steele), 748
Air (Clean), National Society for : Year Book for 1960, 200
Air Force Cambridge Research Center (Geophysics Research Directorate of the United States), with the co-operation of Lowell Technological Institute Research Foundation : Exploding Wires—Based on Conference on the Exploding Wire Phenomenon, 1959 (edited by William G. Chace and Howard K. Moore), *review* by Dr. B. A. Thrush, 726
Air Ministry (Meteorological Office) : Geophysical Memoirs No. 102, Average Water Vapour Content of the Air (J. K. Bannon and L. P. Steele), 748
  Scientific Paper No. 1, Airborne Measurements of Latitudinal Variation of Frost-point Temperature and Wind (N. C. Helliwell), 993
Air-borne Material : Radioactive Labelling of Membrane Filters for the Assay of (Dr. G. Kubie and Dr. K. Spurny), 930
Airborne Measurements of Latitudinal Variation of Frost-point Temperature and Wind (N. C. Helliwell), 993
Airborne *Serratia marcescens* : Delayed Recovery of, after Short-Time Exposure to Ultra-violet Irradiation (Dr. R. L. Dimmick), 251
Air-breathing Engines : High Mach Number (AGARD fourth Colloquium on Combustion and Propulsion), 18
Aitken, Yvonne : Axial Origin of the Terminal Inflorescence in the Genus *Trifolium*, 622
Akcasu, A., and others : 5-Hydroxytryptamine in Cerebrospinal Fluid, 324
Akcasu, M., and others : 5-Hydroxytryptamine in Cerebrospinal Fluid, 324
Akroyd, T. N. W. : Laboratory Testing in Soil Engineering, *review* by Dr. H. L. Penman, 891
Alami, Richard, et Ageron, Paul : Évacuation et Récupération de la Chaleur des Réacteurs Nucléaires, *review* by R. J. Syme, 636
Alberta, Research Council of : Fortieth Annual Report (1959), 660
Albinism in an American Population of the Shore Crab, *Carcinus maenas* (L.), (Anthony J. Provenzano, Jun.), 521
Albino Mouse : A Transplantable Spontaneous Osteogenic Sarcoma observed in the Muscle Tissue of an (R. G. Herne, M. Gregoire and G. Rona), 1129
Albumin (Serum) Concentration in Analbuminaemia and its Immunological Significance (Dr. J. H. Humphrey), 304
Alderson, Dr. Thomas : Mechanism of Formaldehyde-induced Mutagenesis—the Uniqueness of Adenylic Acid in the Mediation of the Mutagenic Activity of Formaldehyde, 485
Aldred, Dr. A. S. : Appointed to a senior lectureship in electric power engineering in the University fo Liverpool, 117
Aldridge, William G. : A New Method for the Differential Precipitation of Nucleic Acids from Aqueous Solutions, 323
Alexander, C. G., and others : Effect of Nitrate Ion on the Distribution of Sucrose in the Rat's Ventricle, 419
Alexander, K. M., and Wardlaw, J. : Dependence of Cement-Aggregate Bond-Strength on Size of Aggregate, 230
Alexander, Peter, and Lett, J. T. : Role of Oxygen in the Cross-linking and Degradation of Deoxyribonucleic Acid by Ionizing Radiations, 933
Alfvén, H. : At the Tenth General Physics Conference of the Swedish National Committee for Physics (Plasma Physics and Magneto-hydrodynamics), 557
Alga (Australian Brown), *Notheia anomala* : Structure and Systematic Position of the (M. Nizamuddin and Dr. H. B. S. Womersley), 673
Algae (Green) : Xylan of Siphonaceous (Yoshihiko Iriki, Takao Suzuki, Kazutosi Nisizawa and Tomoo Miwa), 82
Aliphatic Hydrocarbons : Radiation-induced Nitration of (Dr. Tyson Rigg), 933
Allen, Prof. R. D., and others : Streaming in Cytoplasm dissociated from the Giant Amoeba, *Chaos chaos*, 896
Alivisatos, Prof. S. G. A., and others : Non-Enzymic Reactions of Indoles with Coenzyme I, 374
Alkali Metal Ions in Analcite : Energies of Activation for Self-diffusion of (Prof. R. M. Barrer and L. V. C. Rees), 768
Alkaline C-1 Fructose-1,6-diphosphatase—Evidence for its Participation in Photosynthesis (Dr. Robert Smillie), 1024
Alkaloids : Optical Rotatory Powers of, *review* by Dr. J. Walker, 7
n-Alkyl Chloride Gases : Ionization and Attachment Coefficients in (J. C. Devins and O. H. LeBlanc, Jun.), 409
α-Alkylphenylacetic Acids and 1,2-Benzo-1-cycloalkene-3-carboxylic Acids : Plant-Growth Activity of (Kazuyoshi Kawazu, Toshio Fujita, Tetsuo Mitsui, Jiro Kato and Masayuki Katsumi), 694
All-Transistor Digital Computer : *Leo III*, a New (Leo Computers, Ltd.), 373
Allan, D. L. : Premier Colloque International de Photographie Corpusculaire, *review*, 636
Allan, I. R. H., and others : Recapture in the River Tweed of a Sea-Trout marked in Devonshire, 877
Allan, J. E. : Determination of Nickel and Cobalt by Atomic Absorption, 1110
Allan, J. T., and Scholes, Dr. G. : Effects of pH and the Nature of the Primary Species in the Radiolysis of Aqueous Solutions, 218
Allard, Dr. C. : Intracellular Localization of Enzymes, 836
Alleged Occurrence of the Perchlorate Ion in Sea-Water (R. Greenhalgh and Dr. J. P. Riley), 1107
Allen, Dr. Clifford : The Hidden Mind, *review*, 978
  Existential Psychiatry, *review*, 1062
Allen, G. P. : Awarded a Nature Conservancy Diploma Course in Conservation and Ecology at University College, London, 742
Allen, H. S. : Appointed lecturer in civil engineering at the University of Southampton, 290
Allen, J. W. : Effect of Electric Fields on Hydrogen-like Excitons, 51
  Gallium Arsenide as a Semi-Insulator, 403
Allen, Dr. N. L. : Periodic Magnetic Field Fluctuations in the Sceptre Discharge, 279
Allen, Dr. P. W. : Colloid and Polymer Science (Grafting of Methylmethacrylate Polymers on Natural Rubber Latex), 378
Allies : Parasites as Enemies and (Dr. J. Mahon), 203 ; (Prof. T. H. Davey), 203
Allison, Prof. S. K. : Penetration of Charged Particles in Matter (Measurements on the Formation of Negative Lithium Ions), 1086
Alloiteau, James : Contribution à la Systématique des Madréporaires Fossiles, *review* by Dr. H. Dighton Thomas, 95
Alloxan : Effect of Glutathione and, on the Photoperiodic Response of *Xanthium* (J. Nitsan), 81
Alloys (Gold–Silicon) : Non-crystalline Structure in Solidified (W. Klement, Jun., R. H. Willens and Prof. Pol Duwez), 869
Alloys (Metals and) : Heat Treatment of (Société Française de Métallurgie Meeting on), 559
Allsop, R. T., and others : A New Phase in a Silicon bearing 17 per cent Chromium, 8 per cent Nickel and 1 per cent Niobium Steel, 407
Allsopp, A. : Plant Tissue Cultures, *review*, 976
α-Activity of certain Botanical Materials (Prof. W. V. Mayneord, R. C. Turner and J. M. Radley), 208
α-Alkylphenylacetic Acids and 1,2-Benzo-1-cycloalkene-3-carboxylic Acids : Plant-Growth Activity of (Kazuyoshi Kawazu, Toshio Fujita, Tetsuo Mitsui, Jiro Kato and Masayuki Katsumi), 694
α-Helix in Poly-β-benzyl-L-aspartate : Screw Sense of the (E. M. Bradbury, A. R. Downie, Dr. A. Elliott and W. E. Hanby), 321
α-Pinene : Microbiological Transformation of Terpenes—Hydroxylation of (P. K. Bhattacharyya, B. R. Prema, B. D. Kulkarni and S. K. Pradhan), 689
α- and β-Pinene : Radiolysis of Terpene Hydrocarbons—Isomerization and Polymerization of (T. H. Bates and Dr. T. Ffrancon Williams), 665
Alternating Stresses required to Initiate and Propagate a Fatigue Crack in Mild Steel : Correlation of the (N. E. Frost), 233
Altitude and Distance from the Source of Sodium Chloride : Change of the Chlorine—Sodium Ratio in the Atmosphere with, and the Distribution of Atmospheric Nitrate over the United States (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Altman, K. I., and others : Urinary Excretion of β-Amino-isobutyric Acid after Injection of Thymidine labelled with Tritium, 956
Altman, K. I., and Salomon, Prof. K. : Localization of a Halogenated Porphyrin in Mouse Tumours, 1124
Aluminium Interlayers in Clay Minerals, Montmorillonite and Vermiculite—Laboratory Synthesis (B. L. Sawhney), 261
Aluminium Single Crystal : Borrmann Effect observed in an (Koichi Nakajima and Prof. Shigeyasu Koda), 53
Amaranthus : Chromosome Numbers in (Prof. W. F. Grant), 28
Ambrose, E. J. : Appointed to the University of London readership in physical chemistry at the Institute of Cancer Research, Royal Cancer Hospital, 904
America (Latin) : Scientific Institutions and Scientists in (Unesco Centre for Scientificic Co-operation in Latin America), Vol. 4, Argentine, 29
America (North) : Sap-Transmissible Viruses associated with Diseases o Grape Vines in Europe and (C. H. Cadman, H. F. Dias and B. D. Harrison), 577
America (North), Arctic Institute of : Grant-in-aid Programme, 831
America (South) : Cosmic Radiation Studies in, 648
America's Wild-Life : Chemical Control of Agricultural Pests and Conservation of (United States National Academy of Sciences—National Research Council Committee on), 114
American Book Publishing Record, 116
American Chemical Society : Monograph Series No. 139, The Science of High Explosives (Prof. Melvin A. Cook), *review* by Dr. W. L. Murray, 539
  Monograph Series No. 134, The Chemistry and Technology of Leather (edited by Fred O'Flaherty, William T. Roddy and Robert M. Lollar), Vol. 2, Types of Tannages, *review* by Prof. A. G. Ward, 724
American Institute of Biological Sciences : Translations of Russian Biological Publications, 558
American Institute of Geonomy and Natural Resources : John Fleming Medal awarded to Dr. Maurice Ewing, 905
American Institute of Nutrition : Election of Dr. W. R. Aykroyd as an honorary member, 29
  Election of honorary members, 374
American Institute of Physics : To publish the *Physics of Fluids* monthly starting in 1961, 832
American Journal of Human Genetics : Symposium on Cytology and Cell Culture Genetics of Man, 116
American Meat Institute Foundation (Members of the Research Staff of the) : The Science of Meat and Meat Products, *review* by Prof. J. Hawthorn, 888
American Observatories : New (V. C. Reddish), 910
American Oligocene : The (Dr. R. M. Stainforth), 678 ; (F. E. Eames, F. T. Banner, W. H. Blow and W. J. Clarke), 679
American Population of the Shore Crab, *Carcinus maenas* (L.) : Albinism in an (Anthony J. Provenzano, Jun.), 521
American Research in Neuropsychiatry : Recent, *review* by Dr. D. H. Brinton, 447
American Society for Cell Biology : Organization of the, 649
American (Latin-) Council of Cosmic Radiation : Meeting in Rio de Janeiro, 648
American (North) Fresh-Water Biology, *review* by Dr. T. T. Macan, 6
American (North) Xanthoid Crab New to Britain (E. Naylor), 256
Americium (Internally Deposited) : Removal of, by Chelating Agents (Dr. F. D. Sowby and Dr. D. M. Taylor), 612
Amidase (Penicillin) : Bacterial (Dr. C. A. Claridge, Dr. A. Gourevitch and Dr. J. Lein), 237
Amines (Vasoconstrictor) : Influence on the Effect of, by Pretreatment with Reserpine (H. C. Sabelli), 784
Amino-Acid Pattern (Urinary), of Cats on Diets of varying Protein Content (Dr. J. P. Greaves and Dr. Patricia P. Scott), 242
Amino-Acid Sequence of Human Insulin (Dr. D. S. H. W. Nicol and Dr. L. F. Smith), 483
Amino-Acid Sequence about the Reactive Serine of a Proteolytic Enzyme from *Bacillus subtilis* (Dr. F. Sanger and D. C. Shaw), 872
Amino-Acids (Free), of the Tsetse Fly (*Glossina*), (E. Bursell), 778
Amino-Acids (N-Terminal), of Bovine Antibody (Elizabeth M. Press and R. R. Porter), 59

INDEX

Amino-Acids and related Substances : Infra-Red Spectra of, in Water (Prof. Frank S. Parker and Prof. Donald M. Kirschenbaum), 386
γ-Aminobutyric Acid-Level in the Brain : Effect of Potassium Cyanide Poisoning on the (Dr T. Tursky), 322
β-Amino-isobutyric Acid : Urinary Excretion of, after Injection of Thymidine labelled with Tritium (Dr. Georg B. Gerber, Gisela Gerber and Kurt I. Altman), 956
2-Amino-4-meta-chloro-anilino-1,3,5,triazine (*R*-37) • Diuretic Activity of (D. J. Mehta, Prof. U. K. Sheth and Dr. C. V. Delwala), 1034
Aminoazo Dyes (Protein-bound) : Distribution of, in the Rat Liver Microsome (Dr T. Yamada, M. Matsumoto, S. Kanda and Prof. H. Terayama), 943
6-Aminopenicillanic Acid : Formation of, from Penicillin by Enzymatic Hydrolysis (Dr. G N. Rolinson, F. R. Batchelor, D. Butterworth, J. Cameron-Wood, Dr M Cole, G C. Eustace, Marian V. Hart, Dr. M. Richards and Prof. E. B. Chain), 236
Aminopyrine Analgesia (Morphine, Dihydrocodeine and) : Synergetic Action of 2(*o*-Methoxyphenoxymethyl)-5-Oxazolidone on (Dr. E. Fischer, J. L J. Szabó and M. Stamburgo), *erratum*, 559
Amino-Sugars : Glucosamine Values of Muramic Acid and other, by the Elson and Morgan Method (R. E. Strange), 38
Ammocoetes : Sex Ratio of (M. W Hardisty), *erratum*, 29
Ammonia released on Treating Soils with *N* Sodium Hydroxide as a Possible Means of Predicting the Nitrogen-supplying Power of Soils (A. H. Cornfield), 260
Ammonium Bromide (Urea–) : Mimetic Twinning in (C. G. C. Catesby), 765
Amoeba (Giant), *Chaos chaos* : Streaming in Cytoplasm dissociated from the (Prof. R. D. Allen, J. W. Cooledge and P. J. Hall), 896
Amoeba proteus : Effect of Pyruvate upon Nucleated and Enucleated Fragments of (Dr. Edmund Guttes and Sophie Guttes), 432
  Suppression of Cytoplasmic Division in (Dr. Edmund Guttes and Sophie Guttes), 520
Amos, S. W., and Birkinshaw, D. C. : Television Engineering, Vol 1, Fundamentals, Camera Tubes, Television Optics, Electron Optics (written in collaboration with J L. Bliss) ; Vol. 2, Video-Frequency Amplification ; Vol. 3, Wave-Form Generation ; Vol 4, General Circuit Techniques, *review* by Dr. R. L Smith-Rose, 358
Amount (Limited), of Streptomycin : Absence of Carbon Monoxide-sensitive Respiration in a Streptomycin-dependent Mutant of *Escherichia coli* grown in (Hanna Engelberg and Dr. M. Artman), 801
Amphibian Development : Electrophoretic Pattern during (H Denis), 62
Amphibian Neural Crest Cell : Pterin Synthesis in the (Tadao Hama and Masataka Obika), 326
Amphoteric Antibiotics : 'pH-Chromatography' of some (Vladimir Betina and Prof. Pavel Nemec), 1111
Amplitude of the Diurnal Variation of Cosmic Rays : Dependence on Latitude of the (Arne Eld Sandström, Eric Dyring and Stig Lindgren), 1099
Amplitude Curves for Seismic Body Waves : Oscillatory Character of (Dr. J. Vanek and J. Stelzner), 491
Ampullae of Lorenzini : Electrical Sensitivity of the (Dr. R. W. Murray), 957
Anal Canal : Sensory Innervation of the (R. P. Gould), 337
Analbuminaemia : Serum Albumin Concentration in, and its Immunological Significance (Dr. J. H. Humphrey), 304
Analcite : Energies of Activation for Self-diffusion of Alkali Metal Ions in (Prof. R. M. Barrer and L. V. C. Rees), 768
Analgesia (Morphine, Dihydrocodeine and Aminopyrine) : Synergetic Action of 2(*o*-Methoxyphenoxymethyl)-5-Oxazolidone on (Dr. E. Fischer, J. L J. Szabó and M. Stamburgo), *erratum*, 559
Analogue (Creatine) : Production of Muscular Weakness in Rats by a (Coy D. Fitch and Prof James S. Dinning), 421
Analogue Computer : A New British, the *Radic* (The Redifon Company), 288
Analyser (Interval) : A Biological (G. K. Smith and Prof. B. Delisle Burns), 512
Analyses of Relaxin (Edward H. Frieden), 200
Analysis : Colorimetric, *review* by A. M. G. Macdonald, 3
  Engineering Systems (Prof. Robert L Sutherland), *review* by Prof J. Greig, 359
  Numerical (Delegacy for Extra-Mural Studies, University of Oxford, Non-residential Summer School on), 374
Analysis of Metabolic Rates at the Cellular Level (Dr. L. G. Lajtha, R. Oliver, R. J. Berry and Elizabeth Hell), 919
Analysis of Small Experiments (P. Sprent), 437
Analysis of Solubility Data to estimate Small Amounts of Chain Fracture during the Cross-linking of Rubber (L. Mullins and D. T. Turner), 145
Analysis (Differential Thermal), of some Transition Metal Ethylenediamine Tetraacetic Acid Chelates (Prof. Wesley W. Wendlandt and G. Robert Horton), 769
Analysis (Direct Infra-Red Spectral), of the Cucumber Mosaic Virus Infection Process (Prof. G. W. Cochran, G. W. Welkie and J. L. Chidester), 1049
Analysis (Gas-Liquid Chromatography), of C_4–C_6 Hydrocarbons : Two Highly Selective Solvents for (Dr. A. van der Wiel), 142
Analysis (Isotopic), of Silicon by Solid-Source Mass Spectrometry using Negative Ions (Dr. D. C. Newton, J. Sanders and A. C. Tyrrell), 683
Analysis (Non-destructive), of Microgram Quantities of Silver by Radioactivation (Dr. Minoru Okada), 57
Analysis (Non-destructive), of Selenium by Neutron Activation followed by Gamma-Ray Spectrometry (Dr. Minoru Okada), 594
Analysis (Preliminary), of some International Geophysical Year Observations : Distribution of Atmospheric Ozone—a (J. MacDowall), 382
Analysis (Sugar), International Commission for Uniform Methods of—Report of the Proceedings of the Twelfth Session, Washington, D.C., 1958, *review* by Prof. E. L. Hirst, 9
Analytical Approaches to Engineering Problems: Unification of, *review* by Prof. J. Greig, 359
Analytical Biochemistry, Vol. 1, No. 1, 558
Analytical Chemistry in Nuclear Reactor Technology (Oak Ridge National Laboratory Conference on), 994
Analytical Chemistry of Titanium Metals and Compounds (Maurice Codell), *review* by Prof. A. G. Quarrell, 725
Analytical Chemistry and Applied Spectroscopy (Twelfth Pittsburgh Conference on), 289
Analytical Methods : A Handbook of Colorimetric Chemical (Tintometer, Ltd.), fifth edition, *review* by A. M G Macdonald, 3
Ananthakrishnan, Dr. R. : Light Curves of Meteors, 675
Anaphylactic Sensitization of Isolated Tissues *in vitro* : Influence of the Ionic Strength of the Medium on the (R. Binaghi, M. Liacopoulos-Briot, Dr. B. N Halpern and P. Liacopoulos), 697
Anastomoses in the Phycomycetes (Dr D. M. Griffin and Helen N. Perrin), 1039
Anatomy of Judgment : The (Dr. M. L. Johnson Abercrombie), *review* by Prof. O. L. Zangwill, 817
Anatomy (Topographical), of the Dog (Dr. O. Charnock Bradley), sixth edition revised by Prof. Tom Grahame, *review* by Prof. T. Nicol, 451
Anbar, Dr. Michael, and others : Radiolysis of Highly Enriched Oxygen-18 Water Solutions containing Hydrogen Peroxide-16,16, 57
Anderson, Sir Colin : At the sixty-sixth Annual Conference of the Museums Association (Relations of Museums and Industry), 657
Anderson, J. H. : Food and Animal Production Overseas (Food Production Problems of the Middle East), 1070
Anderson, Dr. J. R., and Baker, B. G. : Hydrocracking of Neopentane and Neohexane over Evaporated Metal Films, 937
Anderson, M. C. : Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Botany), 742
Anderson, W., and others : Radiostrontium and Radiocaesium in Milk during 1959, 108
  Comparison of Fission Product and Beryllium-7 Concentrations in the Atmosphere, 550
Andersson, Dr. Sten, and Wadsley, Dr. A. D. : Five Co-ordinated Titanium in $K_2Ti_2O_5$, 499
Andrade, Prof. E. N. da C. : *Obituary* of H. W. Robinson, 23
  A Brief History of the Royal Society, *review* by Dr. William P. D. Wightman, 356
  A Simple Method of Investigating the Creep of Metals under Simple Shear, 494
Andrewes, Dr. C. H. : Microbial Systematics, 191
Andrews, P. F. L., and others : An Unidentified Pharmacologically Active Substance extracted from Cerebral Hemispheres, 420
Angiosperms : Origin of (Prof. T. M. Harris), 847
Anglia (East) : Nature and Conservation in (Council for Nature), 649
Animal Cellulose : Human and other (Dr D. A. Hall and H. Saxl), 547
Animal Experiment : Achievement—some Contributions of, to the Conquest of Disease (Dr. Geoffrey Lapage), *review* by Dr. W. Lane-Petter, 977
Animal Experiments in Research, *review* by Dr. W. Lane-Petter, 977
Animal Health Trust : Educational Awards for 1960-61, 904
Animal Husbandry at Bristol, 647
Animal Life : South African—Results of the Lund University Expedition in 1950-1951, Vol 6 (edited by Bertil Hanstrom, Per Brinck and Gustav Rudebeck), *review* by H. Oldroyd, 1063
Animal Production Overseas : Food and (British Association for the Advancement of Science, Section M (Agriculture), Discussion on), 1070
Animal Research Laboratory (The Ian Clunie), Prospect, New South Wales (Dr. Ian W. McDonald), 980
Animal Welfare, Universities Federation for : Summer Congress, 374
Animals : Photoperiodism and related Phenomena in Plants and (edited by Robert B. Withrow)—Proceedings of the Conference on Photoperiodism, 1957, sponsored by the Committee on Photobiology of the National Academy of Sciences—National Research Council, supported by the National Science Foundation, *review* by Prof. L J Audus, 96
  Tuberculosis in (Zoological Society of London Symposium on), 996
Animals (Marine) : The Biology of (Dr. J. A. Colin Nicol), *review* by Prof C. M. Yonge, 630
  Physiology of, *review* by Prof. C M. Yonge, 630
Animals (Wild) : Translocation of, as a Means of Game Control (Dr. A. M. Harthoorn, J A. Lock and J. MacKeand), 518
Annals of the South African Museum, Vol. 45, Part 3, 199
Annelid *Lumbricus terrestris* : Biosynthesis of Squalene by the (Joyce M. Wootton and Lemuel D Wright), 1027
Anno, Dr. T. : Japanese fellowship renewed by the Ramsay Memorial Fellowship Trustees, 832
Annona squamosa L. : Unproductivity in the Colchicine-induced Tetraploids of (Prof. Ahmad Shamsul Islam), 343
Annual Review of Entomology (edited by Edward A. Steinhaus and Ray F. Smith), Vol. 5, *review* by Prof V. B. Wigglesworth, 542
Annual Review of Nuclear Science (edited by Emilio Segrè and Leonard L. Schiff, in association with Gerhart Friedlander and Walter E Meyerhof), Vol. 9, *review* by Dr E B. Paul, 182
Annual Reviews on Inorganic Chemistry, *review* by Dr. I. R Beattie, 4
Anodal Polarization : Restoration of Membrane Excitability of Calcium-deficient Muscles by (Prof. K. Koketsu and K Noda), 243
Anomalies (Perceptual), associated with a Single Contour (J. P. Wilson), 137
Anomalous Leads from a Selected Geological Environment in West-Central New Mexico (William F. Slawson and Carl F. Austin), 400
Anopheles gambiae Giles : Experimental Breeding of, in Papyrus Swamps (L. K. H. Goma), 1137
Anoxia : Comparison between the Effects of Cysteine and of, on the Rate of Mitosis in Lens Epithelium (Dr. Antoinette Pirie and Dr. Ruth van Heyningen), 947
Antarctic : Southern Atmospheric Cyclones and the Whale Feeding Grounds in the (Dr. C. W. Beklemishev), 530
Antarctic Convergence—and Divergence (Dr. K. Wyrtki), 581
Antarctic Snows : Isotopic Composition and Temperature of Formation of (Prof E. Picciotto, X. de Maere and Dr. I. Friedman), 857
Antarctica (Byrd Station,) : Association between Aurorae and Very Low-Frequency Hiss observed at (Dr. L. H. Martin, Dr. R. A. Helliwell and K. R. Marks), 751
Anterior Byssus Retractor Muscle of *Mytilus edulis* : The Membrane Potential of the (Dr. D. H Paul), 1121
Anthocyanins : Zone Electrophoresis of (Prof. P. Markakis), 1092
Anthony, Dr. H. D. : The Faith of a Physicist, *review*, 1063
Anthony, Dr. Philip, and Zettlin, Prof. Harry : Solid–Solid Interactions on Active Adsorbents, 936

Anthropological Institute (Royal): Huxley Memorial Medal for 1961 awarded to Dr. A. E. Mourant, 114
  Rivers Memorial Medal awarded to Prof. J. C. Mitchell, 114
  Wellcome Medal for 1959 awarded jointly to E. M. Chilver and Dr. P. Kaberry, 114
  Election of Officers for 1960-61, 114
Antibiotic from Legume Seed Coats: Inhibition of Nodule Bacteria by an (J. A. Thompson), 619
Antibiotic Complex derived from a *Streptomyces* and Active against Gram-positive Bacteria (B. Sgarzi, A. M. Lugli and G. Giolitti), 1029
Antibiotic Therapy and Staphylococcal Diseases (edited by Dr. Henry Welch and Prof. Maxwell Finland), *review* by Prof. R. Knox, 637
Antibiotics *PA114B-1* and *PA114B-3*: Structure of the (D. C. Hobbs and W. D. Celmer), 598
Antibiotics (Amphoteric): 'pH-Chromatography' of some (Vladimír Betina and Prof. Pavel Nemec), 1111
Antibodies (Virus and), in the Lymph and Blood of Sheep infected experimentally with the Virus of Tick-borne Encephalitis (Doubravka Málková), 716
Antibody (Bovine): N-Terminal Amino-Acids of (Elizabeth M. Press and R. R. Porter), 59
Antibody (Ferritin-conjugated): Use of, to Localize Antigen by Electron Microscopy (Richard A. Rifkind, Konrad C. Hsu, Councilman Morgan, Beatrice C. Seegal, Alice W. Knox and Harry M. Rose), 1094
Antibody Responses of the Domestic Fowl to Two Soluble Bacterial Antigens (Dr. G. Gowland), 624
Anticoagulants (Artificial): Lipaemic Clearing Action of (Dr. E. P. George, Dr. G. V. Hall and Dr. G. S. Farkas), 782
Anti-Diuretic Hormone and Calcium: Effect of, on the Equivalent Pore Radius of Kidney Slices from *Necturus* (G. Whittembury, N. Sugino and Dr. A. K. Solomon), 699
Antiferromagnetic Behaviour (Ferromagnetic and), in the Second Transition Group (Dr. B. R. Coles and D. Griffiths), 226
Anti-Fertility Action of a Monoamine Oxidase Inhibitor (W. G. Spector), 514
Antifouling Compositions: Mode of Action of Soluble Matrix (A. Partington), 1105
Antigen: Use of Ferritin-conjugated Antibody to Localize, by Electron Microscopy (Richard A. Rifkind, Konrad C. Hsu, Councilman Morgan, Beatrice C. Seegal, Alice W. Knox and Harry M. Rose), 1094
Antigen, Sw^a: A 'New' Human Blood Group (Dr. T. E. Cleghorn), *erratum*, 743
Antigen or Antiserum labelled with Iodine-131: The Ouchterlony Technique using (Joan M. Rhodes), 793
Antigens: Homotransplant—Preparation of Active Cellular Fractions (L. T. Mann, jun., J. M. Corson and Prof. G. J. Dammin), 774
Antigens (Bacterial): Antibody Responses of the Domestic Fowl to Two Soluble (Dr. G. Gowland), 624
Antigens (Blood-Group): Identification of, *review* by Dr. R. Drummond, 357
Antigens (Erythrocyte): Effect of Ribonuclease on (Prof. Emanuel Hackel and Robert E. Smolker), 1036
Anti-Globulin (Coombs) Test in Laboratory Practice (Dr. L. Dunsford and Jean Grant), *review* by Dr. R. Drummond, 357
Antigonadotropic Function of the Pineal Gland and the Oxytocin of the Neurosecretory Hypothalamic System (Prof. S.-M. Milcou and S. Pavel), 950
Anti-Inflammatory Activity of Salicylate (Dr. V. Marks and Dr. M. J. H. Smith), 610
Antileukaemic Activity of Glycyrrhetinic Acid (Dr. W. Logemann, F. Lauria, G. Cudkowicz and J. Franceschini), 607
Antimetabolites into Metabolites: Adaptive Chain in the Conversion of (Dr. K. I. Markov, Dr. G. K. Saev and Dr. E. V. Golovinsky), 1041
Anti-Mouse Erythrocyte Serum (Rabbit): Electrophoretic Separation of certain *in vitro* and *in vivo* Reactions of (Chang-Ling Lee, Tamon Takahashi and Israel Davidsohn), 157
Anti-neoplastic Activity of Tetrahydro-1,3-oxazine Derivatives (Prof. T. Urbański, D. Gurne, S. Slopek, H. Mordarska and M. Mordarski), 426
Anti-Pneumococcus Type XIV Activity of Precipitins from *Ricinus communis* Seeds (Lieut.-Col. G. W. G. Bird), 415
Antirrhinum Species Hybrid: Autogenous Necrosis in an (B. J. Harrison), 527
Antiserum labelled with Iodine-131: The Ouchterlony Technique using Antigen or (Joan M. Rhodes), 793
Aorta: Role of Mucoid Substances of the, in the Deposition of Lipids (Dr. S. Gero, Dr. J. Gergely, Dr. T. Dévényi, Dr. L. Jakab, Dr. J. Székely and Dr. S. Virág), 152
Aortic Tissue (Human): Presence of Neutral Carbohydrates in (Dr. Sv. Bertelsen), 411
Aphids: Immunity of, to Insect Parasites (D. C. Griffiths), 346
Apothecaries of London, Worshipful Society of: Maccabaean Prize and Medal for an essay on a subject connected with the History of Medicine or Pharmacy, 650
Apothecaries of London, Worshipful Society of, and others: First British Congress on the History of Medicine and Pharmacy, 374
Apparatus (Thread-like), in the Petiole of *Mimosa pudica*: Behaviour of a (Dr. Hideo Toriyama), 709
Appearance ov New Deficient Characters in Streptomycin-resistant Mutants of *Bacillus subtilis* (Masamichi Kohiyama and Yonosuke Ikeda), 168
Appleton, Sir Edward: *Obituary* of Dr. Geoffrey Builder, 828
Application of Computer Techniques to Nuclear Physics Instruments (G. G. Scarrott), 854
Application in Crystal-Structure Investigation: Vector Space and its (Prof. Martin J. Buerger), *review* by Dr. J. W. Jeffery, 975
Application to the Ocean: Introduction to the Theory of Sound Transmission with (Prof. C. B. Officer), *review* by Dr. A. B. Wood, 539
Application (Foliar), of Nutrients, and Rhizosphere Microflora of *Camellia sinensis* (Dr. C. S. Venkata Ram), 621
Applications: Introduction to Symbolic Logic and its (Rudolf Carnap), translated by William H. Meyer and John Wilkinson, *review* by F. I. G. Rawlins, 729
  The Junction Transistor and its (edited by E. Wolfendale), *review* by Dr. J. R. Tillman, 1058
  The Physics of Electrostatic Forces and their (Centre National de la Recherche Scientifique International Colloquium on), 466
Applications to the Ionosphere: The Magneto-Ionic Theory and its (J. A. Ratcliffe), *review* by Sir Harrie Massey, 810
Applications (Autumn), of Potassium Gibberellate: Effect of, on Fruit Production of the Strawberry (Prof. Carter R. Smith), 620
Applied Aspects of Autoxidation: Physicochemical, Biological and (Colloid and Biophysics Committee of the Faraday Society Symposium on), 746
Applied Bacteriology, Society for: Election of Officers, 904
Applied Chemistry: Pure and (International Union of Pure and Applied Chemistry Seventeenth International Congress of), 29, *erratum*, 117
Applied Chemistry (Pure and), International Union of: Seventeenth International Congress of Pure and Applied Chemistry, 29, *erratum*, 117
Applied Chemistry (Pure and), International Union of (sponsored by the): Symposium on the Chemistry of Natural Products (organized by the Australian Academy of Science), 1080
Applied Chemistry (Pure and), International Union of, and others: International Congress on the Technology of Plastics Processing, 559
Applied Mathematics at Bangor, 197
Applied Mechanics: Tenth International Congress of, 201
Applied Physics (Pure and), International Union of: Tenth Annual International Conference on High-Energy Physics, 29
Applied Science of Victoria (Museum of), Melbourne: Annual Report for 1958-59, 372
Applied Spectroscopy: Analytical Chemistry and (Twelfth Pittsburgh Conference on), 289
Approaches (Analytical), to Engineering Problems: Unification of, *review* by Prof. J. Greig, 359
Aquation (Octahedral): Orienting Effects in (Sir Christopher Ingold, Prof. R. S. Nyholm and Dr. M. L. Tobe), 477
Aqueous Electrolyte Solutions: Ultrasonic Velocities in (Dr. C. G. Balachandran), 136
Aqueous Solutions: Effects of pH and the Nature of the Primary Species in the Radiolysis of (J. T. Allan and Dr. G. Scholes), 218
  A New Method for the Differential Precipitation of Nucleic Acids from (William G. Aldridge), 323
Arc (Two-Neuron): Properties of the (Hind-Limb Reflexes in the Kitten), (Dr. Stan Skoglund), 134
Arcamone, F., and others: Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture, 238
Archaeological Field Experiments: Research Committee on, 289
Archer, Dr. R. K.: Eosinophil Leucocyte-attracting Effect of Histamine in Skin, 155
Arcs (Cold-Cathode): Stepwise Ablation and Heat Transfer in (Dr. A. von Engel and Dr. K. W. Arnold), 1101
Arctic Institute of North America: Grant-in-aid Programme, 831
Arden, J. W., and others: Radioactive and Natural Strontium in Human Bone (Atomic Energy Research Establishment, *R3246*), 994
Are the Laws of Nature Symmetrical? (Prof. O. R. Frisch), 638
Argentine (Scientific Institutions and Scientists in Latin America, Vol. 4), (Unesco Centre for Scientific Co-operation in Latin America), 29
Arginine Groups in Nucleoprotein in the Cell Nucleus: Selective Cytochemical Demonstration of (Dr. E. A. Barnard and Dr. L. G. E. Bell), 508
Arginine Vasotocin: Evidence for the Identity of Natriferin, the Frog Water-Balance Principle and (Prof. Wilbur H. Sawyer), 1030
L-Arginyl-L-Prolyl-L-Prolyl-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenylalanyl-L-Arginine, an Octapeptide related to Bradykinin: Synthesis and Biological Properties of (E. D. Nicolaides, H. A. DeWald, Patricia G. Shorley and Dr. H. O. J. Collier), 773
Argon (Potassium–) Ages of some Rocks from the South Atlantic (John A. Miller), 1019
Argyle, Michael: Religion and Social Structure, *review*, 96
Arid Zones: Problems of the (Unesco Symposium on), 295
Armourers and Brasiers' Research Fellowship awarded to Dr. J. H. Brunton, 291
Armstrong, jun., S. Howard, and others: Immunological Relationships between the Rat Glomerulus and Nephritogenic Streptococci, 1095
Arnold, Prof. A. H. M.: General and Linear Circuit Theory, *review*, 811
Arnold, Dr. K. W., (von Engel, Dr. A., and): Stepwise Ablation and Heat Transfer in Cold-Cathode Arcs, 1101
Arnold, Dr. P. W.: Potassium-supplying Power of some British Soils, 436
  Potash in Wet and Dry Soils, *review*, 976
Aromatic Hydroxy Compounds: Effect of some, on the Phagocytic Activity of the Reticulo-Endothelial System (Prof. T. Nicol, C. Druce and C. C. Ware), 422
Arousal in the Drowsy State: Paradoxical Blocking and (Dr. L. Goldie and Dr. J. M. Green), 952
Array: A Highly Directive Rotating, for 16 Mc./s. (Prof. J. A. Thomas and Dr. R. W. E. McNicol), 398
Arsenide (Gallium), for γ-Ray Spectroscopy (W. R. Harding, C. Hilsum, M. E. Moncaster, D. C. Northrop and Dr. O. Simpson), 405
Arsenide (Gallium), as a Semi-insulator (J. W. Allen), 403
Art (Rock-Shelter), in Malaya: Newly Discovered (J. M. Matthews), 373
Artefact due to Thioureas or Thiouracils: Staining for Iodine in Chromatograms of Human Plasma—an (A. Dimitriadou, Prof. T. Russell Fraser, Dr. J. D. H. Slater and P. C. R. Turner), 691; *erratum*, 1079
Arterial Tissue (Human): Effect of Testicular Hyaluronidase on the Permeability of (Jorgen Matzke), 873
Arthropods: Attachment of Immature Simuliidae to other (Dr. D. J. Lewis, E. T. Reid, R. W. Crosskey and J. B. Davies), 618
Artificial Anticoagulants: Lipaemic Clearing Action of (Dr. E. P. George, Dr. G. V. Hall and Dr. G. S. Farkas), 782
Artificial Food: Silkworm Raising on (Toshifumi Fukuda, Mitsumasa Suto and Yoshitochi Higuchi), 669
Artificial Induction of the Imaginal Diapause in *Coccinella 7-punctata* L.: Prevention and (I. Hodek and J. Čerkasov), 345
Artificial Thickening of Bone and the Piltdown Skull (Prof. Ashley Montagu), 174; (Dr. Kenneth P. Oakley), 174
Artman, Dr. M. (Engelberg, Hanna, and): Absence of Carbon Monoxide-sensitive Respiration in a Streptomycin-dependent Mutant of *Escherichia coli* grown in Limited Amount of Streptomycin, 801
Ascaris lumbricoides: Use of Collagenase in the Characterization of Pseudocoelomic Membranes of (Barbara Dawson), 798

Ascites (Mouse): Isolation of a Non-pathogenic Tumour-destroying Virus from (Dr. J. G. Bennette), 72
Ascites Cells (Mouse): Uptake of Thymidine and Synthesis of Deoxyribonucleic Acid in (Dr. A. R. Crathorn and Dr. K. V. Shooter), 614
Ascites Hepatoma (Yoshida): Inhibition of Aerobic Glycolysis in, by Tartronic Acid (Dr. L. Fiume), 792
Ascites Tumour Cells *in vitro*. Optimal Protein Synthesis by (Dr. M. J. Fraser), 1114
Ascorbigen, 3-Indolylacetonitrile and Indole-3-carboxylic Acid from D,L-Tryptophan-3-^{14}C in *Brassica oleracea L.* Biogenesis of (Dr. M. Kutáček, Dr. Z. Procházka and Dr. D. Grunberger), 61
Ashby, Dr. W. Ross: The Relativity of 'Meaning', 532
Ashgar, Dr. A. G.: Problems of the Arid Zones (Public Awareness and the Educational Problem—Irrigation and Land Use—Pakistan), 296
Ashoka: Early India and Pakistan to (Sir Mortimer Wheeler), *review* by M. C. Burkitt, 94
Askochensky, Prof. A. N.: Problems of the Arid Zones (Alternative Uses of Limited Water Supplies—U.S.S.R.—Basic Trends and Methods of Water Control), 296
ASLIB: Survey on Indexes for Scientific and Technical Reports, 372
Aspects of Atherosclerosis: Some, *review* by Dr. G. S. Boyd, 634
Aspects of the Fibrinogen–Fibrin Transition. Some (K. Laki, Jules A. Gladner and J. E. Folk), 758
Aspects of Plant Nutrition, *review* by Prof. Walter Stiles, 815
Aspects (Applied), of Autoxidation: Physico-chemical, Biological and (Colloid and Biophysics Committee of the Faraday Society Symposium on), 746
Aspects (Haemodynamic), of Atherogenesis (Wei Young), 425
Aspects (The Two), of Science (Sir George Thomson), 837
Aspergillus fumigatus, Fresenius. Ubiquinone(50) and Ubichromenol in (N. M. Packter and Dr. J. Glover), 413
Aspheric Imaging Systems (Dr. C. R. Burch), 854
Assay of Air-borne Material: Radioactive Labelling of Membrane Filters for the (Dr. G. Kubie and Dr. K. Spurny), 930
Assay of Corticosteroids in the Chick Embryo (Sir Macfarlane Burnet and N. L. Warner), 938
Assessing the Colour Changes of Ageing Bloodstains. Use of Reflectance Measurements in (Dr. D. Patterson), 688
Assimilation (Radiophosphorus), in Organic and Inorganic Forms in Salmon: Bacterial Effect and (Dr. P. N. Srivastava), 83
Assistance from the United Kingdom for Overseas Development (H. M. Treasury), 266
Assistance (Special), for Effluent Liaison (British Leather Manufacturers' Research Association), 992
Association between Auroras and Very Low-Frequency Hiss observed at Byrd Station, Antarctica (Dr. L. H. Martin, Dr. R. A. Helliwell and K. R. Marks), 751
Association of Cornea Proteins with Water. Infra-red Examination of the (Dr. S. Bakerman and C. Mitchell), 1033
Association of Pigment with the Cell Envelope of *Serratia marcescens* (*Chromobacterium prodigiosum*), (Mira Purkayastha and Prof. R. P. Williams), 349
Astbury, Prof. W. T.: Ninth Procter Memorial Lecture of the Society of Leather Trades Chemists, 905
Astronomes: Les Observatoires Astronomiques et les (Fernand Rigaux), *review* by Dr. R. v. d. R. Woolley, 1063
Astronomiques (Les Observatoires), et les Astronomes (Fernand Rigaux), *review* by Dr. R. v. d. R. Woolley, 1063
Astrophysics of Non-Static Systems, *review* by Prof. W. H. McCrea, 538
Ataractic Drugs. Effects of, on the Blood-Pressure and Heart-Rate of Dogs (L. W. Hall and D. E. Stevenson), 696
Atherogenesis. Haemodynamic Aspects of (Wei Young), 425
Atherosclerosis: Connective Tissue, Thrombosis and—Proceedings of a Conference held at Princeton, N.J., 1958 (edited by Irvine H. Page), *review* by Dr. G. S. Boyd, 634
  Hormones and—Proceedings of the Conference held in Brighton, Utah, 1958 (edited by Gregory Pincus), *review* by Dr. G. S. Boyd, 634
  Some Aspects of, *review* by Dr. G. S. Boyd, 634
Atkin, N. B., and Ross, Angela J.: Polyploidy in Human Tumours, 579
Atkinson, F.: The English Newspaper since 1900 (Library Association, Special Subject List No. 32), 116
Atlantic (South): Pelagic Polychaetes of the (N. Tebble), 289
  Potassium–Argon Ages of some Rocks from the (John A. Miller), 1019
Atlantic Ocean (Eastern): Magnetization of Sediment Cores from the (M. J. Keen), 220
Atlas Podnebí Ceskoslovenské Republiky (Climatic Atlas of the Czechoslovak Republic), *review* by G. A. Bull, 543
Atlas (Climatic), of the Czechoslovak Republic, *review* by G. A. Bull, 543
Atmosphere: Blue Hazes in the (Dr. F. W. Went), 641, *erratum*, 994
  Change of the Chlorine—Sodium Ratio in the, with Altitude and Distance from the Source of Sodium Chloride, and the Distribution of Atmospheric Nitrate over the United States (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
  Comparison of Fission Product and Beryllium-7 Concentrations in the (W. Anderson, R. E. Bentley, R. P. Parker, J. O. Crookall and L. K. Burton), 550
  Energy for the, *review* by Prof. P. A. Sheppard, 974
  Small-Scale Turbulent Diffusion in the (Dr. L. A. Clarenburg and C. E. Speans-v. d. Tang), 586
Atmosphere (Lower): Turbulent Transfer in the (Dr. C. H. B. Priestley), *review* by Prof. P. A. Sheppard, 974
Atmosphere (Solar): Temperatures reached in Electrical Discharges in the (Dr. C. E. R. Bruce), 865
Atmosphere (Upper) Wind: Effect of, on the Rotation of Satellite 1958 δ1 (Dr. C. R. Faulkner), 926
Atmosphere (Upper-) Wind Studies by *Skylark* Rocket Sodium Experiment (Dr. G. V. Groves), 1001
Atmospheric Cyclones (Southern), and the Whale Feeding Grounds in the Antarctic (Dr. C. W. Beklemishev), 530
Atmospheric Nitrate over the United States: Change of the Chlorine—Sodium Ratio in the Atmosphere with Altitude and Distance from the Source of Sodium Chloride, and the Distribution of (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Atmospheric Ozone. Distribution of—a Preliminary Analysis of some International Geophysical Year Observations (J. MacDowall), 382
Atmospheric Research, United States National Centre of: Appointment of Dr. Walter Orr Roberts as director, 200
Atmospherics on 20 kc./s. at the Time of Local Auroras (Father E. Gherzi), 225
Atom 1960, an Illustrated Summary of the Sixth Annual Report (1959-60) of the United Kingdom Atomic Energy Authority, 1084
Atomic Absorption. Determination of Nickel and Cobalt by (J. E. Allan), 1110
Atomic Absorption Spectrophotometric Determination of Molybdenum and Strontium (D. J. David), 1109
Atomic Beam Frequency Standards. A Comparison of (R. E. Beehler, R. C. Mockler and C. S. Snider), 681
Atomic Energy: A Plain Man's Guide to (P. J. Duncton), 1076
Atomic Energy in the Soviet Union (Arnold Kramish), *review* by Dr. S. C. Curran, 630
Atomic Energy Agency (International): Review Series No. 3, Electronic Equipment used in the Nuclear Energy Industry in France (P. Desneiges, M. Doureau, L. Koch and J. Weill), 1076
Atomic Energy Authority (United Kingdom): *Zebra* (Zero Energy Breeder Reactor Assembly), 114
  Report of the Committee on Training in Health and Safety to the Authority Committee on Health and Safety, 471
  Re-appointment of Lord Citrine, Sir James Chadwick and C. F. Kearton as part-time members, 743
  Course for Trade Union Officials on the Industrial Uses of Radioisotopes, 905
  Hector, a New Research Reactor, 992
  Sixth Annual Report (1959-60), 1082
  Atom 1960—an Illustrated Summary of the Sixth Annual Report, 1084
Atomic Energy Authority (United Kingdom), and the Agricultural Research Council: Joint Report on the Deposition of Strontium-89 and Strontium-90 on Agricultural Land and their Entry into Milk after the Reactor Accident at Windscale in October 1957, 1077
Atomic Energy Commission (Danish): Third Annual Report (1958-59), 33
Atomic Energy Research in Denmark, 33
Atomic Energy Research Establishment (United Kingdom). Wantage Research Laboratory (B. S. Smith), 292
  Appointment of Dr. F. A. Vick as director, 556
  Appointment of Dr. R. Spence as deputy director, 556
  Appointment of L. Grainger as assistant director, with special responsibilities for applied research, 556
  Radioactive and Natural Strontium in Human Bone (J. W. Arden, F. J. Bryant, E. H. Henderson, G. D. Lloyd and A. G. Morton), 994
Atomic Energy and Space Research. Resources for, 1055
Atomic Nuclei. Theory of (Publication by the Physical Society of Japan of a volume of papers on), 743
Atomic Radiation. The Biological Effects of—Summary Reports from a Study by the National Academy of Sciences (United States National Academy of Sciences—National Research Council), 380
Atomic Reactor (*Moata*). Australia's Second, 741
Atomkernen: Nutzenergie aus (Dr. Karl Rudolf Schmidt), *review* by K. R. E. Smith, 979
Atoms?: Phlogiston or, 627
Atoms for Peace Digest. Title changed to *Science Horizons* (United States Information Service), 902
Atoms (Oxygen): Recombination of, in the Gas Phase (P. G. Dickens, R. D. Gould, Prof. J. W. Linnett and A. Richmond), 686
Attachment of Immature Simuliidae to other Arthropods (Dr. D. J. Lewis, E. T. Reid, R. W. Crosskey and J. B. Davies), 618
Attachment Coefficients: Ionization and, in *n*-Alkyl Chloride Gases (J. C. Devins and O. H. LeBlanc, jun.), 409
Attainments, Qualifications and Attitudes of Students entering Training Colleges: Recruits to Teaching—a Study of the (F. W. Land), 750
Attitudes of Students entering Training Colleges: Recruits to Teaching—a Study of the Attainments, Qualifications and (F. W. Land), 750
Aubert, Dr. Georges: Problems of the Arid Zones (Soil Science, including Soil Conservation), 295
Audus, Prof. L. J.: Photoperiodic Phenomena, *review*, 96
  Herbicides and the Soil (Microbiological Breakdown of Herbicides in Soils), 376
Auerbach, Dr. C.: Biological Effects of Atomic Radiation, 380
Auerbach, I.: Elected president of the International Federation of Information Processing Societies, 655
Augustin, Dr. Rosa, and Hayward, Barbara J.: Cleavage of Human γ-Globulin, 129
Augustinsson, Dr. K.-B., and Olsson, Dr. B.: A Genetically Determined Enzyme in the Pig, 924
Auroras (Local): Atmospherics on 20 kc./s. at the Time of (Father E. Gherzi), 225
Auroras and Very Low-Frequency Hiss observed at Byrd Station, Antarctica: Association between (Dr. L. H. Martin, Dr. R. A. Helliwell and K. R. Marks), 751
Auroral Structures: Theory of (E. R. Harrison), 383
Austenite. Stabilization of, by Hydrogen (E. G. Ramachandran and C. Dasarathy), 684
Austenite (Retained), and the Tempering of Martensite (S. Matas and Prof. R. F. Hehemann), 685
Austin, Carl F. (Slawson, William F., and): Anomalous Leads from a Selected Geological Environment in West-Central New Mexico, 400
Australia: Biogeography and Ecology in (edited by A. Keast, R. L. Crocker and C. S. Christian), *review* by Prof. A. J. Marshall, 543
  Research on Tinplate in, 904
Australia's Second Atomic Reactor (*Moata*), 741
Australia (South) Museum: Annual Report for 1958-59, 287
Australian Academy of Science: Selby Fellowship for 1960 awarded to Dr. W. Deuchars, 464
  Symposium on the Chemistry of Natural Products (sponsored by the International Union of Pure and Applied Chemistry), 1080
Australian Bivalve Gastropods (Robert Brun), 44
Australian Bread Research Institute Laboratories, 291
Australian Brown Alga, *Notheia anomala*. Structure and Systematic Position of the (M. Nizamuddin and Dr. H. B. S. Womersley), 673

Australian Commonwealth Scientific and Industrial Research Organization: Establishment of a new Sugar Research Laboratory, 372
  Appointment of Dr. H. H. Hatt as leader of research in the Sugar Research Laboratory, 372
  List of Publications to December 31, 1959, 466
  Appointment of Dr. S. D. Hamann as chief of the Division of Physical Chemistry, 901
  Retirement of S. A. Clarke as chief of the Division of Forest Products, 901
  Grant of £6,000 from the Broken Hill Proprietary Company, to support tinplate research, 904
Australian Native Plants for Home Gardens (A. E. Brooks), *review* by Dr. R. Melville, 637
Australian (Aboriginal): Doctor Ruggles Gates and the (Prof. A. A. Abbie), 375
Australian (Central) Aborigine: Haematology of the (J. R. Casey-Smith), 903
Australopithecus. Biography of, *review* by Sonia Cole, 888
Authors (Chemical Society): Handbook for (Chemical Society, Special Publication No. 14), 832
Autogenous Necrosis in an *Antirrhinum* Species Hybrid (B. J. Harrison), 527
Automatic Programming in the U.S.S.R., *review* by R. J. Ord Smith, 92
Autonomic Nerve–Smooth Muscle Transmission (G. Burnstock and Mollie E. Holman), 951
Autoradiography at -195°C. Localization by, of Radioactive Areas in Rats exposed to a High Flux of Thermal Neutrons—Importance of Phosphorus-32 in Consecutive Internal Irradiation (Jean Chanteur and Pierre Pellerin), 472
Autotetraploid Plants: Frequency of Quadrivalents in (Dr. J. W. Morrison and Dr. T. Rajhathy), 528
Autoxidation: Physico-chemical, Biological and Applied Aspects of (Colloid and Biophysics Committee of the Faraday Society Symposium on), 746
Autret, Dr. Marcel: Appointed director of the Nutrition Division of the United Nations Food and Agriculture Organization, 743
Autumn Applications of Potassium Gibberellate: Effect of, on Fruit Production of the Strawberry (Prof. Carter R. Smith), 620
Auxin Transport: A Method for the Detection of Inhibition of (B. E. S. Gunning), 428
Availability (Relative), of some Strontium-90 Compounds in Soil (Dr. R. L. Uhler and Dr. F. P. Hungate), 252
Avena Coleoptile: Plastids of the (Helen P. Sorokin and Prof. Kenneth V. Thimann), 1038
Average Composition of Granites, the Genesis of Tektites, and Petrogenesis (Prof. E. H. Timothy Whitten), 867
Average Water Vapour Content of the Air (J. K. Bannon and L. P. Steele), 748
Avery, R. A.: Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Zoology), 742
Avian Embryo: The (Prof. Alexis L. Romanoff), *review* by Prof. C. H. Waddington, 814
Aviation: Guide to Hygiene and Sanitation in (World Health Organization of the United Nations), 911
Aviation, Ministry of: Retirement of F. S. Barton, 646
  Promotion of C. J. Francis to Deputy Chief Scientific Officer, and appointed counsellor (Defence Research and Supply) to the United Kingdom High Commission, Canada, 646
  Appointment of M. B. Morgan as deputy controller of aircraft (research and development), 646
Awad, Dr Mohammed: Problems of the Arid Zones (Nomadism in relation to Grazing Resources—The Near East Arab Countries), 296
Awards for articles on Electronics (Electronic Engineering Association), 116
Awards (Grants and), for 1961 (Lalor Foundation), 1078
Awards (Studentship and Scholarship), for 1960 (Royal Commission for the Exhibition of 1851), 116
Awards (Technological), National Council for: Report for 1959-1960, 286
Awards (Travel), for Women Engineers (Caroline Haslett Memorial Trust), 116
Axelrod, Dr. J., and others: Effect of Cocaine on the Disposition of Noradrenaline labelled with Tritium, 604
Axial Origin of the Terminal Inflorescence in the Genus *Trifolium* (Yvonne Aitken), 622
Axon, Dr. H. J.: The Sulphide Phase in some Iron Meteorites, 406
Aykroyd, Dr. W. R.: Made an honorary member of the American Institute of Nutrition, 29, 374
Aylmore, L. A. G., and Quirk, Dr. J. P.: Domain or Turbostratic Structure of Clays, 1046
8-Azaguanine: Transformation of Resistance to, in *Diplococcus pneumoniae* (Francis M. Sirotnak, Ramona B. Lunt and Dorris J. Hutchison), 800
Azo-Dye Method (A Simple), for Histochemical Demonstration of Acid Phosphatase (Dr. Tibor Barka), 248
Azo Dyestuffs: Use of, for the Polarographic Determination of the Lanthanides (T. M. Florence and L. E. Smythe), 771
Azotobacter vinelandii as the Test Organism: Microbial Synthesis of Protein in relation to the Biogenesis of Nucleic Acids with (Maharani Chakravorty), 239
Azzone, Dr. Giovanni Felice, and Ernster, Dr. Lars: A High-Energy Phosphate Requirement for Succinate Oxidation in Uncoupled Rat Liver Mitochondria, 65

BAADE, Walter: *Obituary* by Prof. Fred Hoyle, 1075
Bacharach, A. L.: Influence of Editors, 121
Bacilli (Enteric): Effect of the Peritoneal Fluid of the Guinea Pig on Strains of (Prof. R. J. Roantree and L. R. Collis), 1045
Bacillus subtilis: Amino-Acid Sequence about the Reactive Serine of a Proteolytic Enzyme from (Dr. F. Sanger and D. C. Shaw), 872
  Appearance of New Deficient Characters in Streptomycin-resistant Mutants of (Masamichi Kohiyama and Yonosuke Ikeda), 168
Backett, Prof. E. Maurice: Medicine as a Social Science, *review*, 633
Background: Francis Bacon without his, *review* by Prof. B. Farrington, 817
Bacon (Francis), the First Statesman of Science (J. G. Crowther), *review* by Prof. B. Farrington, 817
Bacon (Francis) without his Background, *review* by Prof. B. Farrington, 817
Bacon, Dr. G. E.: Ferrimagnetism in Theory and Practice, *review*, 974
Bacteria as a Source of Food for Black-Fly Larvae (F. J. H. Fredeen), 963
Bacteria (Gram-positive): An Antibiotic Complex derived from a *Streptomyces* and Active against (B. Sgarzi, A. M. Lugli and G. Giolitti), 1029
Bacteria (Green Sulphur): A New Species of (V. V. Shaposhnikov, E. N. Kondratieva and V. D. Federov), 167
Bacteria (Lactic Acid): Two Types of Catalase-like Activity in (R. Whittenbury), 433, *erratum*, 466
Bacteria (Nodule): Inhibition of, by an Antibiotic from Legume Seed Coats (J. A. Thompson), 619
Bacteria (Transformable): Fate of Transforming Deoxyribonucleate following Fixation by, 1 (Dr. Maurice S. Fox and Dr. Rollin D. Hotchkiss), 1002; 2 (Dr. Maurice S. Fox), 1004
Bacterial Antigens: Antibody Responses of the Domestic Fowl to Two Soluble (Dr. G. Gowland), 624
Bacterial Effect of Radiophosphorus Assimilation in Organic and Inorganic Forms of Salmon (Dr. P. N. Srivastava), 83
Bacterial Mutant with Impaired Potassium Transport (Dr. Stanley G. Schultz and Dr. A. K. Solomon), 802
Bacterial Penicillin Amidase (Dr. C. A. Claridge, Dr. A. Gourevitch and Dr. J. Lein), 237
Bacterial Population of the Nose and Skin (H. Williams Smith and W. E. Crabb), 288
Bacteriology (Applied), Society for: Election of Officers, 904
Bacteriophage λ: Mutations affecting the Density of (G. Kellenberger, M. L. Zichichi and J. Weigle), 161
T_2 Bacteriophage: Evidence for Internal Organization of Nucleic Acid in (Irwin J. Bendet, David A. Goldstein and Max A. Lauffer), 781
Bacteriophages (*Lactobacillus*): Host-Range of (Prof. J. N. Coetzee, H. C. de Klerk and T. G. Sacks), 348
Baden-Powell, D. F. W.: Appointed lecturer in prehistoric archaeology at the University of Oxford, 117
Badger, Prof. G. M., and others: Mode of Formation of 3,4-Benzopyrene in Human Environment, 663
Bagnall, Dr. K. W.: Comprehensive Inorganic Chemistry, *review*, 185
Bagshaw, A.: At the second Annual Conference of the British Computer Society (Organization of Computing Centres in Industrial Establishments), 656
Bailey, Prof. W. N.: Confluent Hypergeometric Functions, *review*, 93
Bainbridge, V.: Plankton of the Estuary and Offshore Waters of the Sierra Leone River, 557
Baird, D. E.: Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Zoology), 742
Bajpai, L. S., and others: Action of Tetrakis (Hydroxymethyl) Phosphonium Chloride on Wool, 602
Baker, B. G. (Anderson, Dr. J. R., and): Hydrocracking of Neopentane and Neohexane over Evaporated Metal Films, 937
Baker, Dr. Ruth V., and others: Melanin Granules and Mitochondria, 392
Bakerman, Dr. S., and Mitchell, C.: Infra-red Examination of the Association of Cornea Proteins with Water, 1033
Balachandran, Dr. C. G.: Ultrasonic Velocities in Aqueous Electrolyte Solutions, 135
Balchin, Prof. W. G. V.: Water Resources in the United States, 562
Ball, D. F.: Relic-Soil on Limestone in South Wales, 497
Ball Lightning. Electromagnetic Standing Waves and (Dr. Lewi Tonks), 1013
Ballard, P.: The Royal Botanic Gardens, Kew, 119
Balls, Dr. W. Lawrence: *Obituary* by Dr. D. W. Hill, 989
Baltá Calleja, F.: Spanish fellowship renewed by the Ramsay Memorial Fellowship Trustees, 832
Bamford, Dr. C. H., and Kitchener, Dr J. A. Colloid and Polymer Science (Calculation of Free-radical Reactivity and Stability of Colloidal Model Suspensions), 378
Banana Fruit-spot ('Speckle') caused by *Deightoniella torulosa* (Syd.) Ell. (Dr. D. S. Meredith), 961
Bangor Research Station of the Nature Conservancy, 744
  Appointment of Dr. Elfyn Hughes as director, 744
Bank (International), for Reconstruction and Development: Articles of Agreement of the proposed International Development Association, as approved for submission to Governments by the Executive Directors of the, 266
Banner, F. T., and others: The American Oligocene, 679
Bannon, J. K., and Steele, L. P.: Average Water Vapour Content of the Air, 748
Bantu (South African): The Rh Factor C in (Dr. A. Zoutendyk and Dr. H. Teodorczuk), 790
Barash, M.: Optically Active Forms of a Derivative of Tetra-substituted Sulphur, 591
Barber-Colman Company, Houston: Establishment of a new Gas Chromatography Research Center, 289
Barents Sea: Echo Sounding Experiments in the (I. D. Richardson, D. H. Cushing, F. R. Harden Jones, R. J. H. Beverton and R. W. Blacker), 855
Bargett, W. E.: Effectiveness in Industry (Presidential Address to the Institution of Metallurgists), 378
Barich, Donna Jean, and others: Tumour-promoting Effect of Excessively Large Doses of Oral Griseofulvin on Tumours induced in Mice by Methylcholanthrene, 335
Barich, Louis L., and others: Tumour-promoting Effect of Excessively Large Doses of Oral Griseofulvin on Tumours induced in Mice by Methylcholanthrene, 335
Barka, Dr. Tibor: A Simple Azo-Dye Method for Histochemical Demonstration of Acid Phosphatase, 248
Barker, R. S., and others: Gamma Irradiation of Lead Silicate Glass, 135
Barnard, Dr.: Physico-chemical, Biological and Applied Aspects of Autoxidation (Effects of Tocopherols in Autoxidizing Systems), 747
Barnard, C. C.: Bibliographical Citation, second edition, 27
Barnard, Dr E. A., and Bell, Dr. L. G. E.: Selective Cytochemical Demonstration of Arginine Groups in Nucleoprotein in the Cell Nucleus, 508
Barnard Medal for 1960 of Columbia University, New York, awarded to Prof. I. I. Rabi, 24
Barnes, Dr. H. F.: *Obituary* of Dr. C. B. Williams, 285
Barr, W. (Meleka, Dr. A. H., and): A Possible Origin of Exo-Electron Emission in Plastically Deformed Metals, 232

Barrer, Prof. R. M., and Rees, L. V. C.: Energies of Activation for Self-diffusion of Alkali Metal Ions in Analcite, 768
Barrett, Dr. Jack, and Mansell, Dr. A. L.: Ultra-Violet Absorption Spectra of the Molecules H_2O, HDO and D_2O, 138
Barrier (Thames Flood): Technical Possibilities of a, 294
Barriers (Critical Energy), in the Excretion of Sodium (Prof. E. J. Conway), 394
Barrow, Dr. R. F., and others: Excited Electronic States of Lithium and Sodium Molecules, 141
Barry, Sir Gerald, and others (editorial board: Dr. J. Bronowski, with): Science—Chemistry, Physics, Astronomy, *review* by Dr. D. R. Dickinson, 978
Barth, Dr. F.: Problems of the Arid Zones (Nomadism in relation to Grazing Resources—The Mountain and Plateau Areas of South-West Asia), 296
Bartlett, Prof. M. S.: A Remark on Stochastic Path Integrals, 968
Probability and Physics, *review*, 1060
Barton, Prof. D. H. R.: The Chemistry of Natural Products (Some Aspects of Terpenoid and Steroid Chemistry), 1080
Barton, F. S.: Retirement from the Ministry of Aviation, 646; work of, 646
Base of the Cambrian: Age of the (Dr. G. W. Wetherill), 34; (Prof. Arthur Holmes), 35
Bases (Heterocyclic): Structure of the 1:1-Adducts of Cupric β-Diketone Chelates with (Dr. D. P. Graddon and E. C. Watton), 1021
Basic Acetates (Trinuclear): Structure of the (Dr. L. E. Orgel), 504
Basic Research in the Navy (United States Department of Defense, Department of the Navy, Naval Research Advisory Committee), (Report prepared by Arthur D. Little, Inc.), 178
Basis (Chemical and Molecular), of Nerve Activity (David Nachmansohn), *review* by Dr. D. H. Brinton, 447
Basle: The Story of Chemical Industry in (published by Ciba Limited on the occasion of its 75th Anniversary), *review* by Dr. L. K. Sharp, 540
Batchelor, F. R., and others: Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis, 236
Bateman, Dr. A. J.: Dichorial One-Egg Twins in the Mouse, 339
Bateman, Dr. L.: Physicochemical, Biological and Applied Aspects of Autoxidation (Oxidation and Antioxidant Activity of Organic Sulphur Compounds related to Rubber Vulcanizates), 747
Bates, Prof. D. R.: Grant of £15,005 for Space Research (upper atmospheric rocket research, including artificial air-glow, altitudes of night-glow layers, and a study of micrometeorites), 744
Bates, T. H., and Williams, Dr. T. Ffrancon: Radiolysis of Terpene Hydrocarbons—Isomerization and Polymerization of α- and β-Pinene, 665
Bateson, P. P. G.: Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Zoology), 742
Battisto, Dr. Jack R.: Natural Occurrence of Delayed-type Iso-hypersensitiveness, 69
Baum, Dr. H., and Crowley, Dr. N.: Starch-like Polysaccharide of *Streptococcus pyogenes*, 413
Bawn, Prof. C. E. H.: Physicochemical, Biological and Applied Aspects of Autoxidation (Metal-catalysed Oxidation of Alkyl Aromatics), 747
Baxter, Dr. E. W.: Combined Oil-immersion, Phase-contrast and Dark-ground Viewing of 'Thorotrast' in Tissue Sections, 162
Baxter, Prof. J. S., and others: Effect of Trypan Blue on Rat Embryos, 605
Bayliss, W. M., and Haldane, J. S.: Joint Meeting of the U.S.S.R.–Great Britain Society and the Moscow Physiological Society to celebrate the centenary of the births of (D. A. Sakharov), 912
BBC: Television Field Trials of 405-Line and 625-Line Systems in the UHF and VHF Bands (1957-1958), 288
Reith Lectures, 1959 (Prof. P. B. Medawar), *review* by Dr. J. D. Nisbet, 446
BBC Naturalist: The Second (edited by Desmond Hawkins), *review* by B. J. G. Maitland, 728
Beadle, Prof. G.: Elected to foreign membership of the Royal Society, 112; work of, 112
Beadle, R. (Kelliher, M. G., and): Pulse-shortening in Electron Linear Accelerators, 1099
Bean (Broad): Radiation and the, *review*, 8
Beattie, Dr. I. R.: Annual Reviews on Inorganic Chemistry, *review*, 4
Beaufay, H.: Intracellular Localization of Enzymes, 836
Beauveria bassiana (Bals.) Vuill.: Pathogenicity of *Metarrhizium anisopliae* (Metch.) Sor. and: Pathogenicity of, to Two Species of Elateridae (Dr. R. D. Tinline and R. Y. Zacharuk), 794
Beaven, A.: At the second Annual Conference of the British Computer Society (Training of Operators and the Writing of Programmes to Check and Correct Data), 656
Beck, F., and others: Effect of Trypan Blue on Rat Embryos, 605
Beehler, R. E., and others: A Comparison of Atomic Beam Frequency Standards, 681
Beér, J. M., and Essenhigh, Dr. R. H.: Control of Reaction Rate in Dust Flames, 1106
Beer, Stafford: Cybernetics and Management, *review* by J. A. Easterbrook, 269
Beetroot Pigment (Betanin): Race Differences in the Ability to excrete (Dr. P. H. Saldanha, L. E. Magalhaes and Wanda A. Horta), 806
Beevers, Dr. C. A.: Appointed reader in chemistry at the University of Edinburgh, 465
Begg, Dr. C. M. M.: An Introduction to Genetics, *review* by Wilma George, 357
Beginners: Genetics for, *review* by Wilma George, 357
Beginning of the Royal Society (Margery Purver and Dr. E. J. Bowen), *review* by Dr. William P. D. Wightman, 356
Behavior: The Central Nervous System and—Transactions of the Second Conference, Princeton, 1959 (edited by Mary A. B. Brazier), *review* by Dr. Henry Miller, 6
Behavior (The Chemical), of Zirconium (Warren B. Blumenthal), *review* by Prof. A. G. Quarrell, 725
Behaviour: Brain and, *review* by Dr. Henry Miller, 6
Behaviour of Paper during Tensile Straining (A. E. Ranger and L. F. Hopkins), 1097
Behaviour of Radioactive Griseofulvin in Skin (Dr. A. Scott), 705
Behaviour of a Thread-like Apparatus in the Petiole of *Mimosa pudica* (Dr. Hideo Toriyama), 709
Behaviour (Ferromagnetic and Antiferromagnetic), in the Second Transition Group (Dr. B. R. Coles and D. Griffiths), 226
Behaviour (Visco-elastic), of Blood Vessels of the Muscular Type (V. Harding and Prof. L. Laszt), 330
Behaviours of other Metals having a Hexagonal Structure: Work-Hardening and Ductility of Rhenium and their relation to the (R. A. Jeffery and E. Smith), 52
Behravesh, Z.: Problems of the Arid Zones (Public Awareness and the Educational Problem—Agriculture-Extension Work in the Near East), 296
Behrens, H., and Roessler, F.: Combustion and Propulsion—High Mach Number Air-breathing Engines (Experiments with Supersonic Diffusion Flames), 20
Beilby Medal and Prize for 1961, 742
Beklemishev, Dr. C. W.: Southern Atmospheric Cyclones and the Whale Feeding Grounds in the Antarctic, 530
Belgisch Genootschap voor Pharmaceutische Wetenschappen: International Symposium on Chromatography, 374
Belief (Christian): The Conflict between Evolutionary Theory and (Dr. David Lack), 98
Beljanski, M.: Cytoplasmic Particles and their Role in Protein Synthesis (A Soluble Enzyme Preparation purified from *Alcaligenes faecalis* stimulated the Incorporation of Amino-Acids into the Protein of a Particulate Fraction from the same Micro-organism), 645
Bell, Dr. L. G. E.: Histochemistry, *review*, 185
Bell, Dr. L. G. E. (Barnard, Dr. E. A., and): Selective Cytochemical Demonstration of Arginine Groups in Nucleoprotein in the Cell Nucleus, 508
Bellamy, Prof. E. H.: Appointed to the chair of physics in Westfield College, London, 361; work of, 361
Belyavin, G.: Appointed to the University of London chair of bacteriology at University College Hospital Medical School, 904
Bendall, Fay (Hill, Dr. R., and): Crystallization of a Photosynthetic Reductase from a Green Plant, 417
Bendet, Irwin J., and others: Evidence for Internal Organization of Nucleic Acid in T_2 Bacteriophage, 781
Benedetti, E. L. (Emmelot, P., and): Cytoplasmic Particles and their Role in Protein Synthesis (Inhibition of the Ability of whole Microsomes to Incorporate Amino-Acids in Rats injected with Dimethylnitrosamine), 645
Bennett, Edward L., and others: Strain Differences in Acetylcholine Concentration in the Brain of the Rat, 787
Bennette, Dr. J. G.: Isolation of a Non-pathogenic Tumour-destroying Virus from Mouse Ascites, 72
Benoiton, Leo, and others: Structures of some Acetyl-serine Peptides from Acetyl-chymotrypsin, 596
Bentley, R. E., and others: Comparison of Fission Product and Beryllium-7 Concentrations in the Atmosphere, 550
Bentley, Dr. W. E.: Control of Rats in Sewers, 288
1:2-Benzanthracene (9:10-Dimethyl-): Crystal Structure of (Dr. S. Sayre and Dr. P. H. Friedlander), 139
Benzene and Hexafluorobenzene: A Molecular Complex of (Dr. C. R. Patrick and G. S. Prosser), 1021
1,2-Benzo-1-cycloalkene-3-carboxylic Acids: Plant-Growth Activity of α-Alkylphenylacetic Acids and (Kazuyoshi Kawazu, Toshio Fujita, Tetsuo Mitsui, Jiro Kato and Masayuki Katsumi), 694
3,4-Benzopyrene in Human Environment: Mode of Formation of (Prof. G. M. Badger, R. W. L. Kimber and T. M. Spotswood), 663
Benzothiadiazine Diuretic: A Potent New (Dr. Richard M. Taylor and Martin M. Winbury), 603
Benzylpenicillin at pH 7·5: Degradation of, to D-Benzylpenicilloic Acid (Dr. Bernard B. Levine), 939
D-Benzylpenicilloic Acid: Degradation of Benzylpenicillin at pH 7·5 to (Dr. Bernard B. Levine), 939
D-Benzylpenicilloic Acid with Cystine: Formation of D-Penicillamine-Cysteine Mixed Disulphide by Reaction of (Dr. Bernard B. Levine), 940
Beraldo, W. T., and others: Bradykinin-releasing Factor from *Bothrops jararaca* Venom, 414
Berggård, Dr. I.: The Plasma Proteins in Normal Urine, 776
Bernstein, H. J., and others: High-resolution Nuclear Magnetic Resonance, *review* by Dr. L. M. Jackman, 358
Bernstein, Dr. L. (Hayward, Dr. H. E., and): Problems of the Arid Zones (Salinity Problems of Plants and Soils), 295
Berridge, Dr. N. J.: Microbial Systematics, 191
Berry, Dr. F. B.: Elected an honorary member of the American Institute of Nutrition, 374
Berry, R. J., and others: Analysis of Metabolic Rates at the Cellular Level, 919
Bertelsen, Dr. Sv.: Presence of Neutral Carbohydrates in Human Aortic Tissue, 411
Bertelson, Paul, and Boons, Jean-Paul: Time Uncertainty and Choice Reaction Time, 531
Bertram, Prof. D. S.: The First Decade of DDT, *review*, 271
Beryllium at High Temperatures: An Improvement in the Ductility of (A. Brown, F. Morrow and A. J. Martin), 494
Beryllium-7 Concentrations in the Atmosphere: Comparison of Fission Product and (W. Anderson, R. E. Bentley, R. P. Parker, J. O. Crookall and L. K. Burton), 550
BESM Computer: Programming Programme for the (A. P. Ershov), translated from the Russian by M. Nadler, edited by J. P. Cleave, *review* by R. J. Ord Smith, 92
β-Acylacrylic Acids: Structure of (Prof. Nils Hellström), 146, *erratum*, 650
β-Amino-isobutyric Acid: Urinary Excretion of, after Injection of Thymidine labelled with Tritium (Dr. Georg B. Gerber, Gisela Gerber and Kurt I. Altman), 956
β-Diketone Chelates (Cupric), with Heterocyclic Bases: Structure of the 1:1-Adducts of (Dr. D. P. Graddon and E. C. Watton), 1021
β-D-Fucosidase Activity of Mammalian Tissues and its relation to other Glycosidases (Dr. G. A. Levvy), 1027
β-Globulin Polymorphism in Chimpanzees (Prof. Samuel H. Boyer and Dr. William J. Young), 1035
β-Pinene (α- and): Radiolysis of Terpene Hydrocarbons—Isomerization and Polymerization of (T. H. Bates and Dr. T. Ffrancon Williams), 665
Betaine Esters in Brain Metabolism: Isolation and Probable Functions of (Prof. E. A. Hosein and Peter Proulx), 321

Betanin (Beetroot Pigment) : Race Differences in the Ability to excrete (Dr. P. H. Saldanha, L. E. Magalhaes and Wanda A. Horta), 806
Betina, Vladimír; and Nemec, Prof. Pavel : 'pH-Chromatography' of some Amphoteric Antibiotics, 1111
Betke, K., and others : Sickling Phenomenon in Deer, 333
Bett, Dr. K. E. : High-Pressure Technology, *review*, 541
Beverton, R. J. H., and others : Echo Sounding Experiments in the Barents Sea, 855
Bewick, Alan : Awarded a general fellowship by the Ramsay Memorial Fellowship Trustees, 832
Beyer, Amanda, and others : Absence of Local Cytotoxic Change in Man from Griseofulvin, 335
Beynon, Prof. W. J. G. : Grant of £16,530 for Space Research (measurement of electron density/height profiles with rockets using the Doppler method and the pulse method), 744
Beyond Science Fiction, *review* by Dr. D. J. West, 270
Bharucha, Dr. N. R. : Potentiometric Study of Priming Paints for Metal, 756
Bhattacharyya, P. K., and others : Microbiological Transformation of Terpenes—Hydroxylation of α-Pinene, 689
Bhide, Dr. N. K. : Effect of Hydration on Hexobarbitone-induced Sleep in Mice, 1030
Biberstein, Prof. Ernst L. (Shifrine, Moshe, and) : A Growth Factor for *Haemophilus* Species secreted by a Pseudomonad, 623
Bibliographical Citation (C. C. Barnard), second edition, 27
Bibliographies on Technical and Vocational Education, 741
Bibliography : Safety in Mines Research Establishment (1960), (compiled by E. B. Smith), second edition, *review* by Prof. S. G. Ward, 1063
Bibliography of British Journals and Newspapers, 116
Bibliography of Indian Scientific and Technical Publications (Council of Scientific and Industrial Research, New Delhi), 199
Bibliography on Molecular and Crystal Structure Models (Deane K. Smith), (United States National Bureau of Standards, Monograph No. 14), 903
Bibliography of Natural History, Society for the : Sherborn Fund Facsimile No. 1, Géographie des Plantes (Alexander von Humboldt et A. Bonpland), 904
Bibliography (Abstract), of Fruit Breeding and Genetics to 1955—*Rubus* and *Ribes*, a Survey (Dr. R. L. Knight and Elizabeth Keep), *review* by Dr. G. Haskell, 184
Bickerstaff, E. R., and Woolf, A. L. : The Muscular Disease Myasthenia gravis, 28
Bicyclopentyl Derivatives (New) : Conversion of Cyclopentadiene into—Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy (C. F. Blakely, Dr. R. J. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662 ; Kinetics and Mechanism (C. F. Blakely and Dr. A. Wassermann), 662
Bigelow, Dr. Henry Bryant : Awarded the first Bigelow Medal of the Woods Hole Oceanographic Institution, 647 ; work of, 647
Bigelow Medal of the Woods Hole Oceanographic Institution awarded to Dr. Henry Bryant Bigelow, 647
Billen, Dr. Daniel : Capacity of Extracts from Prestarved *Escherichia coli* to Incorporate Thymidine into Deoxyribonucleic Acid, 1044
Billingham, Jun., Edward J., and others : 'Enthalpy Titrations' and Thermochemistry in Molten Salts, 318
Binaghi, R., and others : Influence of the Ionic Strength of the Medium on the Anaphylactic Sensitization of Isolated Tissues *In vitro*, 697
Bingham Fluid : Yield Stress exerted on a Body immersed in a (G. Boardman and Dr. R. L. Whitmore), 50
Bingham Oceanographic Collection : Bulletin of the, Vol. 17, Article 1, Oceanography of Long Island Sound (Gordon A. Riley, Eugene Harris, Henry M. Schurr, P. T. Wangersky, Sarah W. Richards and R. Wade Covill) ; Guide for Preparing Figures (Y. H. Olsen and James E. Morrow, Jr.), 123
Biochemical Society : Colloquium on the Biosynthesis of Nucleic Acids, 994
Biochemical Society and the British Association for the Advancement of Science : Colloquium on the Organization and Financing of Research in Biochemistry and Allied Sciences, 650
Biochemistry at King's College, London, 286
Biochemistry at Leicester, 1075
Biochemistry : Analytical, Vol. 1, No. 1, 558
Biochemistry, International Union of, and the International Union of Biological Sciences : Symposium on Biological Structure and Function, 905
Biochemistry and Allied Sciences : Organization and Financing of Research in (Biochemical Society and the British Association for the Advancement of Science Colloquium on), 650
Biochemistry and Heredity, *review* by Dr. P. Cohn, 447
Biogenesis of Ascorbigen, 3-Indolylacetonitrile and Indole-3-carboxylic Acid from D,L-Tryptophan-3-^{14}C in *Brassica oleracea* L. (Dr. M. Kutáček, Dr. Z. Procházka and Dr. D. Grunberger), 61
Biogenesis of Nucleic Acids : Microbial Synthesis of Protein in relation to the, with *Azotobacter vinelandii* as the Test Organism (Maharani Chakravorty), 239
Biogeography and Ecology in Australia (edited by A. Keast, R. L. Crocker and C. S. Christian), *review* by Prof. A. J. Marshall, 543
Biography of *Australopithecus*, *review* by Sonia Cole, 888
Biologist : The New, No. 9 (Lancaster Royal Grammar School Natural History Society, 649
Biological Control (Successful), of Insect Pests : Significance of the Type of Host Plant Crop in (D. C. Lloyd), 430
Biological Effects of Atomic Radiation—Summary Reports from a Study by the National Academy of Sciences (United States National Academy of Sciences—National Research Council), 380
Biological Effects of Exposure to Intense Radiation, 910
Biological Function of Fruit (Dr. I. Gindel), 42
Biological Interval Analyser (G. K. Smith and Prof. B. Delisle Burns), 512
Biological Macromolecules : Ultracentrifugation of (Colloid and Biophysics Committee of the Faraday Society Discussion on), 905
Biological Materials : Freezing and Drying of (Dr. Harold T. Meryman, and 12 other Authors), 748
Biological Properties : Synthesis and, of L-Arginyl-L-Prolyl-L-Prolyl-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenylalanyl-L-Arginine, an Octapeptide related to Bradykinin (E. D. Nicolaides, H. A. DeWald, Patricia G. Shorley and Dr. H. O. J. Collier), 773
Biological Publications (Russian) : Translations of (American Institute of Biological Sciences), 558
Biological Sciences, American Institute of : Translations of Russian Biological Publications, 558
Biological Sciences, International Union of (International Union of Biochemistry and the) : Symposium on Biological Structure and Function, 905
Biological Structure and Function (International Union of Biochemistry and the International Union of Biological Sciences Symposium on), 905
Biological (Marine) Reports from Denmark, *review* by Dr. A. J. Southward, 360
Biological and Applied Aspects of Autoxidation : Physico-chemical, (Colloid and Biophysics Committee of the Faraday Society Symposium on), 746
Biology : Fresh-Water (Henry Baldwin Ward and George Chandler Whipple), second edition, edited by Prof. W. T. Edmondson, *review* by Dr. T. T. Macan, 6
International Review of (edited by Carl C. Pfeiffer and John R. Smythies), Vol. 1, *review* by Dr. D. H. Brinton, 447
North American Fresh-Water, *review* by Dr. T. T. Macan, 6
Tropical Climates and (Dr. G. S. Carter), 843
Biology, Institute of : Symposium on the Biology of Space Travel, 29
Symposia No. 8, The Effects of Pollution on Living Material (edited by W. B. Yapp), *review* by Dr. G. C. Ware, 1061
Biology, Institute of (Parasitology Group) : Spring Meeting, 203
Biology of Marine Animals (Dr. J. A. Colin Nicol), *review* by Prof. C. M. Yonge, 630
Biology of Polluted Waters (Dr. H. B. N. Hynes), *review* by Dr. G. C. Ware, 1061
Biology of Pollution, *review* by Dr. G. C. Ware, 1061
Biology of Space Travel (Institute of Biology Symposium on), 29
Biology (Cell), American Society for : Organization of the, 649
Biology (Cell), and Growth Inhibition (Cell Biology Programme of Unesco International Symposium on), 836
Biology (Experimental), Society for : Symposia No. 13, Utilization of Nitrogen and its Compounds by Plants (edited by H. K. Porter), *review* by Prof. Walter Stiles, 815
Biology (Quantitative) : Cold Spring Harbor Symposia on, Vol. 24, Genetics and Twentieth Century Darwinism, *review* by Dr. H. Kalmus, 726
Biology (Radiation), of *Vicia faba* in relation to the General Problem (Dr. John Read), *review*, 8
Biophysical Society (British) : Formation of the, 559
Biosynthesis of Cellulose by *Acetobacter acetigenum* (Dr. A. M. Brown and Dr. J. A. Gascoigne), 1010
Biosynthesis of Linamarin and Lotaustralin in White Clover (G. W. Butler and Beris G. Butler), 780
Biosynthesis of Nucleic Acids (Biochemical Society Colloquium on), 994
Biosynthesis of Squalene by the Annelid *Lumbricus terrestris* (Joyce M. Wootton and Lemuel D. Wright), 1027
Biosynthesis of Sucrose by Preparations from Potatoes stored in the Cold and at Room Temperature (Dr. Sigmund Schwimmer and Edward S. Rorem), 1113
Biosynthesis (Starch) : Mechanism of (Dr. Marta A. Rongine de Fekete, Dr. Luis F. Leloir and Dr. Carlos E. Cardini), 918
Biram, J. G. : Measurement of Slip (*Ko*) and Viscous (*Bo*) Flow Coefficients of Permeable Solids, 865
Birbeck, M. S. C., and Mercer, E. H. : Cytoplasmic Particles and their Role in Protein Synthesis (Electron Microscopy in formulating Hypotheses of some Aspects of Protein Synthesis), 644
Birbeck, M. S. C., and others : Melanin Granules and Mitochondria, 392
Birch, Dr. S. F. : *Obituary* by Dr. R. A. Dean, 111
Bird, Lieut.-Col. G. W. G. : Anti-Pneumococcus Type XIV Activity of Precipitins from *Ricinus communis* Seeds, 415
Bird Preservation, International Council for : Annual Report for 1959, 287
Birds : Effect of Cortisone on Degenerating Nerve Fibres in (Dr. P. Glees), 327
Embryos of, *review* by Prof. C. H. Waddington, 814
Variability in Levels of Blood Uric Acid in Five Species of (Jack W. Hudson and Charles R. Taylor), 788
Birds in Colour (illustrated by Karl Aage Tinggaard, with descriptions by Bruce Campbell), *review* by B. J. G. Marchand, 273
Birkenshaw, D. C. (Amos, S. W., and) : Television Engineering, Vol. 1, Fundamentals, Camera Tubes, Television Optics, Electron Optics (written in collaboration with J.-L. Bliss) ; Vol. 2, Video-Frequency Amplification ; Vol. 3, Wave-form Generation ; Vol. 4, General Circuit Techniques, *review* by Dr. R. L. Smith-Rose, 358
Birmingham, W. B. : Appointed senior lecturer in economics at the University of Leicester, 743
Bishop, Prof. David W. : X and Y Spermatozoa, 255
Bishop, H., and others : Effect of Wheat Gluten on the Peristaltic Reflex, 516
Biswas, A. B., and others : New Compounds for the Control of Water Evaporation, 870
Biswas, Manjula (Sircar, Prof. S. M., and) : Viability and Germination Inhibitor of the Seed of Rice, 620
Bituminous Coal (High-volatile) : Absorption of Ultra-violet and Visible Light by Ultra-thin Sections of Vitrinite from a (Sabri Ergun, J. T. McCartney and R. E. Walline), 1014
Bivalent Metal Ions in Transphosphorylation : Synergism of (Dr. John M. Lowenstein), 570
Bivalve Gastropods : Australian (Robert Burn), 44
Bjotvedt, G., and others : Protection against Liver Injury due to Murine Hepatitis Virus, 507
Black, D. St. C. : Awarded an Overseas Scholarship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Black Chromium Electro-deposit : Hexagonal Modification of (Hideya Okada and Takeo Ishida), 496
Black-Fly Larvae : Bacteria as a Source of Food for (F. J. H. Fredeen), 963
Blacker, R. W., and others : Echo Sounding Experiments in the Barents Sea, 855
Blackwell, M. J. : Recent Scientific Activities at Halley Bay—International Geophysical Co-operation (1959), 982
Blade : Relative Lengths of Leaf Sheath and, with reference to the Developmental Stages of the Rice Plant (Dr. B. Saha), 259

Blaha, M., and others : Measurement of Magnetic Fields in Chromospheric Flares, 224
Blake, J. N. (Simms, E. M., and) : At the Nineteenth Meeting of the Research Panel of the British Gelatine and Glue Research Association (The Swelling of Gelatine Films), 998
Blakely, C. F., and Wassermann, Dr. A.: Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives—Kinetics and Mechanism, 662
Blakely, C. F., and others : Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives—Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy, 662
Blamire, R. V. : Tuberculosis in Animals (Tuberculosis and Food Inspection), 997
Blaschko, Dr. H., and others : Melanin Granules and Mitochondria, 392
Blastopore : Mouth and (Dr. Joan B. Williams), 1132
Blaxland, J. D. . Tuberculosis in Animals (Tuberculosis in Poultry), 997
Bleached Variant of *Euglena gracilis* showing a Doubling of the Content of Deoxyribonucleic Acid (Dr. George Brawerman, Carole A. Rebman and Prof. Erwin Chargaff), 1037
Bloch, Prof. Hubert, and Nordin, Albert A. : Production of Tuberculin Sensitivity, 434
Block, Prof. Matthew : Wound Healing in the New-Born Opossum (*Didelphis virginianam*), 340
Blocking (Paradoxical), and Arousal in the Drowsy State (Dr. L. Goldie and Dr. J. M. Green), 952
Blomgren, Dr. E. A., and Bockris, Dr. J. O'M. : Simultaneous Measurement of Adsorption and Electrodekinetic Parameters at Metal Surfaces, 504
Blood of Normal and Leukaemic Subjects : Zinc Content of Erythrocytes and Leucocytes of (E. Dennes, R. Tupper and Prof. A. Wormall), 302
Blood of the Rabbit Right and Left Heart Ventricles : Platelet-Count Differences in (Dr. J. George Sharnoff and Dr. Vito [illegible]ardino), 334
Blood of Sheep Infected experimentally with the Virus of Tick-borne Encephalitis : Virus and Antibodies in the Lymph and (Doubravka Málková), 716
Blood and Bone Marrow Cells : Acetone Fixation for the Cytochemical Demonstration of Dehydrogenases in (Dennis Quaglino and Dr. F. G. J. Hayhoe), 85
Blood Cell Membrane (Red) : Chemical Constitution of the (Dr. T. Fehér and Dr. Béla Matkovics), 701
Blood Donors (398), from Dakar (Senegal) : Haptoglobin Types in (Dr. J. Moullec, Dr. J. M. Fine and J. Linhard), 517
Blood Donors (English) : MNSS Gene Frequencies in (Dr. T. E. Cleghorn), 701
Blood Glucose in the Rat adapted to a Fat Diet : An Inverse Relation between the Liver Glycogen and the (Dr. P. A. Mayes), 325
Blood Group A : Substance from Erythrocytes of (J. Kościelak and K. Zakrzewski), 516
Blood Group Antigen, Sw^{a} A 'New' Human (Dr. T. E. Cleghorn), *erratum*, 743
Blood-Group Antigens: Identification of, *review* by Dr. R. Drummond, 357
Blood-Pressure and Heart-Rate of Dogs : Effects of Ataractic Drugs on the (L. W. Hall and D. E. Stevenson), 696
Blood Serum and Urine of Cattle · Occurrence of Keto-Acids in, in comparison with Man, Horse, Sheep and Dog (Dr. C. J. G. van der Horst), 146
Bloodstains (Ageing) . Use of Reflectance Measurements in assessing the Colour Changes of (Dr. D. Patterson), 688
Blood-stains (Dried), on Fabrics : Absorption-Elution Grouping of (S. S. Kind), 789
Blood Supply (Tumour) : A Rapid Method for studying, using Lissamine Green (L. N. Owen), 795
Blood Thrombokinase : Chromatography of, on 'DEAE'-Cellulose (Dr. J. H. Milstone), 1127
Blood Transfusion (Japanese Red Cross Society eighth International Congress of), 201
Blood Transfusion (Oliver Memorial Fund Annual Award for work on), 201
Blood Uric Acid in Five Species of Birds : Variability in Levels of (Jack W. Hudson and Charles R. Taylor), 788
Blood Vessels of the Muscular Type : Visco-elastic Behaviour of (V. Hardung and Prof. L. Laszt), 330
Blow, W. H., and others : The American Oligocene, 679
Blue Hazes in the Atmosphere (Dr. F. W. Went), 641, *erratum*, 994
Blumenthal, Warren B. : The Chemical Behavior of Zirconium, *review* by Prof. A. G. Quarrell, 725
Blundell, Dr. . Self-Regulation in Living Systems (Tremor—The Tremor Problem from the point of view of the Surgeon, particularly in relation to Parkinson's Disease), 298
Blunt, Sir Anthony : At the sixty-sixth Annual Conference of the Museums Association (Purchase of Art Objects for Museums), 657
Board Industries (Pulp and), in Britain : Scope for Expanding (J. J. MacGregor, 32
Board Industries (Pulp and Particle) · The Development of, and their Effect on Forest Management (Society of Foresters of Great Britain Discussion on), 32
Boardman, G., and Whitmore, Dr. R. L. : Yield Stress exerted on a Body immersed in a Bingham Fluid, 50
Bockris, Dr. J. O'M. (Blomgren, Dr. E. A., and) · Simultaneous Measurement of Adsorption and Electrodekinetic Parameters at Metal Surfaces, 504
Bodies (Celestial) : Theories of Figures of (Wenceslas S. Jardetzky), *review* by Prof. L. S. Goddard, 890
Bodies (Small) : Dispersal in Space of (Dr. D. O. Wolfenbarger), 1078
Body Immersed in a Bingham Fluid · Yield Stress exerted on a (G. Boardman and Dr. R. L. Whitmore), 50
Body (Rigid) : Effect of a Resisting Couple on the Rotational Motion of a (T. Nonweiler), 311
Bohme, Prof. Horst : Elected a member of the Chemistry section of the Leopoldina Academy of Natural Sciences, 1079
Bolis, L. (Del Vecchio, Prof. A., and) : Depressing Activity of Meprobamate on the Reticulo-Endothelial System, 513
Boll, W. G. (Lowther, R. L., and) : Ethionine and Plant Growth Systems, 831
Bollhagen, H., and others : Ionospheric Modification of the Radio Emission from Jupiter, 568
Bolton, Dr. A. : Appointed to a senior lectureship in civil engineering in the University of Liverpool, 117
Bombyx mori (Silkworm) : Function of the Corpus Allatum in 'Dauer-pupa' of the (Dr. Masatoshi Kobayashi), 346
  Nutritive Values of Carbohydrates for the (Dr. Toshio Ito), 527
Bond, T. J. (Byers, Jun., Ernest H., and) : Enzymatic Synthesis of Formylglutamic Acid by a Plant Protein, 416
Bond (Disulphide), in Wool . Reactivity of the (Dr. L. J. Wolfram and Prof. J. B. Speakman), 595
Bond (Valence-) Structures—a New Proposal (Dr. J. W. Linnett), 859
Bond-Strength (Cement-Aggregate) : Dependence of, on Size of Aggregate (K. M. Alexander and J. Wardlaw), 230
Bonding (Ionic-Covalent), in Crystals (C. H. L. Goodman), 590
Bone · Artificial Thickening of, and the Piltdown Skull (Prof. Ashley Montagu), 174 ; (Dr. Kenneth P. Oakley), 174
Bone (Human) : Radioactive and Natural Strontium in (J. W. Arden, F. J. Bryant, E. H. Henderson, G. D. Lloyd and A. G. Morton), 994
Bone Marrow Cells : Acetone Fixation for the Cytochemical Demonstration of Dehydrogenases in Blood and (Dennis Quaglino and Dr. F. G. J. Hayhoe), 85
Bone Marrow Cells (Transplanted), in Radiation Chimaeras : Identification of (P. Czerski, O. Rosiek and J. Sabliński), 955
Bone Marrow Depression in Murine Leukaemia (James T. Duhig), 71
Bones : Radioactivity of Soils, Plants and (Sir Ernest Marsden), 192
Bones from some Marine Mammals : Laminated Structure of (Dr. R. M. Laws), 338
Bonino, C., and others : Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture, 238
Bonpland, A. (von Humboldt, Alexander, et) . Géographie des Plantes, facsimile edition (Society for the Bibliography of Natural History), 904
Book Publishing Record (American), 116
Book (Reference), of Theoretical Physics, *review* by Prof. R. Eisenschitz, 445
Book-buying Policy of the National Central Library (S. P. L. Filon), 992
Books . Recent Scientific and Technical, Supp. vi, July 30 ; Supp. iv, August 27 ; Supp. vi, September 24
  United States Record of Published, 116
Books (Low-priced), for Overseas, 741
Books and Dictionaries (Japanese Scientific and Technical) : A collection of, presented to the Science Museum Library, London, on behalf of the Prime Minister of Japan, Nobusuke Kishi, 201
Boons, Jean-Paul (Bertelson, Paul, and) : Time Uncertainty and Choice Reaction Time, 531
Booth, Dr. A. N., and others : Excretion of Catechol after Ingestion of Quinic and Shikimic Acids, 691
Bornstein, Dr. J., and Hyde, Deirdre : Polypeptides of the Human Pituitary with Direct Action on Metabolism, 125
Borough Road College, Isleworth : Grant of £50,000 from the Nuffield Foundation, for a new science block to be known as the Nuffield Science Building, 371
  Grant of £75,000 from the British and Foreign School Society, towards the general expansion of the College, 371
Borrmann Effect observed in an Aluminium Single Crystal (Koichi Nakajima and Prof. Shigeyasu Koda), 53
Bosch, L. Cytoplasmic Particles and their Role in Protein Synthesis (Metabolic Behaviour of Fractions obtained by Passing Ribonucleic Acid through a column of 'Ecteola' Resin), 644
Boswell, C. (Lofts, Dr. B., and) : Cyclical Changes in the Distribution of the Testis Lipids in the Common Frog, *Rana temporaria*, 708
Bosworth, Prof. T. J. : Title of professor emeritus of veterinary pathology in the University of London conferred on, 466
Botanic Gardens : Singapore, 1000
Botanic Gardens (Royal), Kew (F. Ballard), 119
Botanical Garden in Tashkent (F. N. Rusanov), 902
Botanical Materials : Alpha Activity of certain (Prof. W. V. Mayneord, R. C. Turner and J. M. Radley), 208
Botany at Adelaide, 740
Botany at St. Andrews, 1075
Bothrops jararaca Venom : Bradykinin-releasing Factor from (Dr. Olga B. Henriques, Mira Fichman and W. T. Beraldo), 414
Boudreau, Dr. F. R. : Elected an honorary member of the American Institute of Nutrition, 374
Bound Phosphate (High-Energy), and Diabetes Mellitus (Dr. Yoshio Goto, Isao Ito, Akihiko Kuwano and Yukio Ujiie), 702
Boundary Problems in Differential Equations—Proceedings of a Symposium conducted by the Mathematics Research Center of the United States Army at the University of Wisconsin, 1959 (edited by Prof. Rudolph E. Langer), *review* by Prof. E. T. Copson, 451
Bourne, Prof. G. H., and Danielli, Prof. J. F. (edited by) · International Review of Cytology, Vol. 8, *review* by the late Prof. J. Bronte Gatenby, 632
Bouvier, I., and others : A Polyploidizing Principle in the Spleen, 965
Bovaird, John (Lenhoff, Dr. Howard M., and) : Enzymatic Activation of a Hormone-like Response in *Hydra* by Proteases, 671
Bovine Antibody : N-Terminal Amino-Acids of (Elizabeth M. Press and R. R. Porter), 59
Bovine Pancreatic Ribonuclease A : Activity of, in Mixed Solvent Systems (Dorothy Findlay, Dr. A. P. Mathias and Dr. B. R. Rabin), 601
Bowen, Prof. E. G. · Welsh Emigration Overseas (Presidential Address to Section E (Geography) of the British Association for the Advancement of Science), 843
Bowen, Dr. E. J. (Purver, Margery, and) . The Beginning of the Royal Society, *review* by Dr. William P. D. Wightman, 356
Bowles, R., and others . Cage Effect in the Liquid-Phase Photolysis of Fluorinated Ketones, 314
Bowley, A. E. (Goldsmid, H. J., and) : Thermal Conduction in Mica along the Planes of Cleavage, 864
Boyd, Dr. G. S. Some Aspects of Atherosclerosis, *review*, 634
Boyd, Dr. R. L. F. : Grants for Space Research—£8,880 (for the development and use of photoelectric satellite tracking equipment, and £35,450 (for rocket research in the upper atmosphere of (1) atmospheric temperature, density and winds, (2) ionospheric temperature, density and composition, (3) short-wavelength solar radiation, and (4) stellar ultra-violet light), 744
Boyer, Prof. Samuel H., and Young, Dr. William J. · β-Globulin Polymorphism in Chimpanzees, 1035

Boyland, Prof. E. : Xenobiochemistry, *review*, 94
Boys (Charles Vernon) Prize Address to the Physical Society (Dr. D. West), 853
Brachet, Prof. J., and Olszewska, Dr. M. J. : Influence of Localized Ultra-violet Irradiation on the Incorporation of Adenine-8-^{14}C and D,L-Methionine-^{35}S in *Acetabularia mediterranea*, 954
Brackish Water Areas (Danish) : The Oligochaeta Fauna of Three (Ingerlise Dahl), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 26), *review* by Dr. A. J. Southward, 360
Bradbury, E. M., and others : Screw Sense of the α-Helix in Poly-β-benzyl-L-aspartate, 321
Bradley, D. E. : Direct Observation of Surface Contamination formed in Demountable Vacuum Systems, 227
Bradley, Dr. O. Charnock : Topographical Anatomy of the Dog, sixth edition, revised by Prof. Tom Grahame, *review* by Prof. T. Nicol, 451
Bradley, James C. : Appointed assistant secretary (management) of the Smithsonian Institution, 743
Bradykinin : Synthesis and Biological Properties of L-Arginyl-L-Prolyl-L-Prolyl-L-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenylalanyl-L-Arginine, an Octapeptide related to (E. D. Nicolaides, H. A. DeWald, Patricia G. Shorley and Dr. H. O. J. Collier), 773
Bradykinin-releasing Factor from *Bothrops jararaca* Venom (Dr. Olga B. Henriques, Mina Fichman and W. T. Beraldo), 414
Brain : Vol. 83, Part 1, 28
Brain : Effect of Potassium Cyanide Poisoning on the γ-Aminobutyric Acid Level in the (Dr. T. Tursky), 322
  A Suggested Effect on Levels of Catecholamine in, produced by Small Doses of Reserpine (F. Barbara Orlans and Dr. Bernard B. Brodie), 1034 ; (Herbert Sheppard and Joseph H. Zimmerman), 1035
Brain and Behaviour, *review* by Dr. Henry Miller, 6
Brain Metabolism : Isolation and Probable Functions of Betaine Esters in (Prof. E. A. Hosein and Peter Proulx), 321
Brain of the Rat : Strain Differences in Acetylcholine Concentration in the (Edward L. Bennett, James Crossland, David Krech and Mark R. Rosenzweig), 787
Brandly, C. A., and Jungherr, E. L. (edited by) : Advances in Veterinary Science, Vol. 5, *review* by Prof. H. Burrow, 448
Branigan, William J., and others : Production of Tumours in *Rattus (Mastomys) natalensis* by Polyoma Virus, 423
Brassica oleracea L. : Biogenesis of Ascorbigen, 3-Indolylacetonitrile and Indole-3-carboxylic Acid from D,L-Tryptophan-3-^{14}C in (Dr. M. Kutáček, Dr. Z. Procházka and Dr. D. Grunberger), 61
Brasted, Prof. Robert C. (Klug, Harold P., and) : The Elements and Compounds of Group IVA (Comprehensive Inorganic Chemistry, edited by Prof. M. Cannon Sneed and Prof. Robert C. Brasted, Vol. 7), *review* by Dr. K. W. Bagnall, 185
Brasted, Prof. Robert C. (edited by Prof. M. Cannon Sneed and) : Comprehensive Inorganic Chemistry, Vol. 7, The Elements and Compounds of Group IVA (Harold P. Klug and Prof. Robert C. Brasted), *review* by Dr. K. W. Bagnall, 185
Braveny, Dr. P. (Kruta, Dr. V., and) : Potentiation of Contractility in the Heart Muscle of the Rat and some other Mammals, 327
Brawerman, Dr. George, and others : A Bleached Variant of *Euglena gracilis* showing a Doubling of the Content of Deoxyribonucleic Acid, 1037
Bray, K. N. C. : Combustion and Propulsion—High Mach Number Air-breathing Engines (Non-equilibrium Flows through Supersonic Nozzles and Shock-waves), 20
Brazier, Mary A. B. (edited by) : The Central Nervous System and Behavior—Transactions of the Second Conference, Princeton, 1959, *review* by Dr. Henry Miller, 6
Bread Research Institute Laboratories (Australian), 291
Breeding of the Rabbit Flea, *Spilopsyllus cuniculi* (Dale)—Requirement of a 'Factor' from a Pregnant Rabbit for Ovarian Maturation (A. R. Mead-Briggs and A. J. B. Rudge), 1136
Breeding (Experimental), of *Anopheles gambiae* Giles in Papyrus Swamps (L. K. H. Goma), 1137
Breeding (Fruit), and Genetics to 1955 : Abstract Bibliography of—*Rubus* and *Ribes*, a Survey (Dr. R. L. Knight and Elizabeth Keep), *review* by Dr. G. Haskell, 184
Breeding (Plant) : The Two R's of, *review* by Dr. G. Haskell, 184
Breeding Plumage of the Weaver Finch, *Quelea quelea* : Effects of Whole-body Irradiation on the (Dr. B. Lofts, Prof. A. J. Marshall and Prof. J. Rotblat), 615
Breeding Sites on Non-Cichlid Fishes in Lake Victoria (Dr. Philip S. Corbet), 616
Bremaud, O., and Pagot, J. : Problems of the Arid Zones (Nomadism in relation to Grazing Resources—Moving of Flocks in the Sahelian Zone), 296
Brickwedde, F. C., and others : The Helium-4 Scale of Temperature, 1077
Bridging the Gap between Science and Christianity, *review* by R. Brightman, 818
Briggs, Dr. B. H. : Roughness of the Moon as a Radar Reflector, 466, 490
Briggs, Prof. George M. : Appointed chairman of the Department of Nutrition in the College of Agriculture at the University of California, Berkeley, 290
Briggs, M. H : Vitamin and Coenzyme Content of Hepatomas induced by Butter Yellow, 249
  Origin of the Solar System, 1102
Brightman, R. : Control of Scientific Research in the United States, *review*, 181
  Guide to Reference Material, *review*, 273
  Bridging the Gap between Science and Christianity, *review*, 818
Brinck, Per, and others (edited by) : South African Animal Life—Results of the Lund University Expedition in 1950-1951, Vol. 6, *review* by H. Oldroyd, 1063
Brinkley, T. A. (Titterton, Prof. E. W., and) : Rare Modes in the Spontaneous Fission of Californium-252, 228
Brinton, Dr. D. H. : Recent American Research in Neuropsychiatry, *review*, 447
Britain : The Decimal System in, 30
  Food Habits in (Scottish Group of the Nutrition Society Symposium on), 905
  Geological Results of Petroleum Exploration in, by the British Petroleum Company during the Years 1945-57 (N. L. Falcon and P. E. Kent), 1078
  Industrial Health in, 648
  Management in—a General Characterization (I. McGivering, D. G. J. Matthews and W. H. Scott), 537
  A North American Xanthoid Crab New to (E. Naylor), 256
  Science and Education in, 906
  Scope for Expanding Pulp and Board Industries in (J. J MacGregor), 32
  Search for Oil in, 1078
  Space Research in—Grants, 744
  University Education in, 719
  See also under Great Britain
British Agricultural Policy : Principles for—a Study sponsored by the Nuffield Foundation (edited by H. T. Williams), *review* by Sir John Russell, 721
British Agriculture : Future of, *review* by Sir John Russell, 721
British Analogue Computer : A New, the *Radic* (The Redifon Company), 288
British Association for the Advancement of Science : Cardiff Meeting, 646, 837
  Presidential Address, The Two Aspects of Science (Sir George Thomson), 837
  Summaries of Addresses of Presidents of Sections, 841
  Presidential Address to Section A (Mathematics and Physics), Stellar Motions (Dr. R. v. d. R. Woolley), 841
  Presidential Address to Section B (Chemistry), Chemistry is Not Enough (Dr. James Taylor), 841
  Presidential Address to Section C (Geology), Pleistocene History of the Irish Sea (G. F. Mitchell), 842
  Presidential Address to Section D (Zoology), Tropical Climates and Biology (Dr. G. S. Carter), 843
  Presidential Address to Section E (Geography), Welsh Emigration Overseas (Prof. E. G. Bowen), 843
  Presidential Address to Section F (Economics), Monetary Thought and Monetary Policy in England (Prof. R. S. Sayers), 844
  Presidential Address to Section G (Engineering), Statics and the Engineer (Sir Alfred Pugsley), 844
  Presidential Address to Section H (Anthropology), The Peasant and the Past (Prof. Estyn Evans), 844
  Presidential Address to Section I (Physiology and Biochemistry), The Physiology of Hearing (Prof. W. Burns), 845
  Presidential Address to Section J (Psychology), Experiment in Psychology—a Centenary and an Outlook (Prof. R. C. Oldfield), 846
  Presidential Address to Section K (Botany), Origin of Angiosperms (Prof. T. M. Harris), 847
  Presidential Address to Section K* (Forestry), The Dangerous Concept of the Natural Forest (T R. Peace), 848
  Presidential Address to Section L (Education), Sixty Years of Progress in English Education (Prof. H. C. Dent), 848
  Presidential Address to Section M (Agriculture), Pastoral Systems in relation to World Food Supplies (Dr. William Davies), 849
  Presidential Address to Section N (Sociology), Population Growth, Fertility and Population Policy (Prof. D. V. Glass), 849
  Presidential Address to Section X (Assembly of Corresponding Societies), Science Broadcasting in Sound and Television (A. B. Oldfield Davies), 850
  Election of Sir Wilfrid Le Gros Clark as president for 1961, 852
  Section M (Agriculture) : Discussion on Food and Animal Production Overseas, 1070
British Association for the Advancement of Science and the Association of British Chambers of Commerce : Decimal Coinage and the Metric System—Should Britain Change ? (A joint Report of Committees appointed by the), 30
British Association for the Advancement of Science (Biochemical Society and the) : Colloquium on the Organization and Financing of Research in Biochemistry and Allied Sciences, 650
British Association of Corrosion Engineers : Elected a member of the European Federation of Corrosion, 25
British Biophysical Society : Formation of the, 559
British Broadcasting Corporation : Television Field Trials of 405-Line and 625-Line Systems in the UHF and VHF Bands (1957-1958), 288
  The Reith Lectures, 1959 (Prof. P. B. Medawar,) *review* by Dr. J. D. Nisbet, 446
  The Second BBC Naturalist (edited by Desmond Hawkins), *review* by B. J. G Marchand, 728
British Chambers of Commerce, Association of (British Association for the Advancement of Science and the) : Decimal Coinage and the Metric System—Should Britain Change ? (A joint Report of Committees appointed by the), 30
British Chemical Manufacturers, Association of : Booklet on Chemical Plant Instrumentation—some Notes on the Use of Measuring Instruments, 1079
British Colonial Territories, 906
British Commonwealth : Plant Pathology in the (Dr. G. C. Ainsworth), 834
British Computer Society : Second Annual Conference (Dr. L. Fox), 655
British Congress on the History of Medicine and Pharmacy : First (Faculty of the History of Medicine and Pharmacy of the Worshipful Society of Apothecaries of London, in co-operation with the Royal College of Physicians, the Royal College of Surgeons of England and the Royal Society of Medicine), 374
British Council · Course on the Non-destructive Testing of Materials, 1079
British Defence Research and Development, 177
British Electrical Power Convention : Presidential Address, Electricity—the New Horizon (Viscount Chandos), 557, 831
British Embassy in Buenos Aires : Appointment of A. G. Mill as agricultural and food attaché, 1075
British Film Institute : National Film Archive Catalogue, Part 2, Silent Non-Fiction Films (1895-1934), 199
British Gelatine and Glue Research Association : Nineteenth Meeting of the Research Panel, 998
British Hydromechanics Research Association : Twelfth Annual Report (1958-59), 26
British Institute of Management (South London Committee) : Conference on Research Necessary for the Preparation and Use of Case Studies, 660
British Institution of Radio Engineers : Report on the Education and Training of the Professional Radio and Electronics Engineer, 115

British Journals and Newspapers : Bibliography of, 116
British Leather Manufacturers' Research Association : Special Assistance for Effluent Liaison, 992
British Men of Science, a New Series to be published by Nelson, 374
British Museum (Natural History) : Bulletin, Historical Series, Vol. 2, No. 3, Darwin's Notebooks on Transmutation of Species (edited by Sir Gavin de Beer), Part 2, 26
  Bulletin, Historical Series, Vol. 2, No 4, Darwin's Notebooks on Transmutation of Species (edited by Sir Gavin de Beer), Part 3, 649
British Odonata · A New Study of the, *review* by Dr D E. Kimmins, 631
British Parchments · Follicle Remains in some (Dr M. L. Ryder), 130
British Petroleum Company Geological Results of Petroleum Exploration in Britain by the, during the Years 1945-57 (N. L. Falcon and P. E. Kent), 1078
British Pharmaceutical Conference : Ninety-seventh Meeting, 117
British Pharmaceutical Industry, Association of the : Report on the Use of Gamma-Radiation Sources for the Sterilization of Pharmaceutical Products, 903
British Poultry Science, Vol. 1, No 1, 465
British Pteridological Society : Work of the, 902
British Rayon Research Association Open Days (L. A Wiseman), 121
British Society for the Philosophy of Science ; Fifth Annual Conference, 559
British Society of Rheology Discussion on Rheology of Polymers, 290
British Soils : Potassium-supplying Power of some (Dr. P. W. Arnold), 436
British Steel Castings Research Association Open Days (Dr. A. H. Sully), 657
  Seventh Annual Report, 658
British Universities : Graduate Schools in (Prof. W. R. Niblett), 560
British Weed Control Council : Symposium on Herbicides and the Soil, 376
British and Foreign School Society : Grant of £75,000 towards the general expansion of the Borough Road College, Isleworth, 371
Broad Bean : Radiation and the, *review*, 8
Broadcasting in Great Britain · Future of, 1076
Broadcasting Corporation, South African : Van Riebeeck Lectures, Africa's Place in the Emergence of Civilization (Prof Raymond A. Dart), *review* by M. C Burkitt, 891
Broadcasting (Science), in Sound and Television (A. B. Oldfield Davies), 850
Broads : The Making of the (Dr. J. M. Lambert, J. N. Jennings, C. T. Smith, Charles Green and J. N. Hutchinson), *review* by Miles Burkitt, 636
Brockington, Prof. Fraser : World Health, *review* by Christine Cockburn, 722
Brockmann, Prof. H : The Chemistry of Natural Products (Chemistry of the Actinomycins), 1080
Brodie, Dr. Bernard B. (Orlans, F. Barbara, and) : A Suggested Effect on Levels of Catecholamine in Brain produced by Small Doses of Reserpine, 1034
Brodsky, K. A , and others : Work of the Antarctic Expeditions of the Academy of Sciences of the U.S.S.R., 287
Broken Hill Proprietary Company · Grant of £6,000 to support tinplate research in the Australian Commonwealth Scientific and Industrial Research Organization, 904
Bromfield, Dr. S. M. : Given an Award under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme, 291
Bromide (Urea-Ammonium) : Mimetic Twinning in (C. G. C. Catesby), 765
Bronowski, Dr. J , with Sir Gerald Barry, James Fisher and Sir Julian Huxley (editorial board) : Science—Chemistry, Physics, Astronomy, *review* by Dr D. R. Dickinson, 978
Brooker, R. : At the second Annual Conference of the British Computer Society (A Common Computer Language), 655
Brooks, A. E : Australian Native Plants for Home Gardens, *review* by Dr. R. Melville, 637
Brooks, Dr. S. A., and others · Phosphate Esters produced by Mammalian Skin from 2-Deoxy-D-Glucose, 1028
Brosset, Prof. Cyrill, and Magnusson, Bengt: The Silicon–Boron System, 54
Brown, A., and others · An Improvement in the Ductility of Beryllium at High Temperatures, 494
Brown, A C. (Krugman, Prof. B J., and) : 'Water Rigour' as an Aid when Operating on Marine Gastropoda, 69
Brown, Dr. A. M., and Gascoigne, Dr. J. A. : Biosynthesis of Cellulose by *Acetobacter acetigenum*, 1010
Brown, F., and Steward, Doreen L. : Infective Ribonucleic Acid from the Viruses of Talfan and Teschen Diseases, 714
Brown, Dr. J. E : Appointed a senior lecturer in engineering at the University of Leicester, 743
Brown, Prof J. H. U. : Specific Inhibitors of the Adrenal Cortex, 985
Brown, R. A., and others : Reversible Dissociation of Ribonucleic Acid, 509
Brown, Ltd , Constructors John, and the Institution of Chemical Engineers : A CJB Scholarship awarded to M. D. Taylor, 650
Brown Alga (Australian), *Notheia anomala* : Structure and Systematic Position of the (M. Nizamuddin and Dr. H. B. S. Womersley), 673
Brown Mutation : Occurrence of a, in the Syrian Hamster (Roy Robinson), 170
Brownbridge, N. : Herbicides and the Soil (Microbiological Breakdown of Herbicides in Soils), 377
Brownlee, G., and others : Effect of Three Compounds related to Diethylstilboestrol on the Phagocytic Activity of the Reticulo-Endothelial System, 1032
Bruce, Dr. C. E. R. : Temperatures reached in Electrical Discharges in the Solar Atmosphere, 865
Brummer, B. : Awarded a Senior Studentship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Brun, Prof. E. A. · Elected a Foreign Associate of the United States National Academy of Sciences, 198
Brunt, A. A., and Wharton, A. L. : Transmission of a Gall Disease of Cocoa, 80
Brunton, Dr J. H. : Appointed by the Committee of the Royal Society and the Armourer and Brasiers' Company to the Armourer and Brasiers' Research Fellowship at the Laboratory for the Physics and Chemistry of Solids, Cavendish Laboratory, Cambridge, 291
Bruun, Dr. Anton, and others (edited by) : Galathea Report—Scientific Results of the Danish Deep-Sea Expedition round the World, 1950-52, *review* by Dr. N. B. Marshall, 443
Bryant, F. J , and others : Radioactive and Natural Strontium in Human Bone (Atomic Energy Research Establishment, *R23246*), 994
Bryophyllum Leaves (Excised) : Effects of Light and Darkness on the Rhythm of Output of Carbon Dioxide of (Dr. Malcolm B. Wilkins), 523
Buchan, Alastair : NATO in the 1960's—the Implications of Interdependence, 179
Buckingham, R : At the second Annual Conference of the British Computer Society (Organization of Computing Centres in Universities), 656
Budden, Dr. K. G. : Grant of £1,694 for Space Research (research into the theory of propagation of radiations from artificial satellites), 744
Buerger, Prof Martin J. : Vector Space and its Application in Crystal-Structure Investigation, *review* by Dr. J. W Jeffery, 975
Builder, Dr. Geoffrey : *Obituary* by Sir Edward Appleton, 828
Building Research Station : Digest 133, Domestic Heating and Thermal Insulation, 999
  Factory Building Studies No. 6, Noise in Factories (A. G Aldersey-Williams), 1085
Bull, G. A. : Climatic Atlas of the Czechoslovak Republic, *review*, 543
Bull Spermatozoa : Effect of Acridine Orange on Living (C. van Duijn, Jun.), 1006
Bulleid, M J., and others : Recapture in the River Tweed of a Sea-Trout marked in Devonshire, 877
Buller, A. J : Appointed reader in physiology at King's College, London, 466
Bullock, A. A. : Flora of the Zambesi Basin, *review*, 449
Bunge, Prof Mario Causality, *review* by Dr. J. O. Wisdom, 92
Burch, Dr. C. R. : Aspheric Imaging Systems (Parsons Memorial Lecture of the Physical Society), 854
Burchfield, Dr. H. P., and Storrs, Eleanor E. : An Ortho Effect influencing Fungitoxicity, Electronic Absorption Spectra, and Chemical Reactivity with Mercaptalbumin, 593
Burchfield, Dr. H. P (Staples, Dr Richard C., and) · Incorporation of Acetate into Protein by Obligately Parasitic and Saprophytic Fungi, 1040
Burgess, Dr. R. C. Elected an honorary member of the American Institute of Nutrition, 374
Burgess, Prof. R. E., and others (edited by) : Progress in Semiconductors, Vol 4, *review* by Dr. J R. Tillman, 185
Burhop, Dr. E. H. S · Title of professor of physics in the University of London (at University College) conferred on, 201
Burkitt, M C Prehistoric India, *review*, 94
  The Making of the Broads, *review*, 636
  Prehistoric Man in Europe, *review*, 729
  Africa's Place in the Emergence of Civilization, *review*, 891
  North African Prehistory, *review*, 1062
Burn, Robert · Australian Bivalve Gastropods, 44
Burnet, Sir Macfarlane, and Warner, N. L. . Assay of Corticosteroids in the Chick Embryo, 938
Burns, Dr. B. D. : Self-Regulation in Living Systems (Tremor—Physiology of the Basic Causal Loop), 297
Burns, Prof B. Delisle (Smith, G. K., and) · A Biological Interval Analyser, 512
Burns, Prof W. : The Physiology of Hearing (Presidential Address to Section I (Physiology and Biochemistry) of the British Association for the Advancement of Science), 845
Burnstock, G , and Holman, Mollie E. : Autonomic Nerve–Smooth Muscle Transmission, 951
Burridge, Dr. K. O. L. : A Mythical Science, *review*, 7
Burrow, Prof. H . Advances in Veterinary Science, *review*, 448
Bursaries Scheme (Commonwealth), (Royal Society and Nuffield Foundation) : Awards, 291
Bursell, E. : Free Amino-Acids of the Tsetse Fly (*Glossina*), 778
Burton, L. K , and others : Radiostrontium and Radiocaesium in Milk during 1959, 108
  Comparison of Fission Product and Beryllium-7 Concentrations in the Atmosphere, 550
Bush, Dr. I. · Influence of Editors, 121
Bush, Dr. I. E Appointed to the Bowman chair of physiology, and to the directorship of the Department of Physiology, in the University of Birmingham, 465
Butenandt, Prof Adolf Elected an honorary member of the Leopoldina Academy of Science, 117
Butler, Bera G. (Butler, G. W., and) · Biosynthesis of Linamarin and Lotaustralin in White Clover, 780
Butler, G. W., and Butler, Bera G. · Biosynthesis of Linamarin and Lotaustralin in White Clover, 780
Butler, Prof. J. A. V. : Colloid and Polymer Science (Flow Properties of Dilute Solutions of Deoxyribonucleic Acid in 0 2 *N* Sodium Chloride), 378
Butler, Prof. J. A. V. (Cohn, Dr. P., and) : Cytoplasmic Particles and their Role in Protein Synthesis (Composition of Ribonucleoprotein Fractions from the Microsomes of Rat Liver), 645
Butter Yellow : Vitamin and Coenzyme Content of Hepatomas induced by (M H. Briggs), 249
Butterworth, D , and others : Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis, 236
Butterworth, Dr. K. R., and Mann, Dr Monica : Proportion of Noradrenaline to Adrenaline in the Adrenal Glands of Litter-mate Cats, 785
n-Butyllithium Initiator : Homogeneous Synthesis of Isotactic Polystyrene using (Dr R. J. Kern), 410
Butyrate (Sodium) : Reduction of the Intestinal Absorption of Glucose, Methionine and, by the Cation Trimethylhexadecylammonium (Dr J. A. Nissim), 308
Byers, Jun., Ernest H., and Bond, T. J. : Enzymatic Synthesis of Formylglutamic Acid by a Plant Protein, 416
Byrd Station, Antarctica : Association between Aurorae and Very Low-Frequency Hiss observed at (Dr. L. H. Martin Dr. R. A. Helliwell and K. R. Marks), 751
Byssus (Anterior) Retractor Muscle of *Mytilus edulis* : The Membrane Potential of the (Dr D. H. Paul), 1121

CADMAN, C. H., and others : Sap-Transmissible Viruses associated with Diseases of Grape Vines in Europe and North America, 577
Cadmium and other Metals : An Abnormal Serum Protein in Experimental Poisoning by (D. J. Lawford), 946
Caesium (Fall-out), in Surface Sea Water off the California Coast (1959-60) by Gamma-Ray Measurements (Dr. Theodore R. Folsom, Dr. G. J. Mohanrao and Perrin Winchell), 480
Caesium-137 and (Zirconium+Niobium)-95 in Swedish Soils : Content of (Kerstin Low and K. Edvarson), 736
Caesium-controlled Oscillators : The 'GBR Experiment'—a Trans-Atlantic Frequency Comparison between (J. A. Pierce, G. M. R. Winkler and R. L. Corke), 914
Cage Effect in the Liquid-Phase Photolysis of Fluorinated Ketones (R. Bowles, Dr. J. R. Majer and Prof. J. C. Robb), 314
Cain, Dr. A. J. : Microbial Systematics, 191
Calcium : Effect of Anti-Diuretic Hormone and, on the Equivalent Pore Radius of Kidney Slices from *Necturus* (G. Whittembury, N. Sugino and Dr. A. K. Solomon), 699
Calcium-deficient Muscles : Restoration of Membrane Excitability of, by Anodal Polarization (Prof. K. Koketsu and K. Noda), 243
Calcium and Citric Acid in the Oviduct of the Hen : Parallel Distribution of (Dr. T. G. Taylor and F. Hertelendy), 244
Calderbank, Dr. P. H. : Appointed to the chair of chemical technology in the University of Edinburgh, 555 ; work of, 555
Caldwell, Dr. P. C. : Appointed lecturer in biochemistry within the Department of Zoology in the University of Bristol, 465
Calf Thymus Nuclei : Water-soluble, Non-fibrous Deoxyribonucleoprotein from (Dr. Richard S. Walsh), 943
California Coast (1959-60) : Fall-out Caesium in Surface Sea Water off the, by Gamma-Ray Measurements (Dr. Theodore R. Folsom, Dr. G. J. Mohanrao and Perrin Winchell), 480
Californium-252 : Rare Modes in the Spontaneous Fission of (Prof. E. W. Titterton and T. A. Brinkley), 228
Callingham, R. S. H. : Elected Master for 1960-61 of the Salters' Company, 29
Callow, Dr. R. K. : Influence of Editors, 121
Camber, Dr. Bernard : Oxosteroids—the Use of Hydrazides for Detection, Characterization and Estimation, *review* by Prof. G. A. D. Haslewood, 183
Calyptraeidae : Protandry and Self-Fertilization in the (Dr. H. V. Wyatt), 520
Cambrian : Age of the Base of the (Dr. G. W. Wetherill), 34 ; (Prof. Arthur Holmes), 35
Cambrian System : Age of the (Prof. C. F. Davidson), 1020
Camellia sinensis : Foliar Application of Nutrients and Rhizosphere Microflora of (Dr. C. S. Venkata Ram), 621
Cameron, Dr. D. A. : New Laboratories of the Australian Bread Research Institute opened by, 291
Cameron-Wood, J., and others : Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis, 236
Campbell, Bruce (descriptions by) : Birds in Colour (illustrated by Karl Aage Tinggaard), *review* by B. J. G. Maitland, 273
Campbell, Dr. F. W., and Gregory, Dr. A. H. : Effect of Size of Pupil on Visual Acuity, 1121
Campbell, Dr. Joseph : The Masks of God—Primitive Mythology, *review* by Dr. K. O. L. Burridge, 7
Campbell, R. B., and others : Growth of Sulphide Films on Steel, 588
Canadian High Polymer Forum : Tenth (National Research Council of Canada and the Chemical Institute of Canada), 117
Canal (Anal) : Sensory Innervation of the (R. P. Gould), 337
Cancer of the Lung : Epidemiology of (United Nations, World Health Organization, Technical Report Series No. 192), 115
Cancer Hospital (Royal), London : Appointment of E. J. Ambrose to the University of London readership in physical chemistry at the Institute of Cancer Research, 904
  Title of reader in chemistry in the University of London conferred on G. M. Timmis, 904
Candida albicans : Effect of, on the Evolution of Experimental Tuberculosis (Dr. E. Mankiewicz and Dr. M. Livak), 250
Cannon, P. (Phillips, V. A., and) : Dislocations in Layer Structures, 313
Capacity of Extracts from Prestarved *Escherichia coli* to Incorporate Thymidine into Deoxyribonucleic Acid (Dr. Daniel Billen), 1044
Capacity (Proliferative), of Acute Leukaemia Cells (Dr. Felice Gavosto, Giovanni Maraini and Alessandro Pileri), 611
Capacity (Total Iron-binding), in certain Mammals : Serum Iron and (Prof. Jose Planas and Sannio de Castro), 1126
Cape and Royal Greenwich Observatories : Integration of the, 464
Capital Investment in the Coal, Electricity and Gas Industries (Ministry of Power), 1055
Capot-Rey, Prof. R. E. : Problems of the Arid Zones (Nomadism in relation to Grazing Resources—the Sahara and the Sahel), 296
Capsule (Kidney) : Development of Mouse Eggs beneath the (D. R. S. Kirby), 707
Capsules from *Discoverer* Satellites : Recovery of, 741
Carbide : An Iron-Silicon (J. G. Humphreys and Prof. Walter S. Owen), 589
Carbohydrates : Nutritive Values of, for the Silkworm, *Bombyx mori* (Dr. Toshio Ito), 527
Carbohydrates of *Ecklonia radiata* (C. M. Stewart and H. G. Higgins), 511
Carbohydrates (Neutral) : Presence of, in Human Aortic Tissue (Dr. Sv. Bertelsen), 411
C-1 Fructose-1,6-diphosphatase : Alkaline—Evidence for its Participation in Photosynthesis (Dr. Robert Smillie), 1024
C^3-C^6 Hydrocarbons : Two Highly Selective Solvents for Gas-Liquid Chromatography Analysis of (Dr. A. van der Wiel), 142
Carbon(III)Ion (*tris*(Ethylenediamine)) : Catalytic Racemization of (Dr. F. P. Dwyer and Dr. A. M. Sargeson), 1022
Carbon-14 Labelled Hybrids of Haemoglobin (Dr. Jerome Vinograd and William D. Hutchinson), 216
^{14}C-Lysine Metabolism in Young Rats : Influence of Different Types of Malnutrition on the (Prof. Kurt Schreier and Corinna Kassens), 1117
^{14}C-Meso-Inositol in the Rat : Metabolism of (Dr. D. A. Nixon), 77
Carbon Dioxide : Effects of Light and Darkness on the Rhythm of Output of, of Excised *Bryophyllum* Leaves (Dr. Malcolm B. Wilkins), 523
Carbon Dioxide Mass Spectra : High-Energy Oxygen Ions in (R. M. S. Hall), 683
Carbon Dioxide Output : Effect of Electronarcosis on Oxygen Consumption and (Dr. Jaroslav Strmiska and Dr. Antonín Vacek), 151
Carbon-Fluorine Compounds in some Species of *Dichapetalum* : Fluorine Compounds in Nature—the Distribution of (Sir Rudolph Peters and R. J. Hall), 573
CF_2 Radical : Photochemical Formation and Stability of the (Dr. J. P. Simons and A. J. Yarwood), 316
Carbon Monoxide-sensitive Respiration : Absence of, in a Streptomycin-dependent Mutant of *Escherichia coli* grown in Limited Amount of Streptomycin (Hanna Engelberg and Dr. M. Artman), 801
Carbons of Different Graphitic Perfection : Dependence on Temperature of the Interlayer Spacing in (E. G. Steward, B. P. Cook and E. A. Kellett), 1015
Carcinus maenas (L.) (Shore Crab) : Albinism in the American Population of the (Anthony J. Provenzano, Jun.), 521
Cardiff Region : The—a Survey (Chairman of the Editorial Committee, Sir J. Frederick Rees), (prepared for the meeting of the British Association in Cardiff), *review*, 851
Cardini, Dr. Carlos E., and others : Mechanism of Starch Biosynthesis, 918
Carlisle, Dr. D. B. : Softening Chitin for Histology, 1132
Carnap, Rudolf : Introduction to Symbolic Logic and its Applications (translated by William H. Meyer and John Wilkinson), *review* by F. I. G. Rawlins, 729
Carnegie United Kingdom Trust : Forty-sixth Annual Report (1959), 566
Carr, T. D., and others : Ionospheric Modification of the Radio Emission from Jupiter, 568
Carter, Dr. G. S. : Tropical Climates and Biology (Presidential Address to Section D (Zoology) of the British Association for the Advancement of Science), 843
Cartwright, K. St. G., and Findlay, W. P. K. : Decay of Timber and its Prevention, *review* by Prof. F. W. Jane, 977
Case, L. C. (Schmoyer, L. F., and) : A New Method for the Synthesis of Cyclic Ethers, 592
Case Studies : Research in, 659
  Research Necessary for the Preparation and Use of (South London Committee of the British Institute of Management Conference on), 660
Casey-Smith, J. R. : Haematology of the Central Australian Aborigine, 903
Cassie, R. M. : Abundance of Marine Plankton, 289
Castner Memorial Lecture (Dr. W. J. Kroll), 994
Catalase-like Activity in Lactic Acid Bacteria : Two Types of (R. Whittenbury), 433, *erratum*, 466
Catalytic Racemization of *tris*(Ethylenediamine)Cobalt(III) Ion (Dr. F. P. Dwyer and Dr. A. M. Sargeson), 1022
Catechol : Excretion of, after Ingestion of Quinic and Shikimic Acids (Dr. A. N. Booth, D. J. Robbins, M. S. Masri and F. DeEds), 691
Catecholamine in Brain : A Suggested Effect on Levels of, produced by Small Doses of Reserpine (F. Barbara Orlans and Dr. Bernard B. Brodie), 1034 ; (Herbert Sheppard and Joseph H. Zimmerman), 1035
Catecholamine Content (Nucleotide and), of the Denervated Adrenal Medulla of the Rat : Effect of Reserpine on the (Prof. Nils-Åke Hillarp), 1032
Catesby, C. G. C. : Mimetic Twinning in Urea-Ammonium Bromide, 765
Cathala, Prof. J. : *Obituary* of Georges Claude, 829
Cathode (Cold-) Arcs : Stepwise Ablation and Heat Transfer in (Dr. A. von Engel and Dr. K. W. Arnold), 1101
Cation Trimethylhexadecylammonium : Reduction of the Intestinal Absorption of Glucose, Methionine and Sodium Butyrate by the (Dr. J. A. Nissim), 308
Cations of the Lyotropic Series : Effect of the, on the Tension of Vascular Muscle (Prof. L. Laszt), 329
Cats on Diets of varying Protein Content : Urinary Amino-Acid Pattern of (Dr. J. P. Greaves and Dr. Patricia P. Scott), 242
Cats (Litter-mate) : Proportion of Noradrenaline to Adrenaline in the Adrenal Glands of (Dr. K. R. Butterworth and Dr. Monica Mann), 785
Cattle : Occurrence of Keto-Acids in Blood Serum and Urine of, in comparison with Man, Horse, Sheep and Dog (Dr. C. J. G. van der Horst), 146
Causality (Prof. Mario Bunge), *review* by Dr. J. O. Wisdom, 92
Causation and Modern Science, *review* by Dr. J. O. Wisdom, 92
Cawood, Dr. W. : Combustion and Propulsion—High Mach Number Air-breathing Engines, 18
Celestial Bodies : Theories of Figures of (Wenceslas S. Jardetzky), *review* by Prof. L. S. Goddard, 890
Cell (Amphibian Neural Crest) : Pterin Synthesis in the (Tadao Hama and Masataka Obika), 326
Cell (Diaphragm-) Technique : Equations for Determining Diffusion Coefficients in Liquid Systems by the (F. A. L. Dullien and Prof. L. W. Shemilt), 767
Cell (Epidermal), in an Insect : The Control of Growth and Form—a Study of the (Prof. V. B. Wigglesworth), *review* by Prof. R. Dennell, 631
Cell (Fuel) Low-Temperature (Shell Research Centre), 994
Cell Biology, American Society for : Organization of the, 649
Cell Biology and Growth Inhibition (Cell Biology Programme of Unesco International Symposium on), 836
Cell Culture Genetics of Man : Cytology and (Symposium published by the *American Journal of Human Genetics*), 116
Cell Division. Growth by, in Insect Tissue Culture (Dr. B. M. Jones and L. Cunningham), 1072
Cell Envelope of *Serratia marcescens* (*Chromobacterium prodigiosum*) : Association of Pigment with the (Mira Purkayastha and Prof. R. P. Williams), 349
Cell Membrane (Red Blood) : Chemical Constitution of the (Dr. T. Fehér and Dr. Béla Matkovics), 701
Cell Nuclei (Somatic) : Absorbance of Feulgen-stained (Dr. Simon Iversen), 86
Cell Nucleus : Selective Cytochemical Demonstration of Arginine Groups in Nucleoprotein in the (Dr. E. A. Barnard and Dr. L. G. E. Bell), 508
Cell Water (Mitochondrial and) : Phosphoproteins and (Dr. J. D. Judah), 506
Cell, Organism and Milieu (edited by Prof. Dorothea Rudnick), (Seventeenth Symposium of the Society for the Study of Development and Growth), *review* by Dr. E. N. Willmer, 650

Cellobiose and other Saccharides (Glucose,) : Synthesis of, by *Acetobacter acetigenum* in a Lactate-buffered Glycerol Medium (Dr. C. P. Jackson and K. Ramamurti), 942
Cells : Uptake of Heparin by (Dr. G Csaba and Dr. Eszter Kapa), 711
Cells and their Environment, *review* by Dr. E. N. Willmer, 450
Cells of *Agrobacterium tumefaciens* : A Vacuolar System in, as shown by Electron Microscopy of Ultra-thin Sections (Miguel-Rubio-Huertos and Paul R. Desjardins), 1043
Cells (Acute Leukaemia) : Proliferative Capacity of (Dr. Felice Gavosto, Giovanni Maraini and Alessandro Pileri), 6[illegible]
Cells (Ascites Tumour), *in vitro* : Optical Protein Synthesis by (Dr. M. J. Fraser), 1114
Cells (Bone Marrow) : Acetone Fixation for the Cytochemical Demonstration of Dehydrogenases in Blood and (Dennis Quaglino and Dr. F. G. J. Hayhoe), 85
Cells (Chick Embryo Fibroblast) : An Interferon-like Substance released from Tick-borne Encephalitis Virus-infected (Dr. J. Vilček), 73
Cells (Homologous Adult Spleen), injected into New-born Mice : Fate of (A. J. S. Davies and Sheila M A. Doak), 610
Cells (Human Red) : Adenosine Triphosphate and Maintenance of Shape of the (Makoto Nakao, Toshiko Nakao and Saburo Yamazoe), 945
Cells (Isolated) : Measuring the Size of (Dr. Samuel S. Epstein and Jacqueline B. Weiss), 461
Cells (Mast), and 5-Hydroxytryptamine in Precancerous Mouse Skin (Dr. R. E. Coupland and Dr. J. F. Riley), 1128
Cells (Mouse Ascites) : Uptake of Thymidine and Synthesis of Deoxyribonucleic Acid in (Dr A. R. Crathorn and Dr. K. V. Shooter), 614
Cells (*L*1210 Mouse Leukaemia) · Effect of 6-Mercaptopurine on the Net *in vitro* Gas Production of Sensitive and Resistant (Dr. H. J. Woodliff), 156
Cells (Transplanted Bone Marrow), in Radiation Chimaeras : Identification of (P. Czerski, O. Rosiek and J. Sabliński), 955
Cellular Fractions (Active) : Homotransplant Antigens—Preparation of (L. T. Mann, jun., J. M. Corson and Prof. G. J. Dammin), 774
Cellular Level : Analysis of Metabolic Rates at the (Dr. L. G. Lajtha, R. Oliver, R. J. Berry and Elizabeth Hall), 919
Cellulase of *Myrothecium verrucaria* : Evidence for Multiple Nature of (P. Y. F. Prins-van der Meulen and G. J. Schuringa), 695
Cellulose · Biosynthesis of, by *Acetobacter acetigenum* (Dr. A. M. Brown and Dr. J. A. Gascoigne), 1010
Cellulose (Animal) · Human and other (Dr. D. A. Hall and H. Saxl), 547
Cellulose ('DEAE'-) : Chromatography of Blood Thrombokinase on (Dr. J H. Milstone), 1127
Cellulose and Cellulose Ion Exchanger : Non-specific Haemagglutinin from (Prof. B. Schmidt, Dr. K. Grossgebauer and D. Hartmann), 790
Cellulose Ion Exchanger : Non-specific Haemagglutinin from Cellulose and (Prof B. Schmidt, Dr. K. Grossgebauer and D. Hartmann), 790
Celmer, W. D. (Hobbs, D. C., and) : Structure of the Antibiotics *PA*1148-I and *PA*1148-3, 598
Cement-Aggregate Bond-Strength : Dependence of, on Size of Aggregate (K. M. Alexander and J. Wardlaw), 230
Cement and Concrete Association : Grant of £2,100 to the Department of Civil Engineering in the University of Leeds, 465
Centenary and an Outlook : Experiment in Psychology—a (Prof. R. C. Oldfield), 846
Centenary Celebrations of the births of W. M. Bayliss and J. S. Haldane in Moscow (D. A. Sakharov), 912
Central Advisory Council for Education—England : Report, Vol. 2, Surveys, 883
Central Advisory Water Committee : Second Report of the Sub-Committee on Growing Demand for Water, 198
Central Australian Aborigine : Haematology of the (J. R. Casey-Smith), 903
Central Nervous System and Behavior—Transactions of the Second Conference, Princeton, 1959 (edited by Mary A. B. Brazier), *review* by Dr. Henry Miller, 6
Centre d'Études Nucléaires (European Productivity Agency of the Organization for European Economic Co-operation and the) : International Information Centre for Food Irradiation, 741
Centre Inter-Universitaire de Recherches Enzymologiques : Colloquium on Intracellular Localization of Enzymes, 836
Centre National de la Recherche Scientifique : International Colloquium on the Physics of Electrostatic Forces and their Applications, 466
  Colloques Internationaux No. 79, Premier Colloque International de Photographie Corpusculaire (Strasbourg, 1957), *review* by D. L. Allan, 636
Cerebral Hemispheres : An Unidentified Pharmacologically Active Substance extracted from (P. F. L. Andrews, Shirley A. P. Price and Dr. G. B. West), 420
Cerebrospinal Fluid : 5-Hydroxytryptamine in (A. Akcasu, M. Akcasu and S. B. Tumay), 324
Cerkasov, J. (Hodek, I., and) : Prevention and Artificial Induction of the Imaginal Diapause in *Coccinella 7-punctata* L., 345
Ceskoslovenské Republiky : Atlas Podnebí (Climatic Atlas of the Czechoslovak Republic), *review* by G. A. Bull, 543
Cestodes of Vertebrates : Classification of the, *review* by Dr. Ben Dawes, 723
Chace, William G., and Moore, Howard K. (edited by) : Exploding Wires—Based on Conference on the Exploding Wire Phenomenon, 1959, conducted by Geophysics Research Directorate of the Air Force Cambridge Research Center, with the co-operation of Lowell Technological Institute Research Foundation), *review* by Dr. B. A. Thrush, 726
Chadwick, Sir James : Re-appointed a part-time member of the United Kingdom Atomic Energy Authority, 743
Chain, Prof E. B., and others : Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis, 236
  Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture, 238
Chain (Adaptive), in the Conversion of Antimetabolites into Metabolites (Dr. K. I. Markov, Dr. G. K. Saev and Dr. E. V. Golovinsky), 1041
Chain Fracture during the Cross-linking of Rubber : Analysis of Solubility Data to estimate Small Amounts of (L. Mullins and D. T. Turner), 145
Chakrabartty, S. K., and others : Initial Stages of Oxidation of Coal, 502
Chakravorty, Maharani : Microbial Synthesis of Protein in relation to the Biogenesis of Nucleic Acids with *Azotobacter vinelandii* as the Test Organism, 239
Chaleur des Réacteurs Nucléaires : Évacuation et Récupération de la (Richard Alami et Paul Ageron), *review* by R. J. Syme, 636
Chalk, Dr. L : The Development of Pulp and Particle Board Industries and their Effect on Forest Management (Problem of 'Juvenile' Wood), 33
Chambers (British) of Commerce, Association of (British Association for the Advancement of Science and the) : Decimal Coinage and the Metric System—Should Britain Change ? (A joint Report of Committees appointed by the), 30
Chance Brothers, Ltd., Smethwick : Retirement of Dr. W. M. Hampton as managing director, 905
Chandos, Viscount : Electricity—the New Horizon (Presidential Address to the British Electrical Power Convention), 557
  Messel Medal Address to the Society of Chemical Industry, 831
Change of the Chlorine—Sodium Ratio in the Atmosphere with Altitude and Distance from the Source of Sodium Chloride, and the Distribution of Atmospheric Nitrate over the United States (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Change (Local Cytotoxic), in Man from Griseofulvin : Absence of (Prof. Leon Goldman, Amanda Beyer and Jan Schwarz), 335
Change (Social), in Tikopia (Prof. Raymond Firth), *review* by Sir Harry Luke, 816
Changes in Conductivity of Pure Water caused by X-Irradiation (K. Schmidt), 931
Changes produced by Cooling and by Drugs known to affect Adrenergic Mechanisms : Parallelism of (Prof. Eleanor Zaimis), 213
Changes (Colour), of Ageing Bloodstains : Use of Reflectance Measurements in assessing the (Dr. D. Patterson), 688
Changes (Cyclical), in the Distribution of the Testis Lipids in the Common Frog, *Rana temporaria* (Dr. B. Lofts and C Boswell), 708
Changes (Oxygen Consumption), in Rats during Irradiation : Role of Initial Value of Metabolic Processes in (Dr. A. Vacek), 76
Changes (*p*H), during Muscle Twitch and Tetanus (A. Distèche), 1119
Changing World Population : Planning for the, *review* by M. K. Milne, 816
Chanteur, Jean, and Pellerin, Pierre : Localization by Autoradiography at -195° C. of Radioactive Areas in Rats exposed to a High Flux of Thermal Neutrons—Importance of Phosphorus-32 in Consecutive Internal Irradiation, 472
Chaos chaos (Giant Amoeba) : Streaming in Cytoplasm dissociated from the (Prof. R. D Allen, J W. Cooledge and P. J. Hall), 896
Chapman, R. E., and others : Abnormal Crimping in Merino and Polwarth Wools, 960
Chapman, Prof. Sydney : I.G.Y., Year of Discovery—the Story of the International Geophysical Year, *review* by Prof. S. K. Runcorn, 185
  Geomagnetic Storms and the Space around the Earth, 824
Chapman, Prof. V. J. : University Education in New Zealand, 107
Chara vulgaris L. subjected to X-Rays : Delayed 'Primary' Effects in (C. M. Gillet), 874
Character of the Ligands in Dibenzene Chromium (Dr. F. Jellinek), 871
Character (Meristic), in Coleoptera : Ovarioles as a (Dr. J. G. Robertson), 526
Character (Oscillatory), of Amplitude Curves for Seismic Body Waves (Dr. J. Vanek and J. Stelzner), 491
Characteristics (Sedimentation), of the γ-Chain Haemoglobin (Haemoglobin 'Bart's'), (Dr R. A. Kekwick and Dr. H. Lehmann), 158
Characterization of Pseudocoelomic Membranes of *Ascaris lumbricoides* : Use of Collagenase in the (Barbara Dawson), 798
Characters (New Deficient), in Streptomycin-resistant Mutants of *Bacillus subtilis* : Appearance of (Masamichi Kohiyama and Yonosuke Ikeda), 168
Chargaff, Prof. Erwin, and others : A Bleached Variant of *Euglena gracilis* showing a Doubling of the Content of Deoxyribonucleic Acid, 1037
Charge : Effect of Surface Density of, on the Physical Swelling of Lithium Montmorillonite (Dr. J. P. Quirk and B. K. G. Theng), 967
  Photo-injection of, into Dielectric Liquids (M. J. Morant), 48
Charged Particles in Matter : Penetration of—Proceedings of an Informal Conference, Gatlinburg, Tennessee, 1958 (edited by A. Vehling), (United States National Academy of Sciences—National Research Council, Nuclear Science Series, Report No. 29), 1086
Charig, Dr. A. J. : *Obituary* of Dr. G. H. Francis, 284
Charlton, T. M. · A Historical Note on the Reciprocal Theorem and Theory of Statically Indeterminate Frameworks, 231
Chatt, Dr. J., and others : Some New Hydrides of Iron and Osmium, 55
Chatterjee, B N. : Food and Animal Production Overseas (Animal Production and Fodder Resources in India), 1071
Chatterton, N., and others : Ionospheric Modification of the Radio Emission from Jupiter, 568
Chelates (Cupric β-Diketone), with Heterocyclic Bases : Structure of the 1,1-Adducts of (Dr. D. P. Graddon and E. C. Watton), 1021
Chelates (Ethylenediamine Tetraacetic Acid) · Differential Thermal Analysis of some Transition Metal (Prof. Wesley W. Wendlandt and G. Robert Horton), 769
Chelating Agents : Removal of Internally Deposited Americium by (Dr. F D. Sowby and Dr. D. M. Taylor), 612
Chelating Agents (Injected) : Sustained Action of (Dr. A. Lindenbaum and Dr J. Schubert), 575
Chemical Analytical Methods : A Handbook of Colorimetric (Tintometer, Ltd.), fifth edition, *review* by A. M. G. Macdonald, 3
Chemical Behavior of Zirconium (Warren B. Blumenthal), *review* by Prof. A. G. Quarrell, 725
Chemical Composition and Magnetic Properties of Tektites and Glasses formed by Fusion of Terrestrial Rocks : Comparison of the (Dr. Irving Friedman, Dr. Arthur Thorpe and Dr. Frank E. Senftle), 1089
Chemical Constitution of the Red Blood Cell Membrane (Dr. T. Fehér and Dr. Béla Matkovics), 701
Chemical Control of Agricultural Pests and Conservation of America's Wild-Life (United States National Academy of Sciences—National Research Council Committee on), 114
Chemical Effects of Ionizing Radiations on Nucleic Acids and Nucleoproteins (P. Emmerson, Dr. G. Scholes, D. H. Thomson, J. F. Ward and Prof. J. Weiss), 319

Chemical Elements (Rare and Dispersed), in the Soil : The Geochemistry of (A. P. Vinogradov), second edition, (translated from the Russian), *review* by A. H. Debnam, 629
Chemical Engineering Practice (edited by Herbert W. Cremer and Sidney B. Watkins), Vol. 11, Works Design, etc., *review* by Prof. J. M. Coulson, 887
Chemical Engineers, Institution of (Constructors John Brown, Ltd., and the) : A CJB Scholarship awarded to M. D. Taylor, 650
Chemical Federation (Royal Netherlands), and others : International Congress on the Technology of Plastics Processing, 559
Chemical Industry in Basle The Story of (published by Ciba Limited on the occasion of its 75th Anniversary), *review* by Dr. L. K. Sharp, 540
Chemical Industry, Society of : Appointment of Dr. T. F. West as editor of *Chemistry and Industry*, 290
  Fourth Robert Horne Memorial Lecture (Prof. F. D. Richardson), 466
  Presidential Address, Research and Development in Industry (Dr. E. J. Solvay), 830
  Messel Medal Address (Viscount Chandos), 831
  Castner Memorial Lecture (Dr. W. J. Kroll), 994
Chemical Industry, Society of (Plastics and Polymer Group) : Symposium on High-Temperature Resistance and Thermal Degradation of Polymers, 466
Chemical Industry, Society of (Corrosion Group of the Birmingham and Midlands Section), Institution of Gas Engineers and the : Symposium on the Protection of Gas Plant and Equipment from Corrosion, 466
Chemical Industry, Society of (Manchester Section and Fine Chemicals Group), (Manchester and District Section of the Royal Institute of Chemistry and the) : Symposium on Drugs for the Treatment of Hypertension, 743
Chemical Institute of Canada (National Research Council of Canada and the) : Tenth High Polymer Forum, 117
Chemical Laboratories (New), in the University of Sydney (Prof. R. J. W. Le Fevre), 833
Chemical Laboratory (National), Teddington : Report for 1959, 902
  Open Days, 994
Chemical Manufacturers (British), Association of : Booklet on Chemical Plant Instrumentation—some Notes on the Use of Measuring Instruments, 1079
Chemical Physics : Advances in (edited by Prof. I. Prigogine), Vols. 1 and 2, *review* by Prof C A Coulson, 812
Chemical Physics Comes of Age, *review* by Prof. C. A. Coulson, 812
Chemical Plant : The Design and Construction of High Pressure (Harold Tongue), second edition, *review* by Dr. K. E. Bett, 541
Chemical Plant Instrumentation—some Notes on the Use of Measuring Instruments (Association of British Chemical Manufacturers), 1079
Chemical Reactions : Initiation of, by Mechanical Forces (Dr. Robert Schnurmann and Ivor S. Stringer), 587
Chemical Reactivity with Mercaptalbumin : An Ortho Effect Influencing Fungitoxicity, Electronic Absorption Spectra, and (Dr. H. P. Burchfield and Eleanor E. Storrs), 593
Chemical Society Grants for assistance in Research in any branch of Chemistry, 466
  Special Publication No. 14, Handbook for Chemical Society Authors, 832
Chemical Society (American) : Monograph Series No. 139, The Science of High Explosives (Prof Melvin A. Cook), *review* by Dr. W. L. Murray, 539
  Monograph Series No. 134, The Chemistry and Technology of Leather (edited by Fred O'Flaherty, William T. Roddy and Robert M. Lollar), Vol. 2, Types of Tannages, *review* by Prof. A. G. Ward, 724
Chemical Society Authors Handbook for (Chemical Society, Special Publication No. 14), 832
Chemical Technology at Edinburgh, 555
Chemical and Molecular Basis of Nerve Activity (David Nachmansohn), *review* by Dr. D. H. Brinton, 447
Chemical and Physical Properties of the Small Deoxyribonucleic Acid Component of Crystalline Cytochrome B_2 (Dr. M. D. Montague and Prof. R. K. Morton), 916
Chemicals (Toxic), in Agriculture and Food Storage : Use of (Request from the Research Study Group for evidence), 290
Chemicus : *Index* (Institute for Scientific Information, Philadelphia), No. 1, 993
Chemist (Government) : Report for 1958-59, 1076
Chemistry is Not Enough (Dr. James Taylor), 841
Chemistry : Fellowships in (Ramsay Memorial Fellowship Trust Awards for 1960-61), 832
  Grants for assistance in Research in any branch of (Chemical Society), 466
  New Horizons in (Sir Alexander Todd), 819
  Nuclear Reactor (Oak Ridge National Laboratory Conference on), 994
  Pure and Applied (International Union of Pure and Applied Chemistry Seventeenth International Congress of), 29, *erratum*, 117
  Quantum—Methods and Applications (R. Daudel, R. Lefebvre and C Moser), *review* by Prof. H. C. Longuet-Higgins, 541
Chemistry, Royal Institute of (Manchester and District Section), and the Society of Chemical Industry (Manchester Section and Fine Chemicals Group) : Symposium on Drugs for the Treatment of Hypertension, 743
Chemistry (Analytical), in Nuclear Reactor Technology (Oak Ridge National Laboratory Conference on), 994
Chemistry (Analytical), of Titanium Metals and Compounds (Maurice Codell), *review* by Prof A. G. Quarrell, 725
Chemistry (Analytical), and Applied Spectroscopy (Twelfth Pittsburgh Conference on), 289
Chemistry (Clinical) : Advances in (edited by Harry Sobotka and C. P. Stewart), Vol. 2, *review* by Dr. R. Consden, 890
Chemistry (Crystal), of Simple Compounds of Uranium, Thorium, Plutonium, Neptunium (E. S. Makarov), translated from the Russian by E B. Uvarov, *review* by Dr. L. E. J. Roberts, 728
Chemistry (Inorganic) : Annual Reviews on, *review* by Dr. L R. Beattie, 4
  Comprehensive (edited by Prof M. Cannon Sneed and Prof. Robert C. Brasted), Vol. 7, The Elements and Compounds of Group IVA (Harold P. Klug and Prof. Robert C. Brasted), *review* by Dr. K. W. Bagnall, 185
  Progress in (edited by F. Albert Cotton), Vol. 1, *review* by Dr. L R. Beattie, 4
Chemistry (Physical), of Aerosols (Faraday Society General Discussion on), 201
Chemistry (Pure and Applied), International Union of : Seventeenth International Congress of Pure and Applied Chemistry, 29, *erratum*, 117
Chemistry (Pure and Applied), International Union of (sponsored by the) : Symposium on the Chemistry of Natural Products (organized by the Australian Academy of Science), 1080
Chemistry (Pure and Applied), International Union of, and others · International Congress on the Technology of Plastics Processing, 559
Chemistry (Steroid) · Recent Advances in (Kingston Technical College Postgraduate Course on), 905
Chemistry of the Earth : Physics and (edited by Prof L. H. Ahrens, Frank Press, Kalervo Rankama and Prof. S. K Runcorn), Vol. 3, *review* by B. E. Leake, 544
Chemistry of Heredity (Prof. Stephen Zamenhof), *review* by Dr. P. Cohn, 447
Chemistry of Metals : The Extraction of Metals and the (Prof F. D. Richardson), 466
Chemistry of Natural Products (Symposium on, sponsored by the International Union of Pure and Applied Chemistry, organized by the Australian Academy of Science), 1080
Chemistry and Industry : Appointment of Dr. T. F. West as editor, 290
Chemistry and Technology of Leather (edited by Fred O'Flaherty, William T. Roddy and Robert M. Lollar), Vol. 2, Types of Tannages, *review* by Prof. A. G. Ward, 724
Cherry, R. D., and others : Major Element Relationships in Tektites, 680
Chick Embryo : Assay of Corticosteroids in the (Sir Macfarlane Burnet and N. L. Warner), 938
Chick Embryo Fibroblast Cells : An Interferon-like Substance released from Tick-borne Encephalitis Virus-infected (Dr. J. Vilček), 73
Chidester, J. L., and others : Direct Infra-Red Spectral Analysis of the Cucumber Mosaic Virus Infection Process, 1049
Child, the Parent and the State (Dr. James Bryant Conant), *review* by Brian Holmes, 635
Chilver, E. M., and Kaberry, Dr. P. : Awarded jointly the Wellcome Medal for 1959 of the Royal Anthropological Institute, 114
Chimaeras (Homologous Radiation) : Polyvalent Immunological Tolerance in (Alena Lengerová), 160
Chimaeras (Radiation) : Identification of Transplanted Bone Marrow Cells in (P. Czerski, O. Rosiek and J. Sabliński), 955
Chimie Physique, Société de : Annual Meeting (Structure, Synthesis and Function of Deoxyribonucleic Acid), 1079
Chitin for Histology : Softening (Dr D. B. Carlisle), 1132
Chimpanzees : β-Globulin Polymorphism in (Prof. Samuel H. Boyer and Dr. William J. Young), 1035
Chittleborough, Dr. R. G. : Marked Humpback Whale of Known Age, 164
Chloramphenicol . Recovery in the Presence of, of *Escherichia coli* B(H) Irradiated with Ultra-violet Light (Kenshi Suzuki and Yukiko Iwama), 347
Chloride (Sodium) : Change of the Chlorine—Sodium Ratio in the Atmosphere with Altitude and Distance from the Source of, and the Distribution of Atmospheric Nitrate over the United States (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Chloride (Tetrakis (Hydroxymethyl) Phosphonium) : Action of, on Wool (L. S. Bajpai, Prof. C. S. Whewell and J. M. Woodhouse), 602
Chloride Gases (*n*-Alkyl) : Ionization and Attachment Coefficients in (J. C. Devins and O H. LeBlanc, jun.), 409
Chlorine—Sodium Ratio in the Atmosphere : Change of the, with Altitude and Distance from the Source of Sodium Chloride, and the Distribution of Atmospheric Nitrate over the United States (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Choice Reaction Time : Time Uncertainty and (Paul Bertelson and Jean-Paul Boons), 531
Chopra, H. C. : Cytochemical Evidence of the Origin of Lipid Bodies (so-called Golgi Bodies) from Mitochondria, 713
Chordotonal Organs in Crustacea (Dr. Mary Whitear), 522
'Chorus' at the South Pole : Observations of 'Whistlers' and (Dr. L. H. Martin), 1018
Christian, Dr. Charles L. (Robinson, Dr. John L., and) : 6-Mercaptopurine in Immunological Responsiveness, 796
Christian, C. S., and others (edited by) : Biogeography and Ecology in Australia, *review* by Prof. A. J. Marshall, 543
Christian Belief : The Conflict between Evolutionary Theory and (Dr. David Lack), 98
Christianity : Bridging the Gap between Science and, *review* by R. Brightman, 818
Christmas 1959 : Road Accidents during (Road Research Laboratory, Technical Paper No. 49), 1000
Christodoulou, Dr. Demetrious . The Evolution of the Rural Land Use Pattern in Cyprus, *review* by Prof. M. J. Wise, 628
Christophers, Sir S. Rickard : *Aedes aegypti* (L), the Yellow Fever Mosquito —its Life History, Bionomics and Structure, *review* by Prof. V. B. Wigglesworth, 813
Chromatograms of Human Plasma : Staining for Iodine in—an Artefact due to Thioureas or Thiouracils (A. Dimitriadou, Prof. T. Russell Fraser, Dr. J. D. H. Slater and P. C. R. Turner), 691 ; *erratum*, 1079
Chromatographic Separation (Gas-Solid), of Hydrocarbons of High Molecular Weight (C. G. Scott and D. A. Rowell), 143
Chromatography (Belgisch Genootschap voor Pharmaceutische Wetenschappen International Symposium on), 374
Chromatography : 'Eddy' Diffusion in (A. Klinkenberg and F. Sjenitzer), 1023 ; (J. Calvin Giddings), 1023
Chromatography of Blood Thrombokinase on 'DEAE'-Cellulose (Dr. J. H. Milstone), 1127
Chromatography (Gas) : Determination of Fatty Acids of Lower Molecular Weight by (Marie L. Vorbeck, Leonard R. Mattick, Frank A. Lee and Carl S. Pederson), 689
  Microanalytical Separation of Steroids by (C. C. Sweeley and Dr. E. C. Horning), 144
Chromatography (Gas) Research Center : A New (Barber-Colman Company, Houston), 289
Chromatography (Gas Liquid), of Conjugated Fatty Acids (Dr. N. W. R. Daniels and J. Wendy Richmond), 55
Chromatography' ('*pH*-), of some Amphoteric Antibiotics (Vladimir Betina and Prof. Pavel Nemec), 1111

Chromatography Analysis (Gas-Liquid), of C_5–C_6 Hydrocarbons : Two Highly Selective Solvents for (Dr. A. van der Wiel), 142
Chromium (Dibenzene) : Character of the Ligands in (Dr. F. Jellinek), 871
Chromium Electro-deposit . Hexagonal Modification of Black (Hideya Okada and Takeo Ishida), 496
Chromium (17 per cent), 8 per cent Nickel and 1 per cent Niobium Steel : A New Phase in a Silicon bearing (M. J. O'Hara, D. Wilkinson and R. T. Allsop), 407
Chromobacterium prodigiosum (Serratia marcescens) : Association of Pigment with Cell Envelope of (Mira Purkayastha and Prof. R. P. Williams), 349
Chromosome Numbers in *Amaranthus* (Prof. W F. Grant), 28
Chromosome Ploidy and Radiosensitivity of Tumours (László Revész and Ulla Norman), 861
Chromosomes and the Theory of Heredity (Prof. C. D. Darlington), 892
Chromospheric Flares : Measurement of Magnetic Fields in (M. Blaha, M. Kopecky and Z. Svestka), 224
Chronic Prostato-vesiculitis : Urinary Excretion of Œstrogens in Cases of (Prof Gunnar Nylander), 154
Churchill College, Cambridge : Election of C. St. J. Wilson to a Fellowship, 742
  Election of R. A. Y. Jones, A. O. Gilchrist, C. B. Cottrell and A. Howie to Junior Research Fellowships, 742
  Election of Prof. E. E. Saltpeter and Dr. J. D. Watson to Overseas Fellowships, 742
Chymotrypsin (Acetyl-) : Structures of some Acetyl-serine Peptides from (Leo Benoiton, Prof. H. N. Rydon, R. A. Oosterbaan, M. E. Van Adrichem and Prof. J A Cohen), 596
Ciba, Limited : The Story of Chemical Industry in Basle (published on the occasion of its 75th Anniversary), *review* by Dr. L. K. Sharp, 540
Cichlid (Non-) Fishes in Lake Victoria : Breeding Sites of (Dr. Philip S. Corbet), 616
Ciliate (Histophagous) : Increase of Esterase Activity during Intracellular Digestion in a (Dr. Miklós Muller, József Tóth and Prof. Imre Toro), 65
Circuit Theory : General (Prof. Gordon Newstead), *review* by Prof. A. H. M. Arnold, 811
  General and Linear, *review* by Prof. A. H. M. Arnold, 811
Circulation (Extracorporeal) · Influence of 5-Hydroxytryptamine on Renal Function in (Dr. M. H. Frick), 609
Citation : Bibliographical (C. C. Barnard), second edition, 27
Citric Acid in the Oviduct of the Hen : Parallel Distribution of Calcium and (Dr. T G Taylor and F. Hertelendy), 244
Citrine, Lord : Re-appointed a part-time member of the United Kingdom Atomic Energy Authority, 743
Civil Service : Overseas (House of Commons Adjournment Debate on the), 371
Civil Service (Overseas) : Supplementary Pay and Allowances, 556
Civilisation : Africa's Place in the Emergence of (Prof. Raymond A. Dart), *review* by M C. Burkitt, 891
Clarenburg, Dr L. A., and Tang, C. E. Spanne-v d. : Small-Scale Turbulent Diffusion in the Atmosphere, 586
Claridge, Dr. C. A., and others : Bacterial Penicillin Amidase, 237
Claringbull, Dr G. F., and Moss, A A : The Enkomi Silver Cup, 1051
Clark, Colin : The Conditions of Economic Progress, 537
Clark, F : Influence of Editors, 121
Clark, Dr. V. M., and others : Oxidative Phosphorylation—Synthesis of Adenosine Diphosphate by the Oxidation of Quinol Phosphates, 59
Clark, Sir Wilfrid Le Gros : Elected president for 1961 of the British Association for the Advancement of Science, 852 ; work of, 852
  The Jaws and Teeth of Primates, *review*, 891
Clarke, S. At the second Annual Conference of the British Computer Society (Russian Interest in British Computing Equipment), 656
Clarke, S. A. : Retirement as chief of the Division of Forest Products of the Australian Commonwealth Scientific and Industrial Research Organization, 901 ; work of, 901
Clarke, W. J., and others : The American Oligocene, 679
Clason, W. E. : Swedish Supplement to Elsevier's Dictionary of Electronics and Waveguides, *review* by Dr. R L Smith-Rose, 1059
Classification : Coral Structures and, *review* by Dr. H. Dighton Thomas, 95
Classification of the Cestodes of Vertebrates, *review* by Dr. Ben Dawes, 723
Classification of Pharmaceutical Preparations—a Survey of Existing Legislation (World Health Organization of United Nations), 287
Claude, Georges . *Obituary* by Prof. J. Cathala, 829
Clause, A. : Intracellular Localization of Enzymes, 836
Claviceps paspali Stevens and Hall in Submerged Culture : Production of Lysergic Acid Derivatives by a Strain of (F. Arcamone, C. Bonino, Prof. E. B. Chain, A. Ferretti, P. Pennella, A. Tonolo and Lidia Vero), 238
Clay Minerals, Montmorillonite and Vermiculite : Aluminium Interlayers in—Laboratory Synthesis (B. L. Sawhney), 261
Clays : Domain or Turbostratic Structure of (L. A. G. Aylmore and Dr. J. P. Quirk), 1046
Clean Air, National Society for : Year Book for 1960, 200
Clearing Action (Lipaemic), of Artificial Anticoagulants (Dr. E. P. George, Dr. C. V. Hall and Dr. G. S. Farkas), 782
Cleavage : Thermal Conduction in Mica along the Planes of (H. J. Goldsmid and A. E. Bowley), 864
Cleavage of Human γ-Globulin (Dr. Rosa Augustin and Barbara J. Hayward), 129
Cleaveland, Dr. Frederic N. : Science and State Government—a Study of the Scientific Activities of State Government Agencies in Six States, *review* by R. Brightman, 181
Cleghorn, Dr. T. E. · MNSs Gene Frequencies in English Blood Donors, 701
  A 'New' Human Blood Group Antigen, Sw^a, *erratum*, 743
Clement, J. R., and others : The Helium-4 Scale of Temperature, 1077
Clements, Dr. F. W. : Elected an honorary member of the American Institute of Nutrition, 374
Climates (Tropical), and Biology (Dr. G. S. Carter), 843
Climatic Atlas of the Czechoslovak Republic, *review* by G. A. Bull, 543
Clinical Chemistry : Advances in (edited by Harry Sobotka and C. P. Stewart), Vol. 2, *review* by Dr. R. Consden, 890
Clinical and Genetico-Statistical Study of Schizophrenia and Low-Grade Mental Deficiency in a Large Swedish Rural Population (Bertil Hallgren and Torsten Sjogren), 298
Clitoria marina Linn. : Isolation of a δ-Lactone Compound from the Leaves of (Dr. A. Sinha), 149
Clone Culture : Morphogenetics of *Micrasterias americana* in (Prof. Paavo Kallio), 164
Closed Conduits : Flow Measurement in (National Engineering Laboratory Symposium on), 905
Cloud Pictures from Satellite *Tiros* I, 647
Clover (White) : Biosynthesis of Linamarin and Lotaustralin in (G. W. Butler and Bera G Butler), 780
Coal : Initial Stages of Oxidation of (S. K. Chakrabartty, B. K. Mazumdar and A. Lahiri), 502
Coal (High-volatile Bituminous) : Absorption of Ultra-violet and Visible Light by Ultra-thin Sections of Vitrinite from a (Sabri Ergun, J. T. McCartney and R. E. Walline), 1014
Coal, Electricity and Gas Industries Capital Investment in the (Ministry of Power), 1055
Coast (California), 1959-60 : Fall-out Caesium in Surface Sea Water off the, by Gamma-Ray Measurements (Dr. Theodore R. Folsom, Dr. G. J. Mohanrao and Perrin Winchell), 480
Cobalt in Nitrogen Fixation : Copper and (Prof. E. G. Hallsworth, S. B. Wilson and E. A. N. Greenwood), 79
Cobalt (Nickel and) : Determination of, by Atomic Absorption (J. E. Allan), 1110
Cocaine : Effect of, on the Disposition of Noradrenaline labelled with Tritium (Dr. L. G. Whitby, G. Hertting and Dr. J. Axelrod), 604
Coccinella 7-punctata L. : Prevention and Artificial Induction of the Imaginal Diapause in (I. Hodek and J. Cerkasov), 345
Cochran, Prof G. W., and others : Direct Infra-Red Spectral Analysis of the Cucumber Mosaic Virus Infection Process, 1049
Cockayne, B. : Appointed to a Research Fellowship in physical metallurgy in the University of Birmingham, 117, 465
Cockburn, Christine : In Pursuit of World Health, *review*, 722
Cockcroft, Dr. W. H. : Title of reader in mathematics in the University of Southampton conferred on, 290
Cocking, Dr. E. C. : A Method for the Isolation of Plant Protoplasts and Vacuoles, 962
Cockrell, D J. : Appointed lecturer in engineering at the University of Leicester, 743
Cocoa : Transmission of a Gall Disease of (A. L. Wharton and A. A. Brunt), 80
Cocoa (Self-incompatible) : Selfing of (D. R. Glendenning), 170
Codell, Maurice : Analytical Chemistry of Titanium Metals and Compounds, *review* by Prof. A. G. Quarrell, 725
Coed Rheidol Nature Reserve : Addition to the (Nature Conservancy), 464
Coefficient (The Second Virial), of Methane at Low Temperature (G. Thomaes and R. Van Steenwinkel), 229
Coefficients (Attachment) : Ionization and, in *n*-Alkyl Chloride Gases (J. C Devins and O H. LeBlanc, jun), 409
Coefficients (Diffusion), in Liquid Systems by the Diaphragm-Cell Technique : Equations for determining (F. A. L. Dullien and Prof. L. W. Shemilt), 767
Coefficients (Flow), of Permeable Solids · Measurement of Slip (*Ko*) and Viscous (*Bo*), (J. G. Biram), 865
Coenzyme I : Non-Enzymic Reactions of Indoles with (Prof. S. G. A. Alivisatos, G. A. Mourkides and A. Jibril), 374
Coenzyme Content of Hepatomas induced by Butter Yellow : Vitamin and (M. H. Briggs), 249
Coetzee, Prof. J. N., and others : Host-Range of *Lactobacillus* Bacteriophages, 348
Cohen, Prof. J. A., and others : Structures of some Acetyl-serine Peptides from Acetyl-chymotrypsin, 596
Cohen, P. S : Appointed lecturer in sociology at the University of Leicester, 743
Cohn, Dr P. : Biochemistry and Heredity, *review*, 447
  Cytoplasmic Particles and their Role in Protein Synthesis, 643
Cohn, Dr. P., and Butler, Prof. J. A. V. : Cytoplasmic Particles and their Role in Protein Synthesis (Composition of Ribonucleoprotein Fractions from the Microsomes of Rat Liver), 645
Coinage (Decimal), and the Metric System—Should Britain Change ? (A Joint Report of Committees appointed by the British Association for the Advancement of Science and the Association of British Chambers of Commerce), 30
Colchicine-induced Tetraploids of *Annona squamosa* L. : Unproductivity in the (Prof. Ahmad Shamsul Islam), 343
Cold and at Room Temperature : Biosynthesis of Sucrose by Preparations from Potatoes stored in the (Dr. Sigmund Schwimmer and Edward S. Rorem), 1113
Cold-Cathode Arcs Stepwise Ablation and Heat Transfer in (Dr. A. von Engel and Dr. K. W. Arnold), 1101
Cold Spring Harbor Symposia on Quantitative Biology · Vol. 24, Genetics and Twentieth Century Darwinism, *review* by Dr H. Kalmus, 726
Cole, Dr. L. J. (Rosen, jun., Lieut. V J , and) : Radiosensitivity of Mouse Kidney undergoing Compensatory Hypertrophy, 612
Cole, Dr. M., and others : Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis, 236
Cole, Sonia : Biography of *Australopithecus*, *review*, 888
Coleman, G. S. : Effect of Penicillin on the Maintenance of Rumen Oligotrich Protozoa, 518
Coleoptera : Ovarioles as a Meristic Character in (Dr. J. G. Robertson), 526
Coleoptile (*Avena*) : Plastids of the (Helen P. Sorokin and Prof. Kenneth V. Thimann), 1038
Coleoptiles : Electrostatic Measurement of the Geoelectric Effect in (Carl Hellmuth Hertz), 320
Coles, Dr. B. R., and Griffiths, D. : Ferromagnetic and Antiferromagnetic Behaviour in the Second Transition Group, 226
Colicinogeny : Genetic Recombination in *Salmonella typhimurium* occurring during Transmission of (Dr. Ozeki and Dr Howarth), 649
Colin, R., and others . Mass Spectrometric Investigation of the Vaporization of Sulphides and the Dissociation Energy of S_2, 408
Collagen : Hydroxyproline and the Shrinkage Temperature of (B. J Rigby and Dr. J. D. Spikes), 150
Collagenase : Use of, in the Characterization of Pseudocoelomic Membranes of *Ascaris lumbricoides* (Barbara Dawson), 798
Colleges (Training) Recruits to Teaching—a Study of the Attainments, Qualifications and Attitudes of Students entering (F. W. Land), 750

Colles des Glutinants et Matières d'Apprêts : Traité Général de la Fabrication des (Dr. Maurice de Keghel), nouvelle édition, *review* by Prof. A. G. Ward, 890
Collier, Dr. H. O. J., and others : Synthesis and Biological Properties of L-Arginyl-L-Prolyl-L-Prolyl-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenylalanyl-L-Arginine, an Octapeptide related to Bradykinin, 773
Collins, Rear-Admiral K. St.B. : Retirement as hydrographer to the Navy, 285 ; work of, 285
Collinson, Dr. E., and others : Effects of Linear Energy Transfer on the Radiolyses of Water and Heavy Water, 475
Collis, L. R. (Rowntree, Prof. R. J., and) : Effect of the Peritoneal Fluid of the Guinea Pig on Strains of Enteric Bacilli, 1045
Collisions (Sir Harrie Massey), 853
Colloid and Polymer Science (Seminar at University College, London, on), 378
Colonial Development Corporation : Annual Report for 1959, 854, 971
Colonial Office : Fishery Publications No. 13, Plankton of the Estuary and Offshore Waters of the Sierra Leone River (V. Bainbridge), 557
Colonial Office (Commonwealth Relations Office) : Commonwealth Educational Co-operation, 441
Colonial Sugar Refining Co. : The David North Plant Research Centre (K. T. Glasziou), 745
Colonial Territories, 1959-1960 : The, 906
Colonial Territories : British, 906
Colorimetric Analysis, *review* by A. M. G. Macdonald, 3
Colorimetric Chemical Analytical Methods : A Handbook of (Tintometer, Ltd.), fifth edition, *review* by A. M. G. Macdonald, 3
Colorimetric Determination of Traces of Metals (Prof. E. B. Sandell), third edition, *review* by A. M. G. Macdonald, 3
Colour : Birds in (illustrated by Karl Aage Tinggaard, with descriptions by Bruce Campbell), *review* by B. J. G. Marland, 273
Colour Changes of Ageing Bloodstains : Use of Reflectance Measurements in assessing the (Dr. D. Patterson), 688
Colter, Dr. J. S., and others : Reversible Dissociation of Ribonucleic Acid, 509
Columbia University, New York : Barnard Medal for 1960 awarded to Prof. I. L. Rabi, 24
Colwyn Medal of the Institution of the Rubber Industry awarded to Dr. Erich Konrad, 464
Combating the Decay of Timber, *review* by Prof. F. W. Jane, 977
Combined Oil-immersion, Phase-contrast and Dark-ground Viewing of 'Thorotrast' in Tissue Sections (Dr. E. W. Baxter), 162
Combustion and Propulsion (AGARD fourth Colloquium on—High Mach Number Air-breathing Engines), 18
Commerce (British Chambers of), Association of (British Association for the Advancement of Science and the) : Decimal Coinage and the Metric System—Should Britain Change? (A Joint Report of Committees appointed by the), 30
Commons, House of : Second Reading of the International Development Association Bill, 266
  Adjournment Debate on the Overseas Civil Service, 371
  Second reading of the Commonwealth Teachers Bill, 441
  Debates on Science and Education, 906
Commonwealth : Educational Co-operation in the, 113, 441
Commonwealth (British) : Plant Pathology in the (Dr. G. C. Ainsworth), 834
Commonwealth Bureau of Horticulture and Plantation Crops : Technical Communication No. 25, Abstract Bibliography of Fruit Breeding and Genetics to 1955—*Rubus* and *Ribes*, a Survey (Dr. R. L. Knight and Elizabeth Keep), *review* by Dr. G. Haskell, 184
Commonwealth Bursaries Scheme (Royal Society and Nuffield Foundation) : Awards, 291
Commonwealth Educational Co-operation, 113 ; (Commonwealth Relations Office, Colonial Office), 441
Commonwealth Mycological Conference : Sixth (Commonwealth Mycological Institute), 834
Commonwealth Mycological Institute : Sixth Commonwealth Mycological Conference, 834
Commonwealth Relations Office (Colonial Office) : Commonwealth Educational Co-operation, 441
Commonwealth Scholarship Commission (United Kingdom) : Scholarship Awards, 464
Commonwealth Scientific and Industrial Research Organization (Australian) : Establishment of a new Sugar Research Laboratory, 372
  Appointment of Dr. H. H. Hatt as leader of research in the Sugar Research Laboratory, 372
  List of Publications to December 31, 1959, 466
  Appointment of Dr. S. D. Hamann as chief of the Division of Physical Chemistry, 901
  Retirement of S. A. Clarke as chief of the Division of Forest Products, 901
  Grant of £6,000 from the Broken Hill Proprietary Company, to support tinplate research, 904
Commonwealth Teachers Bill (Second Reading in the House of Commons), 441
Communications (Inter-Library) : 'Telex' and, 558
Communications and Electronics Dictionaries, *review* by Dr. R. L. Smith-Rose, 1059
Comparative Education : Essays in, *review* by Brian Holmes, 635
Comparison of Atomic Beam Frequency Standards (R. E. Beehler, R. C. Mockler and C. S. Snider), 681
Comparison between Caesium-controlled Oscillators : The 'GBR Experiment'—a Trans-Atlantic Frequency (J. A. Pierce, G. M. R. Winkler and R. L. Corke), 914
Comparison of the Chemical Composition and Magnetic Properties of Tektites and Glasses formed by Fusion of Terrestrial Rocks (Dr. Irving Friedman, Dr. Arthur Thorpe and Dr. Frank E. Senftle), 1089
Comparison between the Effects of Cysteine and of Anoxia on the Rate of Mitosis in Lens Epithelium (Dr. Antoinette Pirie and Dr. Ruth van Heyningen), 947
Comparison of Fission Product and Beryllium-7 Concentrations in the Atmosphere (W. Anderson, R. E. Bentley, R. P. Parker, J. O. Crookall and L. K. Burton), 550
Comparison of Iodine-124 and Iodine-131 in Inhibition of Goitrogenesis in the Rat (Dr. L. Doniach and Dr. P. E. Francois), 704
Comparison of Sampling Methods : Earthworm Population Studies—a (F. Raw), 257
Compensatory Hypertrophy : Radiosensitivity of Mouse Kidney undergoing (Lieut. V. J. Rosen, Jun., and Dr. L. J. Cole), 612
Complex (An Antibiotic), derived from a *Streptomyces* and Active against Gram-positive Bacteria (B. Sgarzi, A. M. Lugli and G. Giolitti), 1029
Complex (A Molecular), of Benzene and Hexafluorobenzene (Dr. C. R. Patrick and G. S. Prosser), 1021
Component (Deoxyribonucleic Acid), of Crystalline Cytochrome b_2 : Chemical and Physical Properties of the Small (Dr. M. D. Montague and Prof. R. K. Morton), 916
Component (Melanocyte-stimulating), in the Dorsal Skin Secretion of *Xenopus laevis* : Serotonin, a (Dr. F. C. G. van de Veerdonk), 948
Components (Precipitating), in Sera from Pregnant Women : Immunoelectrophoretic Demonstration of (Dr. Jan Hirschfeld and Dr. Ulf Soderberg), 332
Composition (Average), of Granites, the Genesis of Tektites, and Petrogenesis (Prof. E. H. Timothy Whitten), 867
Composition (Chemical), and Magnetic Properties of Tektites and Glasses formed by Fusion of Terrestrial Rocks : Comparison of the (Dr. Irving Friedman, Dr. Arthur Thorpe and Dr. Frank E. Senftle), 1089
Composition (Fatty Acid), of the Lipids of Pasture Grasses (Dr. G. A. Garton), 511
Composition (Isotopic), and Temperature of Formation of Antarctic Snows (Prof. E. Picciotto, X. de Maere and Dr. I. Friedman), 857
Compositions (Soluble Matrix Antifouling) : Mode of Action of (A. Partington), 1105
Compound (δ-Lactone) : Isolation of a, from the Leaves of *Clitoria marina* Linn. (Dr. A. Sinha), 149
Compounds : Utilization of Nitrogen and its, by Plants—Symposia of the Society for Experimental Biology, No. 13 (edited by H. K. Porter), *review* by Prof. Walter Stiles, 815
Compounds of Group IVA : The Elements and (Harold P. Klug and Prof. Robert C. Brasted), (Comprehensive Inorganic Chemistry, edited by Prof. M. Cannon Sneed and Prof. Robert C. Brasted, Vol. 7), *review* by Dr. K. W. Bagnall, 185
Compounds related to Diethylstilboestrol : Effect of Three, on the Phagocytic Activity of the Reticulo-Endothelial System (Prof. T. Nicol, G. Brownlee, C. Druce and C. C. Ware), 1032
Compounds (Aromatic Hydroxy) : Effect of some, on the Phagocytic Activity of the Reticulo-Endothelial System (Prof. T. Nicol, C. Druce and C. C. Ware), 422
Compounds (Carbon-Fluorine), in some Species of *Dichapetalum* : Fluorine Compounds in Nature—the Distribution of (Sir Rudolph Peters and R. J. Hall), 573
Compounds (Fluorine), in Nature—the Distribution of Carbon-Fluorine Compounds in some Species of *Dichapetalum* (Sir Rudolph Peters and R. J. Hall), 573
Compounds (New), for the Control of Water Evaporation (A. V. Deo, N. R. Sanjana, S. B. Kulkarni, M. K. Gharpurey and A. B. Biswas), 870
Compounds (Simple), of Uranium, Thorium, Plutonium, Neptunium : Crystal Chemistry of (E. S. Makarov), translated from the Russian by E. B. Uvarov, *review* by Dr. L. E. J. Roberts, 728
Compounds (Strontium-90), in Soil : Relative Availability of some (Dr. R. L. Uhler and Dr. P. P. Hungate), 252
Compounds (Surface-active) : Action of some, on the Gastro-Intestinal Mucosa (Dr. J. A. Nissim), 305
Compounds (Titanium Metals and) : Analytical Chemistry of (Maurice Codell), *review* by Prof. A. G. Quarrell, 725
Comprehensive Inorganic Chemistry (edited by Prof. M. Cannon Sneed and Prof. Robert C. Brasted), Vol. 7, The Elements and Compounds of Group IVA (Harold P. Klug and Prof. Robert C. Brasted), *review* by Dr. K. W. Bagnall, 185
Computer : A New British Analogue, the *Radic* (The Rediffon Company), 288
  Leo III, a New All-Transistor Digital (Leo Computers, Ltd.), 373
Computer (BESM) : Programming Programme for the (A. P. Ershov), translated from the Russian by M. Nadler, edited by J. P. Cleave, *review* by R. J. Ord Smith, 92
Computer Society (British) : Second Annual Conference (Dr. L. Fox), 655
Computer Techniques : Application of, to Nuclear Physics Instruments (G. G. Scarrott), 854
Computers (Electronic) : Research in the Use of (Unesco Fellowships for), 465
Conant, Dr. James Bryant : The Child, the Parent and the State, *review* by Brian Holmes, 635
Concentrated Urea–Lithium Bromide Solutions : Viscosity of (Dr. Irving I. Geschwind), 324
Concentration (Acetylcholine), in the Brain of the Rat : Strain Differences in (Edward L. Bennett, James Crossland, David Krech and Mark R. Rosenzweig), 787
Concentration (Serum Albumin), in Analbuminaemia and its Immunological Significance (Dr. J. H. Humphrey), 304
Concentrations of Solutions : Expression of (E. H. Leach), 350
Concentrations (Fission Product and Beryllium-7), in the Atmosphere : Comparison of (W. Anderson, R. E. Bentley, R. P. Parker, J. O. Crookall and L. K. Burton), 550
Concept of the Electric and Magnetic Field : Michael Faraday and the Evolution of the (Prof. L. Pearce Williams), 730
Concept (The Dangerous), of the Natural Forest (T. R. Peace), 848
Conditioning *Ostrea edulis* L. from the Limfjord for Reproduction out of Season (I. A. Aboul-Ela), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 25), *review* by Dr. A. J. Southward, 360
Conditions of Economic Progress (Colin Clark), 537
Conductance (Decreased Membrane) : Excitation at the Crayfish Neuromuscular Junction with (Dr. Josef Dudel and Prof. Stephen W. Kuffler), 246
Conduction : Velocity of, and Spinal Transmission of Proprioceptive Hind-Limb Reflexes (Hind-Limb Reflexes in the Kitten), (Dr. Sten Skoglund), 132
Conduction (Thermal), in Mica along the Planes of Cleavage (H. J. Goldsmid and A. E. Bowley), 864
Conductivity of Pure Water : Changes in, caused by X-Irradiation (K. Schmidt), 931

Conduits (Closed): Flow Measurement in (National Engineering Laboratory Symposium on), 905
Configuration (Intracellular), and Dedifferentiation in *Splachnum ampullaceum* (L.) Hedw. (Prof. Kraft E. von Maltzahn and Mary M. MacNutt), 344
Confinement Geometry: A New Plasma (James L. Tuck), 863
Conflict between Evolutionary Theory and Christian Belief (Dr. David Lack), 98
Confluent Hypergeometric Functions (Dr. L. J. Slater), *review* by Prof. W. N. Bailey, 93
Conjugated Fatty Acids. Gas Liquid Chromatography of (Dr. N. W. R. Daniels and J. Wendy Richmond), 55
Connan, R. M.: Awarded a R.A.S.E. Research Training Scholarship by the Animal Health Trust, 904
Connective Tissue, Thrombosis and Atherosclerosis—Proceedings of a Conference held at Princeton, N.J., 1958 (edited by Irvine H. Page), *review* by Dr. G. S. Boyd, 634
Connors, J. F., and Oberry, L. J.: Combustion and Propulsion—High Mach Number Air-breathing Engines (Basic Studies on Air Intakes), 20
Conquest of Disease: Achievement—some Contributions of Animal Experiment to the (Dr. Geoffrey Lapage), *review* by Dr. W. Lane-Petter, 977
Conran, G. L.: At the sixty-sixth Annual Conference of the Museums Association (Purchase of Art Objects for Museums), 657
Consden, Dr. R.: Advances in Clinical Chemistry, *review*, 890
Consecutive Internal Irradiation: Localization by Autoradiography at −195°C. of Radioactive Areas in Rats exposed to a High Flux of Thermal Neutrons—Importance of Phosphorus-32 in (Jean Chanteur and Pierre Pellerin), 472
Conservation of America's Wild-Life: Chemical Control of Agricultural Pests and (United States National Academy of Sciences—National Research Council Committee on), 114
Conservation in East Anglia: Nature and (Council for Nature), 649
Constants and Numerical Data: Tables of, Vol. 11, Selected Constants—Optical Rotatory Power, 4, Alkaloids (Prof. J.-P. Mathieu and Prof. M.-M. Janot), *review* by Dr. J. Walker, 7
Constitution (Chemical), of the Red Blood Cell Membrane (Dr. T. Fehér and Dr. Béla Matkovics), 701
Construction of High Pressure Chemical Plant: The Design and (Harold Tongue), second edition, *review* by Dr. K. E. Bett, 541
Consumption (Oxygen), and Carbon Dioxide Output: Effect of Electronarcosis on (Dr. Jaroslav Strmiska and Dr. Antonin Vacek), 151
Consumption Changes (Oxygen), in Rats during Irradiation: Role of Initial Value of Metabolic Processes in (Dr. Antonin Vacek), 76
Contamination (Surface), formed in Demountable Vacuum Systems: Direct Observation of (D. E. Bradley), 227
Continental Slope: Occurrence of *Pyrosoma* on the (P. J. Whitehead), 878
Continuity in a Small Pacific Island, *review* by Sir Harry Luke, 816
Continuous Variation: Genetics of, *review* by Prof. Kenneth Mather, 813
Contour (Single): Perceptual Anomalies associated with a (J. P. Wilson), 137
Contractility in the Heart Muscle of the Rat and some other Mammals: Potentiation of (Dr. V. Kruta and Dr. P. Braveny), 327
Contraction in Striated Muscle: A Hypothesis of (Dr. M. Spencer and Dr. C. R. Worthington), 388
Contreras, José Garcia: Awarded a Spanish fellowship by the Ramsay Memorial Fellowship Trustees, 832
Control: Noise in Factories and its (S. Weintroub), 1085
Control of Flight: Stability and, *review*, 444
Control of *Glossina palpalis* (R-D) in Nigeria: Use of Dieldrin in the (J. B. Davies), 84
Control of Growth and Form—a Study of the Epidermal Cell in an Insect (Prof. V. B. Wigglesworth), *review* by Prof. R. Dennell, 631
Control of Pre-Natal Growth in Mammals (Dr. Anne McLaren and Dr. Donald Michie), 363
Control of Rats in Sewers (Dr. W. E. Bentley), 288
Control of Reaction Rate in Dust Flames (J. M. Beér and Dr. R. H. Essenhigh), 1106
Control of Scientific Research in the United States, *review* by R. Brightman, 181
Control of Water Evaporation: New Compounds for the (A. V. Deo, N. R. Sanjana, S. B. Kulkarni, M. K. Gharpurey and A. B. Biswas), 870
Control (Chemical), of Agricultural Pests and Conservation of America's Wild-Life (United States National Academy of Sciences—National Research Council Committee on), 114
Control (Game): Translocation of Wild Animals as a Means of (Dr. A. M. Harthoorn, J. A. Lock and J. MacKeand), 518
Control (Radio Frequency), in Space Telecommunications (Edward Wenk, Jun.), 373
Control (Successful Biological), of Insect Pests: Significance of the Type of Host Plant Crop in (D. C. Lloyd), 430
Convergence—and Divergence: The Antarctic (Dr. K. Wyrtki), 581
Conversion of Antimetabolites into Metabolites: Adaptive Chain in the (Dr. K. I. Markov, Dr. G. K. Saev and Dr. E. V. Golovinsky), 1041
Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives—Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy (C. F. Blakely, Dr. R. J. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662; Kinetics and Mechanism (C. F. Blakely and Dr. A. Wassermann), 662
Conway, Prof. E. J.: Critical Energy Barriers in the Excretion of Sodium, 394
Cook, B. P., and others: Dependence on Temperature of the Interlayer Spacing in Carbons of Different Graphitic Perfection, 1015
Cook, Prof. C. Sharp, and others: Fractionation of Nuclear Weapon Debris, 1100
Cook, Dr. J. W.: Molecular Geometry, *review*, 812
Cook, L. M., and Kettlewell, Dr. H. B. D.: Radioactive Labelling of Lepidopterous Larvae—a Method of Estimating Late Larval and Pupal Mortality in the Wild, 301
Cook, Prof. Melvin A.: The Science of High Explosives, *review* by Dr. W. L. Murray, 539
Cook, R.: At the second Annual Conference of the British Computer Society (Language and General-purpose Programmes for Market Research), 655
Cooke, Dr. G. W.: The Measurement of Grassland Productivity, *review* 544
Cooledge, J. W., and others: Streaming in Cytoplasm dissociated from the Giant Amoeba, *Chaos chaos*, 896
Cooling: Parallelism of Changes produced by, and by Drugs known to affect Adrenergic Mechanisms (Prof. Eleanor Zaimis), 213
Coombs (The Anti-Globulin) Test in Laboratory Practice (Dr. I. Dunsford and Jean Grant), *review* by Dr. R. Drummond, 357
Co-operation: Commonwealth Educational (Commonwealth Relations Office, Colonial Office), 441
Co-operation (Educational), in the Commonwealth, 113, 441
Co-operation and Scientific and Industrial Research, 89
Co-ordinated (Five) Titanium in $K_2Ti_2O_5$ (Dr. Sten Andersson and Dr. A. D. Wadsley), 499
Co-ordination (The International), of Time Signals and Standard Frequency Transmissions (Dr. L. Essen), 452
Copeman, C. B.: Awarded the Hancock Medal for 1960 of the Institution of the Rubber Industry, 464
Copper and Cobalt in Nitrogen Fixation (Prof. E. G. Hallsworth, S. B. Wilson and E. A. N. Greenwood), 79
Copson, Prof. E. T.: Boundary Problems in Differential Equations, *review*, 451
Coral Structures and Classification, *review* by Dr. H. Dighton Thomas, 95
Corbet, Dr. Philip S.: Recognition of Nulliparous Mosquitoes without Dissection, 525
  Breeding Sites of Non-Cichlid Fishes in Lake Victoria, 616
Corbet, Dr. Philip S., and others: Dragonflies, *review* by Dr. D. E. Kimmins, 631
Cores (Sediment), from the Eastern Atlantic Ocean: Magnetization of (M.-J. Keen), 220
Cori's Ester and Phosphorylated Glucides: First International Symposium on, 117, 290
Corke, R. L., and others: The 'GBR Experiment'—a Trans-Atlantic Frequency Comparison between Caesium-controlled Oscillators, 914
Corlett, E. N.: Appointed senior research fellow in the Department of Engineering Production in the University of Birmingham, 117
Cornea Proteins: Infra-red Examination of the Association of, with Water (Dr. S. Bakerman and C. Mitchell), 1033
Cornelius, Elsie M. (Greig, H. B. W., and): Isolation of Material with Proactivator Activity from Human Serum, 1125
Cornfield, A. H.: Ammonia released on Treating Soils with *N* Sodium Hydroxide as a Possible Means of Predicting the Nitrogen-supplying Power of Soils, 260
Cornforth, Dr. J. W.: The Chemistry of Natural Products (The Biosynthesis of Polyisoprenoids), 1080
Corpus Allatum in 'Dauer-pupa' of the Silkworm, *Bombyx mori*: Function of the (Dr. Masatoshi Kobayashi), 346
Corpusculaire (Photographie): Premier Colloque International de (Strasbourg, 1957), *review* by D. L. Allan, 636
Correlation of the Alternating Stresses required to Initiate and Propagate a Fatigue Crack in Mild Steel (N. E. Frost), 233
Correspondence of Isaac Newton (edited by Prof. H. W. Turnbull), Vol. I, 1661-1675, *review* by Prof. L. Rosenfeld, 537
Corrosion: Metallic, *review* by Dr. J. M. West, 182
  The Protection of Gas Plant and Equipment from (Institution of Gas Engineers and the Corrosion Group of the Birmingham and Midlands Section of the Society of Chemical Industry Symposium on), 466
Corrosion, European Federation of: Election of the British Association of Corrosion Engineers as a member, 25
Corrosion and Oxidation of Metals (Dr. Ulick R. Evans), *review* by Dr. J. M. West, 182
Corrosion Engineers, British Association of: Elected member of the European Federation of Corrosion, 25
Corson, J. M., and others: Homotransplant Antigens—Preparation of Active Cellular Fractions, 774
Cortex (Adrenal): Specific Inhibitors of the (Prof. J. H. U. Brown), 985
Corticosteroids in the Chick Embryo: Assay of (Sir Macfarlane Burnet and N. L. Warner), 938
Cortisone: Effect of, on Degenerating Nerve Fibres in Birds (Dr. P. Glees), 327
Cory, V.: Appointed county advisory officer for Yorkshire (West Riding) in the National Agricultural Advisory Service, 1079
Cosmic Radiation: Local Increase of Intensity of (J.-P. Legrand and A. Helary), 397
Cosmic Radiation, Latin American Council of: Meeting in Rio de Janeiro, 648
Cosmic Radiation Studies in South America, 648
Cosmic Rays: Dependence on Latitude of the Amplitude of the Diurnal Variation of (Arne Eld Sandstrom, Eric Dyring and Stig Lindgren), 1099
Cosmology: Interpretation of (Dr. W. Davidson), 583; (Prof. W. H. McCrea), 583
  A Philosophy of, *review* by Dr. C. W. Kilmister, 634
Cosmology (Unified): Towards a (Prof. Reginald O. Kapp), *review* by Dr. C. W. Kilmister, 634
Cossor Communications, Ltd.: N. Elson has joined as technical director, 832
Cost of Scientific Periodical Publications (Capt. L. R. Maxwell), 1052
Cotton, F. Albert (edited by): Progress in Inorganic Chemistry, Vol. I, *review* by Dr. L. R. Beattie, 4
Cottrell, Prof. A. H.: The Strength of Solids, 659
Cottrell, C. B.: Elected to a Junior Research Fellowship (Gulbenkian Fellowship) of Churchill College, Cambridge, 742
Coulson, Prof. C. A.: Chemical Physics Comes of Age, *review*, 812
Coulson, Prof. J. M.: Chemical Engineering Practice, *review*, 887
Council for Nature: Nature and Conservation in East Anglia, 649
Council for the Preservation of Rural England: Twenty-first National Conference for the Preservation of the Countryside, 559
Council (Universities), for Adult Education: Report on the Year 1958-1959, 906
Countries (European), in Process of Development: Shortages of Scientific Personnel in, 565
Countries (Under-developed): Support for, 971
Countries (The Under-developed), of the World, 266
Countryside: Preservation of the (Council for the Preservation of Rural England twenty-first National Conference for the), 559

Coupland, Dr. R. E., and Riley, Dr. J. F.: Mast Cells and 5-Hydroxytryptamine in Precancerous Mouse Skin, 1128
Couple (Resisting): Effect of a, on the Rotational Motion of a Rigid Body (T. Nonweiler), 311
Cours Internationaux de Lyophilisation, Association des: Second International Course on Lyophilization, 29
Course on the Non-destructive Testing of Materials (British Council), 1079
Course for Trade Union Officials on the Industrial Uses of Radioisotopes (United Kingdom Atomic Energy Authority), 905
Course (Advanced), on Direction and Supervision of Scientific and Engineering Personnel (Northampton College of Advanced Technology, London), 905
Course (International Summer), on Solid State Physics (Società Italiana di Fisica), 201
Course (Postgraduate), on Recent Advances in Steroid Chemistry (Kingston Technical College), 905
Courses (Part-Time), in Further Education (J. Heywood), 189
Covalent Super-Exchange in Solid State Physics (Prof. W. S. Fyfe and Prof. J. Verhoogen), 1108
Covalent (Ionic-) Bonding in Crystals (C. H. L. Goodman), 590
Covill, R. Wade, and others: Oceanography of Long Island Sound, 123
Cowan, Dr. S. T.: Microbial Systematics, 191
Cowper, T. R.: Occurrence of *Pyrosoma* on the Continental Slope, 878
Cox, Ian: At the sixty-sixth Annual Conference of the Museums Association (Relations of Museums and Industry), 657
Cox, Peter R.: Demography, third edition, *review* by Prof. E. Grebenik, 97
Cox, Dr. Trenchard: At the sixty-sixth Annual Conference of the Museums Association (Purchase of Art Objects for Museums), 657
Crab (Horseshoe): Summative Action of Acetylcholine with Physiological Stimulus on the Generator Potential in the Lateral Eye of the (R. Kikuchi, K. Naito and S. Minagawa), 1118
Crab (A North American Xanthoid), New to Britain (E. Naylor), 256
Crab (Shore), *Carcinus maenas* (L.): Albinism in an American Population of the (Anthony J. Provenzano, jun.), 521
Crabb, W. W. (Smith, H. Williams, and): Bacterial Population of the Nose and Skin, 288
Crack (Fatigue), in Mild Steel: Correlation of the Alternating Stresses required to Initiate and Propagate a (N. E. Frost), 233
Craig, Dennis (Dart, Prof. Raymond A., with): Adventures with the Missing Link, *review* by Sonia Cole, 888
Crathorn, Dr. A. R., and Shooter, Dr. K. V.: Uptake of Thymidine and Synthesis of Deoxyribonucleic Acid in Mouse Ascites Cells, 614
Crayfish Neuromuscular Junction: Excitation at the, with Decreased Membrane Conductance (Dr. Josef Dudel and Prof. Stephen W. Kuffler), 246
A Second Mechanism of Inhibition at the (Dr. Josef Dudel and Prof. Stephen W. Kuffler), 247
Cresser, Dr. E. H.: Appointed lecturer in microbiology at the University of Birmingham, 117
Creatine Analogue: Production of Muscular Weakness in Rats by a (Coy D. Fitch and Prof. James S. Dinning), 421
Creep of Metals under Simple Shear: A Simple Method of Investigating the (Prof. E. N. da C. Andrade), 494
Creese, Dr. Richard: Appointed to the readership in physiology at St. Mary's Hospital Medical School, London, 743
Cremer, Herbert W., and Watkins, Sidney B. (edited by): Chemical Engineering Practice, Vol. 11, Works Design, etc., *review* by Prof. J. M. Coulson, 887
Crimping (Abnormal), in Merino and Polwarth Wools (R. E. Chapman, B. F. Short and P. G. Hyland), 960
Crisis (The Spiritual), of the Scientific Age (G. D. Yarnold), *review* by R. Brightman, 818
Critical Energy Barriers in the Excretion of Sodium (Prof. E. J. Conway), 394
Crocker, R. L., and others (edited by): Biogeography and Ecology in Australia, *review* by Prof. A. J. Marshall, 543
Crofton, Prof. J. W.: Tuberculosis in Animals (Tuberculosis in Man), 997
Crookall, J. O., and others: Radiostrontium and Radiocaesium in Milk during 1959, 108
Comparison of Fission Product and Beryllium-7 Concentrations in the Atmosphere, 550
Crop (Host Plant), in Successful Biological Control of Insect Pests: Significance of the Type of (D. C. Lloyd), 430
Crops (Glasshouse) Research Institute: Open Day (F. W. Toovey), 204
Appointment of Sir William Slater as chairman of the governing body, 1079
Crops (Plantation), Commonwealth Bureau of Horticulture and: Technical Communication No. 25, Abstract Bibliography of Fruit Breeding and Genetics to 1955—*Rubus* and *Ribes*, a Survey (Dr. R. L. Knight and Elizabeth Keep), *review* by Dr. G. Haskell, 184
Cross-linking of Rubber: Analysis of Solubility Data to estimate Small Amounts of Chain Fracture during the (L. Mullins and D. T. Turner), 145
Cross-linking and Degradation of Deoxyribonucleic Acid by Ionizing Radiations: Role of Oxygen in the (Peter Alexander and J. T. Lett), 933
Crosskey, R. W., and others: Attachment of Immature Simuliidae to other Arthropods, 618
Crossland, James, and others: Strain Differences in Acetylcholine Concentration in the Brain of the Rat, 787
Crowley, Dr. N. (Baum, Dr. H., and): Starch-like Polysaccharide of *Streptococcus pyogenes*, 413
Crowther, J. G.: Francis Bacon, the First Statesman of Science, *review* by Prof. B. Farrington, 817
Cruickshank, A. J. B.: Appointed lecturer in physical chemistry at the University of Bristol, 465
Cruickshank, I. A. M., and Perrin, Dawn R.: Isolation of a Phytoalexin from *Pisum sativum* L., 799
Cruickshank, I. A. M., and others: Differentiation in *Peronospora tabacina* Adam., 710
Crustacea: Chordotonal Organs in (Dr. Mary Whitear), 522
Cryomagnetics Laboratory (Mullard), at Oxford, 25
Crystal (Aluminium Single): Borrmann Effect observed in an (Koichi Nakajima and Prof. Shigeyasu Koda), 53
Crystal Chemistry of Simple Compounds of Uranium, Thorium, Plutonium, Neptunium (E. S. Makarov), translated from the Russian by E. B. Uvarov, *review* by Dr. L. E. J. Roberts, 728
Crystal Growth in Paraffin (R. J. Jaccodine), 498
Crystal Physics at Cambridge, 25
Crystal Structure of 9:10-Dimethyl-1:2-benzanthracene (Dr. D. Sayre and Dr. P. H. Friedlander), 139
Crystal Structure Determination: Modern Methods of (Manchester College of Science and Technology Summer School in), 201
Crystal Structure Investigation: Vector Space and its Application in (Prof. Martin J. Buerger), *review* by Dr. J. W. Jeffery, 975
Crystal Structure Models: Bibliography on Molecular and (Deane K. Smith), (United States National Bureau of Standards, Monograph No. 14), 903
Crystal Structures of the High-Pressure Forms of Ice—Ice III (Prof. W. Barclay Kamb and Sankar K. Datta), 140
Crystalline Cytochrome b_2: Chemical and Physical Properties of the Small Deoxyribonucleic Acid Component of (Dr. M. D. Montague and Prof. R. K. Morton), 916
Crystalline (Non-) Structure in Solidified Gold–Silicon Alloys (W. Klement jun., R. H. Willens and Prof. Pol Duwez), 869
Crystallization (Principles of Sugar Technology, edited by Pieter Honig, Vol. 2), *review* by H. C. S. de Whalley, 979
Crystallization: Dendritic (D. D. Saratovkin), translated from the Russian by Dr. J. E. S. Bradley, second edition, *review* by A. F. Wells, 93
A New Technique for Following Rapid Rates of (J. H. Magill), 770
Crystallization of a Photosynthetic Reductase from a Green Plant (Dr. R. Hill and Fay Bendall), 417
Crystals: Dendritic Growth of, *review* by A. F. Wells, 93
Ionic-Covalent Bonding in (C. H. L. Goodman), 590
Crystals (Vermiculite), in Water: Macroscopic Swelling of (G. F. Walker), 312
Csaba, Dr. G., and Kapa, Dr. Eszter: Uptake of Heparin by Cells, 711
Cucumber Mosaic Virus Infection Process: Direct Infra-Red Spectral Analysis of the (Prof. G. W. Cochran, G. W. Welkie and J. L. Chidester), 1049
Cudkowicz, G., and others: Antileukaemic Activity of Glycyrrhetinic Acid, 607
Culture in Southern Rhodesia: Environment and (Roger Summers), 993
Culture des Tissus Végétaux (Prof. R. J. Gautheret), *review* by A. Allsopp, 976
Culture, Society and Health (Division of Anthropology of the New York Academy of Sciences and the Research Institute for the Study of Man Conference on), 658
Culture (Cell) Genetics of Man: Cytology and (Symposium published by the *American Journal of Human Genetics*), 116
Culture (Clone): Morphogenetics of *Micrasterias americana* in (Prof. Paavo Kallio), 164
Culture (Insect Tissue): Growth by Cell Division in (Dr. B. M. Jones and I. Cunningham), 1072
Culture (Submerged): Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in (F. Arcamone, C. Bonino, Prof. E. B. Chain, A. Ferretti, P. Pennella, A. Tonolo and Lidia Vero), 238
Cultures: Plant Tissue, *review* by A. Allsopp, 976
Cummins, Dr. C. S.: Microbial Systematics, 191
Cunningham, I. (Jones, Dr. B. M., and): Growth by Cell Division in Insect Tissue Culture, 1072
Cup: The Enkomi Silver (Dr. G. F. Claringbull and A. A. Moss), 1051; (Dr. Harold J. Plenderleith), 1052
Cupric β-Diketone Chelates with Heterocyclic Bases: Structure of the 1:1-Adducts of (Dr. D. P. Graddon and E. C. Watton), 1021
Curran, Dr. S. C.: Nuclear Research in the U.S.S.R., *review*, 630
Currents (Ocean), in McMurdo Sound (A. E. Gilmour, W. J. P. Macdonald and F. G. Van der Hoeven), 867
Curves (Amplitude), for Seismic Body Waves: Oscillatory Character of (Dr. J. Vanek and J. Stelzner), 491
Curves (Light), of Meteors (Dr. R. Ananthakrishnan), 675
Cushing, D. H., and others: Echo Sounding Experiments in the Barents Sea, 855
Cuthbertson, Dr. D. P.: Elected an honorary member of the American Institute of Nutrition, 374
Cuticle (Provisional Embryonic), of a Lepidopteran: Occurrence and Function of the (Dr. R. K. Sharan), 1040
Cutteridge, Dr. O. P. D.: Appointed a senior lecturer in engineering at the University of Leicester, 743
Cwm Glas, Crafnant, Nature Reserve (Nature Conservancy), 464
Cybernetics and Management (Stafford Beer), *review* by J. A. Easterbrook, 269
Cyclic Ethers: A New Method for the Synthesis of (L. F. Schmoyer and L. C. Case), 592
Cyclical Changes in the Distribution of the Testis Lipids in the Common Frog, *Rana temporaria* (Dr. B. Lofts and C. Boswell), 708
Cyclones (Southern Atmospheric), and the Whale Feeding Grounds in the Antarctic (Dr. C. W. Beklemishev), 530
Cyclopentadiene: Conversion of, into New Bicyclopentyl Derivatives—Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy (C. F. Blakely, Dr. R. J. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662; Kinetics and Mechanism (C. F. Blakely and Dr. A. Wassermann), 662
Cyclotron (Stockholm): Modernization of the, 381
Cyprus: The Evolution of the Rural Land Use Pattern in (Dr. Demetrious Christodoulou), *review* by Prof. M. J. Wise, 628
Cyprus Problem: Land Use and the, *review* by Prof. M. J. Wise, 628
Cysteine: Protective Effect of, against Retinal Degeneration induced by Iodate and Iodoacetate (Prof. Arnold Sorsby and Ronald Harding), 608
Cysteine and of Anoxia: Comparison between the Effects of, on the Rate of Mitosis in Lens Epithelium (Dr. Antoinette Pirie and Dr. Ruth van Heyningen), 947
Cystine. Formation of D-Penicillamine-Cysteine Mixed Disulphide by Reaction of D-Benzylpenicilloic Acid with (Dr. Bernard B. Levine), 940
Cytochemical Demonstration of Dehydrogenases in Blood and Bone Marrow Cells: Acetone Fixation for the (Dennis Quaglino and Dr. F. G. J. Hayhoe), 85

Cytochemical Demonstration (Selective), of Arginine Groups in Nucleoprotein in the Cell Nucleus (Dr. E. A. Barnard and Dr. L. G. E. Bell), 508
Cytochemical Evidence of the Origin of Lipid Bodies (so-called Golgi Bodies) from Mitochondria (H. C. Chopra), 713
Cytochemistry : Histochemistry and (Société Française d'Histochimie first International Congress on), 29
Cytochrome b_2 (Crystalline) : Chemical and Physical Properties of the Small Deoxyribonucleic Acid Component of (Dr. M. D. Montague and Prof. R. K. Morton), 916
Cytology : International, *review* by the late Prof. J. Bronte Gatenby, 632
  International Review of (edited by Prof. G. H. Bourne and Prof. J. F. Danielli), Vol. 8, *review* by the late Prof. J. Bronte Gatenby, 632
Cytology and Cell Culture Genetics of Man (Symposium published by the *American Journal of Human Genetics*), 116
Cytoplasm : The Relationship between Nucleus and—Proceedings of the Symposium held at the Université Libre de Bruxelles, 1958 (edited by Dr. R. J. C. Harris), *review* by Dr. E. N. Willmer, 450
Cytoplasm dissociated from the Giant Amoeba, *Chaos chaos* : Streaming in (Prof. R. D. Allen, J. W. Cooledge and P. J. Hall), 896
Cytoplasmic Division in *Amoeba proteus* : Suppression of (Dr. Edmund Guttes and Sophie Guttes), 520
Cytoplasmic Particles and their Role in Protein Synthesis (Colloid and Biophysics Committee of the Faraday Society Informal Discussion on), 643
Cytotoxic Change (Local), in Man from Griseofulvin : Absence of (Prof. Leon Goldman, Amanda Beyer and Jan Schwarz), 335
Czechoslovak Academy of Science : International Conference on Semiconductor Physics, 29
Czechoslovak Republic : Climatic Atlas of the, *review* by G. A. Bull, 543
Czerski, P., and others : Identification of Transplanted Bone Marrow Cells in Radiation Chimaeras, 955

DAGLEY, Dr. S., and Sykes, J. : Cytoplasmic Particles and their Role in Protein Synthesis (One Effect of Chloramphenicol on Micro-organisms is to inhibit Protein Synthesis), 644
Dahl, Ingerlise : The Oligochaete Fauna of Three Danish Brackish Water Areas (Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 26), *review* by Dr. A. J. Southward, 360
Daily Food Consumption by South African University Students (Sonia E. Walker), 381
Dainton, Prof. F. S., and others : Effects of Linear Energy Transfer on the Radiolysis of Water and Heavy Water, 475
Dairying, National Institute for Research in : Report for 1959, 909
Dakar (Senegal) : Haptoglobin Types in 398 Blood Donors from (Dr. J. Moullec, Dr. J. M. Fine and J. Linhard), 517
Damage to Liver induced by DL-Methionine-Ethylester (I. Fehér, F. V. Selmeczi, K. Szalay and Dr. T. Kemény), 421
Damage (X-Ray), in Diploid Yeast : Dye-sensitized Photo-reactivation of (Dr. David Freifelder and Prof. Robert B. Uretz), 953
Dammin, Prof. G. J., and others : Homotransplant Antigens—Preparation of Active Cellular Fractions, 774
Dancis, Joseph, and others : Delayed-type Hypersensitivity in Premature Neonatal Humans, 1130
Dancy, T. E., and Robinson, E. L. (edited by) : Flat Rolled Products—Rolling and Treatment, *review* by Prof. F. C. Thompson, 273
Dangerous Concept of the Natural Forest (T. R. Peace), 848
Danielli, Prof. J. F. (edited by Prof. G. H. Bourne and) : International Review of Cytology, Vol. 8, *review* by the late Prof. J. Bronte Gatenby, 632
Daniels, Dr. Fred B. : Radar Determination of the Scattering Properties of the Moon, 399
Daniels, Dr. N. W. R., and Richmond, J. Wendy : Gas Liquid Chromatography of Conjugated Fatty Acids, 55
Danish Atomic Energy Commission : Third Annual Report (1958-59), 33
Danish Brackish Water Areas : The Oligochaete Fauna of Three (Ingerlise Dahl), (Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 26), *review* by Dr. A. J. Southward, 360
Danish Deep-Sea Expedition round the World, 1950-52 : Galathea Report—Scientific Results of the (edited by Dr. Anton Bruun, Capt. Sv. Greve and Prof. R. Spärck), *review* by Dr. N. B. Marshall, 443
Dark-ground Viewing of 'Thorotrast' in Tissue Sections : Combined Oil-immersion, Phase-contrast and (Dr. E. W. Baxter), 162
Darkness : Effects of Light and, on the Rhythm of Output of Carbon Dioxide of Excised Bryophyllum Leaves (Dr. Malcolm B. Wilkins), 523
Darlington, Prof. C. D. : Chromosomes and the Theory of Heredity, 892
Dart, Prof. Raymond A. : Africa's Place in the Emergence of Civilisation (Van Riebeeck Lectures of the South African Broadcasting Corporation), *review* by M. C. Burkitt, 891
Dart, Prof. Raymond A., with Dennis Craig : Adventures with the Missing Link, *review* by Sonia Cole, 888
Darwin's Notebooks on Transmutation of Species (edited by Sir Gavin de Beer), (British Museum (Natural History)) Part 2, 26 ; Part 3, 649
Darwinism (Twentieth Century) : Genetics and (Cold Spring Harbor Symposia on Quantitative Biology, Vol. 24), *review* by Dr. H. Kalmus, 726
Dasarathy, C. (Ramachandran, E. G., and) : Stabilization of Austenite by Hydrogen, 684
Data (Numerical) : Tables of Constants and, Vol. 11, Selected Constants—Optical Rotatory Power, 4, Alkaloids (Prof. J.-P. Mathieu and Prof. M.-M. Janot), *review* by Dr. J. Walker, 7
Data (Solubility) : Analysis of, to estimate Small Amounts of Chain Fracture during the Cross-linking of Rubber (L. Mullins and D. T. Turner), 145
Data Transmission (Benelux Section of the Institute of Radio Engineers, in co-operation with the Nederlands Radiogenootschap and the Group on Communications Systems of the Institute of Radio Engineers International Symposium on), 290
Datta, Sankar K. (Kamb, Prof. W. Barclay, and) : Crystal Structures of the High-Pressure Forms of Ice—Ice III, 140
Daudel, R., and others : Quantum Chemistry—Methods and Applications, *review* by Prof. H. C. Longuet-Higgins, 541
'Dauer-pupa' of the Silkworm, *Bombyx mori* : Function of the Corpus Allatum in the (Dr. Masatoshi Kobayashi), 346
Davey, Prof. T. H. : Parasites as Enemies and Allies, 203
David, D. J. : Atomic Absorption Spectrophotometric Determination of Molybdenum and Strontium, 1109
Davidsohn, Israel, and others : Electrophoretic Separation of certain *in vitro* and *in vivo* Reactions of Rabbit Anti-Mouse Erythrocyte Serum, 157
Davidson, Prof. C. F. : Age of the Cambrian System, 1020
Davidson, J. M. : Awarded a Nature Conservancy Diploma Course in Conservation and Ecology at University College, London, 742
Davidson, Dr. W. : Interpretation of Cosmology, 583
Davies, A. B. Oldfield : Science Broadcasting in Sound and Television (Presidential Address to Section X (Assembly of Corresponding Societies) of the British Association for the Advancement of Science), 850
Davies, A. J. S., and Doak, Sheila M. A. : Fate of Homologous Adult Spleen Cells injected into New-born Mice, 610
Davies, Dr. D. R. : Appointed to the newly created chair of applied mathematics in the University College of North Wales, Bangor, 197 ; work of, 197
Davies, J. B. : Use of Dieldrin in the Control of *Glossina palpalis* (R-D) in Nigeria, 84
Davies, J. B., and others : Attachment of Immature Simuliidae to other Arthropods, 618
Davies, Dr. J. Griffiths : Food and Animal Production Overseas (Pasture Development of Tropical Australia), 1071
Davies, Dr. R. D., and others : A New Limit to the Galactic Magnetic Field set by Measurements of the Zeeman Splitting of the Hydrogen Line, 1088
Davies, Dr. R. O. : Solid State Physics, *review*, 886
Davies, Dr. William : Pastoral Systems in relation to World Food Supplies (Presidential Address to Section M (Agriculture) of the British Association for the Advancement of Science), 849
Dawes, Dr. Ben : Classification of the Cestodes of Vertebrates, *review*, 723
Dawson, Barbara : Use of Collagenase in the Characterization of Pseudocoelomic Membranes of *Ascaris lumbricoides*, 798
Day, G. J. : Weather Problems in Agriculture (Radiation Climatology), 995
Day, Prof. J. H. : Polychaete Fauna of South Africa, Part 5, 199
DDT : The First Decade of, *review* by Prof. D. S. Bertram, 271
DDT—the Insecticide DDT and its Significance (edited by Paul Muller), Vol. 2, Human and Veterinary Medicine (Dr. W. J. Hayes, Jr., Dr. S. W. Simmons and Dr. E. F. Knipling), (edited by Dr. S. W. Simmons), *review* by Prof. D. S. Bertram, 271
de Beer, Sir Gavin (edited by) : Darwin's Notebooks on Transmutation of Species, (British Museum (Natural History)), Part 2, 26 ; Part 3, 649
de Castro, Sisinio (Planas, Prof. Jose, and) : Serum Iron and Total Iron-binding Capacity in certain Animals, 1126
de Duve, Prof. C. : Cytoplasmic Particles and their Role in Protein Synthesis (Limits of Resolving Power of Techniques of Cell Fractionation), 634
  Intracellular Localization of Enzymes, 836
DeEds, F., and others : Excretion of Catechol after Ingestion of Quinic and Shikimic Acids, 691
de Keghel, Dr. Maurice : Traité Général de Fabrication des Colles des Glutinants et Matières d'Apprêts, *review* by Prof. A. G. Ward, 890
de Klerk, H. C., and others : Host-Range of *Lactobacillus* Bacteriophages, 348
de Koninck, Prof. Charles : The Hollow Universe, (Whidden Lectures, Series 4), *review* by F. I. G. Rawlins, 890
de Maere, X., and others : Isotopic Composition and Temperature of Formation of Antarctic Snows, 857
de Pasqualini, C. D., and others : Fertility of Mice treated with Phosphorus-32, 876
DeWald, H. A., and others : Synthesis and Biological Properties of L-Arginyl-L-Prolyl-L-Prolyl-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenylalanyl-L-Arginine, an Octapeptide related to Bradykinin, 773
de Whalley, H. C. S. : Principles of Sugar Technology, *review*, 979
de Wilde, Prof. J. (Van Wyk, Prof. W. R., and) : Problems of the Arid Zones (Microclimatology, physical and biological), 295
Deacon, Dr. G. E. R. : Studies in Marine Physics, *review*, 183
  The Indian Ocean Expedition, 561
  Submarine Geology, *review*, 629
'DEAE'-Cellulose : Chromatography of Blood Thrombokinase on (Dr. J. H. Milstone), 1127
Dean, Dr. R. A. : *Obituary* of Dr. S. F. Birch, 111
Debnam, A. H. : Minor Elements in Soils, *review*, 629
Debris (Nuclear Weapon) : Fractionation of (Prof. C. Sharp Cook, R. L. Mather, R. F. Johnson and F. M. Tomnovec), 1100
Decade (The First), of DDT, *review* by Prof. D. S. Bertram, 271
Decay of Timber : Combating the, *review* by Prof. F. W. Jane, 977
Decay of Timber and its Prevention (K. St. G. Cartwright and W. P. K. Findlay), *review* by Prof. F. W. Jane, 977
Decimal Coinage and the Metric System—Should Britain Change ? (A Joint Report of Committees appointed by the British Association for the Advancement of Science and the Association of British Chambers of Commerce), 30
Decimal System in Britain, 30
Decreased Membrane Conductance : Excitation at the Crayfish Neuromuscular Junction with (Dr. Josef Dudel and Prof. Stephen W. Kuffler), 246
Dedifferentiation in *Splachnum ampullaceum* (L.) Hedw : Intracellular Configuration and (Prof. Kraft E. von Maltzahn and Mary M. MacNutt), 344
Dedijer, S. : Scientific Research and Development—a Comparative Study, 458
De-embryonated Eggs : Physical Incompleteness of Influenza Virus propagated in (Martin Hanig and Joseph M. Stein), 40
Deep-Sea Expedition (Danish), round the World, 1950-52 : Galathea Report—Scientific Results of the (edited by Dr. Anton Bruun, Capt. Sv. Greve and Prof. R. Spärck), *review* by Dr. N. B. Marshall, 443
Deer : Sickling Phenomenon in (E. Undritz, K. Betke and Dr. H. Lehmann), 333
Defence Research and Development : British, 177

Defense, United States Department of (Department of the Navy, Naval Research Advisory Committee) : Basic Research in the Navy (Report prepared by Arthur D. Little, Inc.), 178
Deficiency (Low-Grade Mental), in a Large Swedish Rural Population : A Clinical and Genetico-Statistical Study of Schizophrenia and (Bertil Hallgren and Torsten Sjogren), 298
Deficiency (Pyridoxine), in Rats : Polyenoic Acid in Hypercholesterolaemia induced by (Ajit Goswami and Prof. D. P. Sadhu), 786
Deficient Characters (New), in Streptomycin-resistant Mutants of *Bacillus subtilis* : Appearance of (Masamichi Kohiyama and Yonosuke Ikeda), 168
Deformed Metals (Plastically) : A Possible Origin of Exo-Electron Emission in (Dr. A. H. Meleka and W. Barr), 232
Degenerating Nerve Fibres in Birds : Effect of Cortisone on (Dr. P. Glees), 327
Degeneration (Retinal), induced by Iodate and Iodoacetate : Protective Effect of Cysteine against (Prof. Arnold Sorsby and Ronald Harding), 608
Degradation of Benzylpenicillin at pH 7·5 to D-Benzylpenicilloic Acid (Dr. Bernard B. Levine), 939
Degradation of Deoxyribonucleic Acid by Ionizing Radiations : Role of Oxygen in the Cross-linking and (Peter Alexander and J. T. Lett), 933
Degradation (Proteolytic), of Human γ-Globulin : Presence of Immunologically Active Fragments after (L. A. Hanson and B. G. Johansson), 599
Degradation (Thermal), of Polymers : High-Temperature Resistance and (Plastics and Polymer Group of the Society of Chemical Industry Symposium on), 466
Dehydrogenase (Steroid 11 β-ol), in Human Placenta (Dr. P. A. Osinski), 777
Dehydrogenases in Blood and Bone Marrow Cells : Acetone Fixation for the Cytochemical Demonstration of (Dennis Quaglino and Dr. F. G. J. Hayhoe), 85
Dehydrogenases (17β-Œstradiol) : Histochemical Localization of Human, Term Placental—Implications for the Transhydrogenase Reaction (Dr. Donald A. Kellogg and Dr. George G. Glenner), 763
Deightoniella torulosa (Syd.) Ell : Banana Fruit-spot ('Speckle') caused by (Dr. D. S. Meredith), 961
De-iodination (Enzymic), of Thyroxine : Transiodination of Proteins during (Dr. J. R. Tata), 1025
Del Vecchio, Prof. A., and Bolis, L. : Depressing Activity of Meprobamate on the Reticulo-Endothelial System, 513
Delayed 'Primary' Effects in *Chara vulgaris* L. subjected to X-Rays (C. M. Gillet), 874
Delayed Recovery of Airborne *Serratia marcescens* after Short-Time Exposure to Ultra-violet Irradiation (Dr. R. L. Dimmick), 251
Delayed-type Hypersensitivity in Guinea Pig Embryos : Development of (Jonathan W. Uhr), 957
Delayed-type Hypersensitivity in Premature Neonatal Humans (Jonathan W. Uhr, Joseph Dancis and Charlotte Grantz Neumann), 1130
Delayed-type Iso-hypersensitiveness : Natural Occurrence of (Dr. Jack R. Battisto), 69
Deliwala, Dr. C. V., and others : Diuretic Activity of 2-Amino-4-meta-chloroanilino-1,3,5,triazine (*R*-37), 1034
δ-Lactone Compound : Isolation of a, from the Leaves of *Clitoria mariana* Linn. (Dr. A. Sinha), 149
Demand (Growing), for Water : Second Report of the Sub-Committee on (Central Advisory Water Committee), 198
Demography (Peter R. Cox), third edition, *review* by Prof. E. Grebenik, 97
Demonstration (Cytochemical), of Dehydrogenases in Blood and Bone Marrow Cells : Acetone Fixation for the (Dennis Quaglino and Dr. F. G. J. Hayhoe), 85
Demonstration (Histochemical), of Acid Phosphatase : A Simple Azo-Dye Method for (Dr. Tibor Barka), 248
Demonstration (Immuno-electrophoretic), of Precipitating Components in Sera from Pregnant Women (Dr. Jan Hirschfeld and Dr. Ulf Soderberg), 332
Demonstration (Selective Cytochemical), of Arginine Groups in Nucleoprotein in the Cell Nucleus (Dr. E. A. Barnard and Dr. L. G. E. Bell), 508
Demountable Vacuum Systems : Direct Observation of Surface Contamination formed in (D. E. Bradley), 227
Denatured Haemoglobin and Myoglobin (Native and) : Nature of the Haem-binding Groups in (Dr. Joan Keilin), 365
Dendritic Crystallization (D. D. Saratovkin), translated from the Russian by Dr. J. E. S. Bradley, second edition, *review* by A. F. Wells, 93
Dendritic Growth of Crystals, *review* by A. F. Wells, 93
Denervated Adrenal Medulla of the Rat : Effect of Reserpine on the Nucleotide and Catecholamine Content of the (Prof. Nils-Åke Hillarp), 1032
Denis, H : Electrophoretic Pattern during Amphibian Development, 62
Denmark : Atomic Energy Research in, 34
  Marine Biological Reports from, *review* by Dr. A. J. Southward, 360
Dennell, Prof. R. : Growth and Form in an Insect, *review*, 631
Dennes, E., and others : Zinc Content of Erythrocytes and Leucocytes of Blood of Normal and Leukaemic Subjects, 302
Density of Bacteriophage λ : Mutations affecting the (G. Kellenberger, M. L. Zichichi and J. Weigle), 161
Density (Surface), of Charge : Effect of, on the Physical Swelling of Lithium Montmorillonite (Dr. J. P. Quirk and B. K. G. Theng), 967
Dent, Prof. H. C. : Sixty Years of Progress in English Education (Presidential Address to Section L (Education) of the British Association for the Advancement of Science), 848
Dental Research, 556
Deo, A. V., and others : New Compounds for the Control of Water Evaporation, 870
2-Deoxy-D-glucose : Phosphate Esters produced by Mammalian Skin from (Dr. S. A. Brooks, Dr. J. C. Lawrence and Dr. C. R. Ricketts), 1028
Deoxyribonucleate : Fate of Transforming, following Fixation by Transformable Bacteria, 1 (Dr. Maurice S. Fox and Dr. Rollin D. Hotchkiss), 1002 ; 2 (Dr. Maurice S. Fox), 1004
Deoxyribonucleic Acid : A Bleached Variant of *Euglena gracilis* showing a Doubling of the Content of (Dr. George Brawerman, Carole A. Rebman and Prof. Erwin Chargaff), 1036
  Capacity of Extracts from Prestarved *Escherichia coli* to Incorporate Thymidine into (Dr. Daniel Billen), 1044
  Interaction of Actinomycin with (Prof. J. Kawamata and M. Imanishi) 1112
  Role of Oxygen in the Cross-linking and Degradation of, by Ionizing Radiations (Peter Alexander and J. T. Lett), 933
  Structure, Synthesis and Function of (Société de Chimie Physique Meeting on), 1079
Deoxyribonucleic Acid in Mouse Ascites Cells : Uptake of Thymidine and Synthesis of (Dr. A. R. Crathorn and Dr. K. V. Shooter), 614
Deoxyribonucleic Acid in Thymus Nucleoprotein : Labilization of, after Whole-body Irradiation (Dr. Ulrich Hagen), 1123
Deoxyribonucleic Acid Component of Crystalline Cytochrome b_2 : Chemical and Physical Properties of the Small (Dr. M. D. Montague and Prof. R. K. Morton), 916
Deoxyribonucleoprotein (Water-soluble, Non-fibrous), from Calf Thymus Nuclei (Dr. Richard S. Welsh), 943
Dependence of Cement-Aggregate Bond-Strength on Size of Aggregate (K. M. Alexander and J. Wardlaw), 230
Dependence on Latitude of the Amplitude of the Diurnal Variation of Cosmic Rays (Arne Eld Sandstrom, Eric Dyring and Stig Lindgren), 1099
Dependence on Temperature of the Electrical Resistivity of Thermosetting Polymers (R. W. Warfield and M. C. Petree), 316
Dependence on Temperature of the Interlayer Spacing in Carbons of Different Graphitic Perfection (E. G. Stewart, B. P. Cook and E. A. Kellett), 1015
Deposited (Internally) Americium : Removal of, by Chelating Agents (Dr. F. D. Sowby and Dr. D. M. Taylor), 612
Deposition of Lipids : Role of Mucoid Substances of the Aorta in the (Dr. S. Gerö, Dr. J. Gergely, Dr. T. Dévényi, Dr. L. Jakab, Dr. J. Székely and Dr. S. Virág), 152
Deposition of Strontium-89 and Strontium-90 on Agricultural Land and their Entry into Milk after the Reactor Accident at Windscale in October 1957 (United Kingdom Atomic Energy Authority and the Agricultural Research Council joint Report on), 1077
Depressing Activity of Meprobamate on the Reticulo-Endothelial System (Prof. A. Del Vecchio and L. Bolis), 513
Depression (Bone Marrow), in Murine Leukaemia (James T. Duhig), 71
Derivative of Tetra-substituted Sulphur : Optically Active Forms of a (M. Baresh), 591
Derivatives (Lysergic Acid) : Production of, by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture (F. Arcamone, C. Bonino, Prof. E. B. Chain, A. Ferretti, P. Pennella, A. Tonolo and Lidia Vero), 238
Derivatives (New Bicyclopentyl) : Conversion of Cyclopentadiene into—Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy (C. F. Blakeley, Dr. R. J. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662 ; Kinetics and Mechanism (C. F. Blakely and Dr. A. Wassermann), 662
Derivatives (Tetrahydro-1,3-oxazine) : Anti-neoplastic Activity of (Prof. T. Urbański, D. Gurne, S. Slopek, H. Mordarska and M. Mordarski), 426
Descent of Satellite *Sputnik* 3 : Final Months and (B. R. May and D. E. Smith), 456
Design of Semiconductor Devices : The Properties, Physics and (John N. Shive), *review* by Dr. J. R. Tillman, 1058
Design (Nuclear Power Plant) : Evolution of (Sir Christopher Hinton), 1064
Design and Construction of High Pressure Chemical Plant (Harold Tongue), second edition, *review* by Dr. K. E. Bett, 541
Designing for Space Travel, *review*, 884
Desjardins, Paul R. (Rubio-Huertos, Miguel, and) : A Vacuolar System in Cells of *Agrobacterium tumefaciens* as shown by Electron Microscopy of Ultra-thin Sections, 1043
Desneiges, P., and others : Electronic Equipment used in the Nuclear Energy Industry in France, 1076
Detecting Ionospheric Drifts : Possibility of, from the Occurrence of Spread *F* Echoes at Low Latitudes (R. W. Knecht), 927
Detection of Inhibition of Auxin Transport : A Method for the (B. E. S. Gunning), 428
Detector (An Ionization), for Permanent Gases (Dr. J. E. Lovelock), 49
Determination of Fatty Acids of Lower Molecular Weight by Gas Chromatography (Marie L. Vorbeck, Leonard R. Mattick, Frank A. Lee and Carl S. Pederson), 689
Determination of Molecular Structure (P. J. Wheatley), *review* by Dr. J. W. Cook, 812
Determination of Nickel and Cobalt by Atomic Absorption (J. E. Allan), 1110
Determination of Nonanol Residues in Potatoes (W. F. van Vliet and W. H. Schriemer), 235
Determination (Age), of Seals (H. R. Hewer), 959
Determination (Atomic Absorption Spectrophotometric), of Molybdenum and Strontium (D. J. David), 1109
Determination (Colorimetric), of Traces of Metals (Prof. E. B. Sandell), third edition, *review* by A. M. G. Macdonald, 3
Determination (Crystal Structure) : Modern Methods of (Manchester College of Science and Technology Summer School in), 201
Determination (Polarographic), of the Lanthanides : Use of Azo Dyestuffs for the (T. M. Florence and L. E. Smythe), 771
Determination (Radar), of the Scattering Properties of the Moon (Dr. Fred B. Daniels), 399
Determination (Structure), with the Help of Proton Magnetic Resonance Spectroscopy (Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives), (C. F. Blakely, Dr. R. J. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662
Determined (A Genetically) Enzyme in the Pig (Dr. K.-B. Augustinsson and Dr. B. Olsson), 924
Determining Diffusion Coefficients in Liquid Systems by the Diaphragm-Cell Technique : Equations for (F. A. L. Dullien and Prof. L. W. Shemilt), 767
Detoxication Mechanisms (Prof. R. Tecwyn Williams), second edition, *review* by Prof. E. Boyland, 94
Deuchars, Dr. W. : Awarded the Selby Fellowship for 1960, 464
Deutsche Akademie der Naturforscher Leopoldina : Election of Prof. Adolf Butenandt as an honorary member, 117
  Election of new Members, 1079

Deuterium Oxide : Ultra-violet Absorption Spectra of Proteins in (Dr. Shiro Takashima), 597
Developing World : Our (Prof. L. Dudley Stamp), *review* by M. K. Milne, 816
Development : British Defence Research and, 177
  Scientific Research and—a Comparative Study (S Dedijer), 458
  Shortages of Scientific Personnel in European Countries in Process of, 565
Development of Delayed-type Hypersensitivity in Guinea Pig Embryos (Jonathan W Uhr), 957
Development in Fuel and Power : Advisory Council for Research and, 286
Development of the Gonads in Parasitic and Non-Parasitic Lampreys (M W Hardisty), 341
Development of Mouse Eggs beneath the Kidney Capsule (D. R. S. Kirby), 707
Development of Pulp and Particle Board Industries and their Effect on Forest Management (Society of Foresters of Great Britain Discussion on), 32
Development (Aeronautical Research and), Advisory Group for—*see under* AGARD
Development (Amphibian) Electrophoretic Pattern during (H. Denis), 62
Development (Materials Research and), for National Security . More Effective Organization and Administration of (United States National Academy of Sciences—National Research Council, Publication No. 718), 470
Development (Research and), in Industry (Dr. E J. Solvay), 830
Development (Overseas) · Assistance from the United Kingdom for (H.M. Treasury), 266
Development (Reconstruction and), International Bank for Articles of Agreement of the proposed International Development Association, as approved for submission to Governments by the Executive Directors of the, 266
Development (Social), through the Family and Home : Report of the Conference on, 567
Development and Growth, Society for the Study of Seventeenth Symposium—Cell Organism and Milieu (edited by Prof Dorothea Rudnick), *review* by Dr. E. N Willmer, 450
Development Association (International) Articles of Agreement as approved for submission to Governments by the Executive Directors of the International Bank for Reconstruction and Development, and Accompanying Report of the Executive Directors, 266
Development Corporation (Colonial) : Annual Report for 1959, 854, 971
Developmental Stages of the Rice Plant . Relative Lengths of Leaf Sheath and Blade with reference to the (Dr. B Saha), 259
Developments of the Optical Lever · Some (Prof R V Jones), 905
Dévényi, Dr. T , and others . Role of Mucoid Substances of the Aorta in the Deposition of Lipids, 152
Devices (Semiconductor) . The Properties, Physics and Design of (John N. Shive), *review* by Dr. J R. Tillman, 1058
Devins, J. C., and LeBlanc, jun , O. H. · Ionization and Attachment Coefficients in *n*-Alkyl Chloride Gases, 409
Devonshire : Recapture in the River Tweed of a Sea-Trout marked in (A Swain, L R H. Allan and M J. Bulleid), 877
Dewey, Dr D L : Effect of Glycerine on the X-Ray Sensitivity of *Serratia marcescens*, 1008
'Dex' or 'Order of Magnitude' ? (Prof. J. B. S. Haldane), 879
Dextran and Insulin in Rats (Dr. L H. Marshall and C H. Hanna), 1118
Diabetes Mellitus · High-Energy Bound Phosphate and (Dr Yoshio Goto, Isao Ito, Akihiko Kuwano and Yukio Ujile), 702
Diamagnetic Moment of Gaseous Plasmas measured by Spin Resonance Techniques (T C. Marshall, R. A. Kawcyn and Prof. L. Goldstein), 584
Diamond Physics (Institute of Physics and the Physical Society Conference on), 905
Diapause (Imaginal), in *Coccinella 7-punctata* L. : Prevention and Artificial Induction of the (I Hodek and J Cerkasov), 345
Diaphragm-Cell Technique · Equations for Determining Diffusion Coefficients in Liquid Systems by the (F. A. L Dullien and Prof L. W. Shemilt), 767
Dias, H. F , and others : Sap-Transmissible Viruses associated with Diseases of Grape Vines in Europe and North America, 577
Diazines · Ultra-violet Absorption Spectra of the (Prof K. Keith Innes, James A. Merritt, Wayne C. Tincher and Shelby G Tilford), 500
Dibenzene Chromium · Character of the Ligands in (Dr F Jellinek), 871
Dichapetalum Fluorine Compounds in Nature—the Distribution of Carbon-Fluorine Compounds in some Species of (Sir Rudolph Peters and R J. Hall), 573
Dichorial One-Egg Twins in the Mouse (Dr. A J Bateman), 339
Dickens, P. G , and others : Recombination of Oxygen Atoms in the Gas-Phase, 686
Dickinson, Dr D. R. : Science for the Family, *review*, 978
Dictionaries : Communications and Electronics, *review* by Dr. R. L. Smith-Rose, 1059
Dictionaries (Japanese Scientific and Technical Books and) · A collection of, presented to the Science Museum Library, London, on behalf of the Prime Minister of Japan, Nobusuke Kishi, 201
Dictionary : Elsevier's Telecommunication, in Six Languages—English/American, French Spanish, Italian, German, Dutch (compiled and arranged on an English alphabetical base by A. Visser), *review* by Dr. R L. Smith-Rose, 1059
Dictionary of Electronics and Wave-guides : Swedish Supplement to Elsevier's (W E. Clason), *review* by Dr R. L Smith-Rose, 1059
Didelphus virginianam (Opossum) : Wound Healing in the New-Born (Prof. Matthew Block), 340
Dieldrin · Use of, in the Control of *Glossina palpalis* (R-D) in Nigeria (J. B. Davies), 84
Dielectric Liquids Photo-Injection of Charge into (M. J Morant), 48
Dielectrics · Digest of Literature on, Vol 22, 1958 (edited by R. A Sodermann and L F Frisco), (United States National Academy of Sciences—National Research Council, Publication No 713), *review* by S. Weintroub, 728
Diet (Fat) · An Inverse Relation between the Liver Glycogen and the Blood Glucose in the Rat adapted to a (Dr P A. Mayes), 325
Diet (Meat) · Lack of Haematopoietic Potency of Liver of Mice fed on a (Judith Ilan and Prof. K. Guggenheim), 698
Diethylamide (Lysergic Acid) : Effect of, on Larval Growth (Dr. D. V. Siva Sankar, Arthur Kopelman, Peter Schilder and Eleanor Gold), 153
Diethylstilboestrol . Effect of Three Compounds related to, on the Phagocytic Activity of the Reticulo-Endothelial System (Prof. T. Nicol, G. Brownlee, C. Druce and C. C. Ware), 1032
Diets of varying Protein Content : Urinary Amino-Acid Pattern of Cats on (Dr J. P. Greaves and Dr. Patricia P. Scott), 242
Difference between the Sub-Units of Tobacco Mosaic Virus Protein ? (Dr. H G Aach), 75
Difference between Two Means : Significance of the, when the Population Variances may be Unequal (John B de V Weir), 438
Differences (Platelet-Count) in Blood of the Rabbit Right and Left Heart Ventricles (Dr. J. George Sharnoff and Dr. Vito Scardino), 334
Differences (Race), in the Ability to excrete Beetroot Pigment (Betanin), (Dr P. H Saldanha, L E. Magalhaes and Wanda A Horta), 806
Differences (Strain), in Acetylcholine Concentration in the Brain of the Rat (Edward L. Bennett, James Crossland, David Krech and Mark R. Rosenzweig), 787
Different Graphitic Perfection : Dependence on Temperature of the Interlayer Spacing in Carbons of (E. G. Steward, B. P Cook and E. A. Kellett), 1015
Different Types of Malnutrition : Influence of, on the ^{14}C-Lysine Metabolism in Young Rats (Prof. Kurt Schreier and Corinna Kazassis), 1117
Differential Equations : Boundary Problems in—Proceedings of a Symposium conducted by the Mathematics Research Center of the United States Army at the University of Wisconsin, 1959 (edited by Prof. Rudolph E. Langer), *review* by Prof E T Copson, 451
Differential Precipitation of Nucleic Acids from Aqueous Solutions : A New Method for the (William G. Aldridge), 323
Differential Reactivity of Saliva from 'Tasters' and 'Non-Tasters' of 6-*n*-Propylthiouracil (Frances Griffin and Prof. Roland Fischer), 417
Differential Thermal Analysis of some Transition Metal Ethylenediamine Tetraacetic Acid Chelates (Prof. Wesley W. Wendlandt and G. Robert Horton), 769
Differentiation in *Peronospora tabacina* Adam. (Dr. D. C. Wark, A V. Hill, M. Mandryk and I A. M. Cruickshank), 710
Differentiation (Immuno-Electrophoretic), of Haptoglobins from another Group-Specific Inheritable System in Normal Human Sera (Dr. Jan Hirschfeld), 126
Diffraction (Mellon Institute, Pittsburgh, Conference on), 650
Diffusion of Knowledge (Dr Michael Grant), 371
Diffusion Coefficients in Liquid Systems by the Diaphragm-Cell Technique : Equations for determining (F. A. L. Dullien and Prof. L. W. Shemilt), 767
Diffusion ('Eddy'), in Chromatography (A. Klinkenberg and F. Sjenitzer), 1023 · (J. Calvin Giddings) 1023
Diffusion (Self-) of Alkali Metal Ions in Analcite : Energies of Activation for (Prof R. M Barrer and L. V. C Rees), 768
Diffusion (Turbulent), in the Atmosphere Small-Scale (Dr. L. A. Clarenburg and C. E. Spaans-v. d Tang), 586
Digest of Literature on Dielectrics, Vol 22, 1958 (edited by R. A. Sodermann and L. F Frisco), (United States National Academy of Sciences—National Research Council, Publication No. 713), *review* by S. Weintroub, 728
Digestion (Intracellular), in a Histophagous Ciliate : Increase of Esterase Activity during (Dr. Miklós Muller, József Tóth and Prof. Imre Toro), 65
Digital Computer : *Leo III*, a New All-Transistor (Leo Computers, Ltd.), 373
Dihydrocodeine and Aminopyrine Analgesia (Morphine,) : Synergetic Action of 2(*o*-Methoxyphenoxymethyl)-5-Oxazolidone on (Dr. E. Fischer, J L J. Szabó and M. Stamburgo), *erratum*, 559
β-Diketone Chelates (Cupric), with Heterocyclic Bases . Structure of the 1·1-Adducts of (Dr. D P. Graddon and E. C. Watton), 1021
9 10-Dimethyl-1-2-benzanthracene . Crystal Structure of (Dr. D. Sayre and Dr. P. H. Friedlander), 139
Dimitriadou, A., and others : Staining for Iodine in Chromatograms of Human Plasma—an Artefact due to Thioureas or Thiouracils, 691 ; *erratum*, 1079
Dimmick, Dr R L. · Delayed Recovery of Airborne *Serratia marcescens* after Short-Time Exposure to Ultra-violet Irradiation, 251
Dinning Prof James S (Fitch, Coy D., and) Production of Muscular Weakness in Rats by a Creatine Analogue, 421
Diodone · Use of, in Renal Studies in Sheep (B. J. Pitter), 698
Dioxide (Carbon) : Effects of Light and Darkness on the Rhythm of Output of, of Excised *Bryophyllum* Leaves (Dr. Malcolm B Wilkins), 523
Dioxide (Carbon) Mass Spectra . High-Energy Oxygen Ions in (R. M. S. Hall), 683
Dioxide (Carbon) Output : Effect of Electronarcosis on Oxygen Consumption and (Dr. Jaroslav Strmiska and Dr. Antonín Vacek), 151
Diphosphopyridine Nucleotide : Synthesis of, in Irradiated Rats (Dr D. K. Myers), 1124
Diphtheria and Tetanus · Vaccination against Whooping Cough (Research Defence Society, *Conquest* Pamphlet No. 11), 649
Diplococcus pneumoniae : Transformation of Resistance to 8-Azaguanine in (Francis M. Sirotnak, Ramona B Lunt and Dorris J. Hutchison), 800
Diplodiscus Species Parasitic in the Snail *Paludina vivipara* Lm. (M. R. Honer), 431
Diploid Yeast : Dye-sensitized Photoreactivation of X-Ray Damage in (Dr. David Freifelder and Prof Robert B Uretz), 953
Diphosphate (Adenosine) . Oxidative Phosphorylation—Synthesis of, by the Oxidation of Quinol Phosphates (Dr. V. M. Clark, D. W. Hutchinson and Sir Alexander Todd), 59
Diploma in Mathematics (Mathematical Association), 114
Diptera (Euryhaline) . Osmotic Regulation in the Larvae of some (D. W. Sutcliffe), 331
Direct Action on Metabolism : Polypeptides of the Human Pituitary with (Dr J Bornstein and Deirdre Hyde), 125
Direct Infra-Red Spectral Analysis of the Cucumber Mosaic Virus Infection Process (Prof. G. W. Cochran, G. W. Welkie and J. L. Chidester), 1049
Direct Observation of Surface Contamination formed in Demountable Vacuum Systems (D. E. Bradley), 227

Direction and Supervision of Scientific and Engineering Personnel (Northampton College of Advanced Technology, London, Advanced Course on), 905
Directive Rotating Array (A Highly), for 16 Mc./s. (Prof. J. A. Thomas and Dr. R. W. E. McNicol), 398
Directory of Libraries in the United Kingdom with access to 'Telex' (Library Association), 558
Discharge (Sceptre): Periodic Magnetic Field Fluctuations in the (Dr. N. L. Allen), 279
Discharges (Electrical), in the Solar Atmosphere: Temperatures reached in (Dr. C. E. R. Bruce), 865
Discontinuity (The Sudden), in the Orbital Period of *Sputnik* 4 Satellite (B. R. May and D. E. Smith), 866
Discoverer Satellites: Recovery of Capsules from, 741
Discovery: Appointment of S. Edward Gamarekian as Editor, 741
Discovery (Possible), of Ion-Pairs by Interferometry (Prof. R. N. O'Brien and C. Rosenfield), 935
Discrimination (Visual): Problems of (Prof. R. W. Ditchburn), 854
Disease: Achievement—some Contributions of Animal Experiment to the Conquest of (Dr. Geoffrey Lapage), *review* by Dr. W. Lane-Petter, 977
Disease (Gall), of Cocoa: Transmission of a (A. L. Wharton and A. A. Brunt), 80
Disease (Muscular) Myasthenia gravis (E. R. Bickerstaff and A. L. Woolf), 28; (Violet MacDermot), 28
Disease (Streak-Virus), of Tomatoes (B. H. MacNeill and Hikmet Isman), 903
Diseases of Grape Vines in Europe and North America: Sap-Transmissible Viruses associated with (C. H. Cadman, H. F. Dias and B. D. Harrison), 577
Diseases (Staphylococcal): Antibiotic Therapy and (edited by Dr. Henry Welch and Prof. Maxwell Finland), *review* by Prof. R. Knox, 637
Diseases (Talfan and Teschen): Infective Ribonucleic Acid from the Viruses of (F. Brown and Doreen L. Stewart), 714
Dislocations: Electron Microscope Images of (Dr. Hatsujiro Hashimoto and Dr. Kazuo Fujita), 51
Dislocations in Layer Structures (V. A. Phillips and P. Cannon), 313
Dispersed Chemical Elements (Rare and), in Soils: The Geochemistry of (A. P. Vinogradov), second edition (translated from the Russian), *review* by A. H. Debnam, 629
Dispersion in Space of Small Bodies (Dr. D. O. Wolfenbarger), 1078
Disposition of Noradrenaline labelled with Tritium: Effect of Cocaine on the (Dr. L. G. Whitby, G. Hertting and Dr. J. Axelrod), 604
Dissection: Recognition of Nulliparous Mosquitoes without (Dr. Philip S. Corbet), 525
Dissociation (Reversible), of Ribonucleic Acid (R. A. Brown, K. A. O. Ellem and Dr. J. S. Colter), 509
Dissociation Energy of S_2: Mass Spectrometric Investigation of the Vaporization of Sulphides and the (R. Colin, Prof. P. Goldfinger and M. Jeunehomme), 408
Distance from the Source of Sodium Chloride: Change of the Chlorine–Sodium Ratio in the Atmosphere with Altitude and, and the Distribution of Atmospheric Nitrate over the United States (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Distèche, A.: pH Changes during Muscle Twitch and Tetanus, 1119
Distorted Wave Approximation for Scattering Phase-Shifts (Dr. P. Swan), 585
Distribution of Atmospheric Nitrate over the United States: Change of the Chlorine–Sodium Ratio in the Atmosphere with Altitude and Distance from the Source of Sodium Chloride, and the (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Distribution of Atmospheric Ozone—a Preliminary Analysis of some International Geophysical Year Observations (J. MacDowall), 382
Distribution of Carbon–Fluorine Compounds in some Species of *Dichapetalum*: Fluorine Compounds in Nature—the (Sir Rudolph Peters and R. J. Hall), 573
Distribution of Protein-bound Aminoazo Dyes in the Rat Liver Microsome (Dr. T. Yamada, M. Matsumoto, S. Kanda and Prof. H. Terayama), 943
Distribution of Sucrose in the Rat's Ventricle: Effect of Nitrate Ion on the (S. T. Taketa, C. G. Alexander and Prof. G. A. Feigen), 419
Distribution of the Testis Lipids in the Common Frog, *Rana temporaria*: Cyclical Changes in the (Dr. B. Lofts and C. Boswell), 708
Distribution of Thyrotrophin labelled with Iodine-131: Sialoadenectomy and the (Prof. Arthur W. Wase and Dr. Yu Sheng Louise Feng), 778
Distribution (Parallel), of Calcium and Citric Acid in the Oviduct of the Hen (Dr. T. G. Taylor and F. Hertelendy), 244
Distribution (Quantitative and Qualitative), of Zooplankton in the Southern Part of the Norwegian Sea: Investigations on the (V. K. Hansen), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 23), *review* by Dr. A. J. Southward, 360
Disulphide Bond in Wool: Reactivity of the (Dr. L. J. Wolfram and Prof. J. B. Speakman), 595
Disulphide (D-Penicillamine-Cysteine Mixed): Formation of, by Reaction with D-Benzylpenicilloic Acid with Cysteine (Dr. Bernard B. Levine), 940
Ditchburn, Prof. R. W.: Problems of Visual Discrimination (Twentieth Thomas Young Oration of the Physical Society), 854
Diuretic Activity of 2-Amino-4-metachloro-anilino-1,3,5,triazine (R-37), (D. J. Mehta, Prof. U. K. Sheth and Dr. C. V. Delwala), 1034
Diuretic (Anti-) Hormone and Calcium: Effect of, on the Equivalent Pore Radius of Kidney Slices from *Necturus* (G. Whittembury, N. Sugino, and Dr. A. K. Solomon), 699
Diuretic (Benzothiadiazine): A Potent New (Dr. Richard M. Taylor and Martin M. Winbury), 603
Diurnal Variation of Cosmic Rays: Dependence on Latitude of the Amplitude of the (Arne Eld Sandström, Eric Dyring and Stig Lindgren), 1099
Divergence: The Antarctic Convergence—and (Dr. K. Wyrtki), 581
  Evolutionary, *review* by C. S. Elton, 446
Divided Self: The—a Study of Sanity and Madness (Dr. R. D. Laing), *review* by Dr. Clifford Allen, 1062
Division (Cytoplasmic), in *Amoeba proteus*: Suppression of (Dr. Edmund Guttes and Sophie Guttes), 520
Dixey, Dr. F. A.: Arid Zone Problems, 295
  Problems of the Arid Zones (Geology, Geomorphology and Ground-Water Hydrology), 295
Dixon, Dr. R. N.: Appointed lecturer in chemistry at the University of Sheffield, 466
Djerassi, Prof. C.: The Chemistry of Natural Products (Application of Optical Rotatory Dispersion Studies to Problems in Natural Products Chemistry), 1080
D_2O (Molecules H_2O, HDO and): Ultra-violet Absorption Spectra of the (Dr. Jack Barrett and Dr. A. L. Mansell), 138; (R. M. Golding), 139
Doak, Sheila M. A. (Davies, A. J. S., and): Fate of Homologous Adult Spleen Cells injected into New-born Mice, 610
Dodd, Dr. J. M.: Appointed to the chair of zoology in the University of Leeds, 197; work of, 197
Dodds, Dr. K. S.: The John Innes Institute, 467
Dog: Topographical Anatomy of the (Dr. O. Charnock Bradley), sixth edition revised by Prof. Tom Grahame, *review* by Prof. T. Nicol, 451
Dog (Man, Horse, Sheep and): Occurrence of Keto-Acids in Blood Serum and Urine of Cattle in comparison with (Dr. C. J. G. van der Horst), 146
Dogs: Effects of Ataractic Drugs on the Blood-Pressure and Heart-Rate of (L. W. Hall and D. E. Stevenson), 696
Doireau, M., and others: Electronic Equipment used in the Nuclear Energy Industry in France, 1076
Dolerites (Quartz-): Stress-Dependent Magnetization in some (Dr. D. W. Powell), 225
Dollery, C. T., and West, J. B.: Metabolism of Oxygen-15, 1121
Domain or Turbostratic Structure of Clays (L. A. G. Aylmore and Dr. J. P. Quirk), 1046
Domestic Fowl: Antibody Responses of the, to Two Soluble Bacterial Antigens (Dr. G. Gowland), 624
Domestic Heating and Thermal Insulation (Building Research Station, Digest 133), 999
Doniach, Dr. I.: Appointed to the chair of morbid anatomy at the London Hospital Medical School, 466
Doniach, Dr. I., and Francois, Dr. P. E.: Comparison of Iodine-124 and Iodine-131 in Inhibition of Goitrogenesis in the Rat, 704
Dorsal Skin Secretion of *Xenopus laevis*: Serotonin, a Melanocyte-stimulating Component in the (Dr. F. C. G. van de Veerdonk), 948
Doses (Excessively Large), of Oral Griseofulvin: Tumour-promoting Effect of, on Tumours induced in Mice by Methylcholanthrene (Louis L. Barich, Takashi Nakai, Jan Schwarz and Donna Jean Barich), 335
Doses (Small), of Reserpine: A Suggested Effect on Levels of Catecholamine in Brain produced by (F. Barbara Orlans and Dr. Bernard B. Brodie), 1034; (Herbert Sheppard and Joseph H. Zimmerman), 1035
Doubling of the Content of Deoxyribonucleic Acid: A Bleached Variant of *Euglena gracilis* showing a (Dr. George Brawerman, Carole A. Rebman and Prof. Erwin Chargaff), 1036
Douglas, A.: At the second Annual Conference of the British Computer Society (Language and General-purpose Programmes for Market Research), 655
Douglas, Dr. A. W.: Appointed to a senior lectureship in inorganic and physical chemistry at the University of Liverpool, 117
Douglas, Prof. R. W.: *Obituary* of Prof. H. Moore, 1074
Dowben, Robert M., and others: Inhibition of Glucuronosyl Transferase by Progestational Agents from Serum of Pregnant Women, 693
Dowden, R. L.: Geomagnetic Noise at 230 kc./s., 677
Dowdeswell, W. H.: Ecological Processes, *review*, 451
Dowell, Dr. J. D.: Appointed a lecturer in physics at the University of Birmingham, 465
Downie, A. R., and others: Screw Sense of the α-Helix in Poly-β-benzyl-L-aspartate, 321
Downman, Dr. C. B. B.: Appointed to the Sophia Jex-Blake chair of physiology at the Royal Free Hospital School of Medicine, London, 466
Doyle, Dr. William T.: Maternal Inheritance and Interspecific Hybrids of the Liverwort *Sphaerocarpos*, 429
Dragonflies (Dr. Philip S. Corbet, Cynthia Longfield and Dr. N. W. Moore), *review* by Dr. D. E. Kimmins, 631
Drake, J. A.: Combustion and Propulsion—High Mach Number Air-breathing Engines (The Ram Jet as an Entity), 20
Dried Blood-stains on Fabrics: Absorption-Elution Grouping of (S. S. Kind), 789
Drifts (Ionospheric): Possibility of Detecting, from the Occurrence of Spread *F* Echoes at Low Latitudes (R. W. Knecht), 927
Droplet Growth in Gaseous Media: Evaporation and (N. A. Fuchs), translated from the Russian by J. M. Pratt; edited by Dr. R. S. Bradley, *review* by Prof. F. H. Garner, 451
Drouhin, G.: Problems of the Arid Zones (Alternative Uses of Limited Water Supplies—Algeria—Possibility of Using Minor Water Resources), 296
Drowsy State: Paradoxical Blocking and Arousal in the (Dr. L. Goldie and Dr. J. M. Green), 952
Druca, C., and others: Effect of some Aromatic Hydroxy Compounds on the Phagocytic Activity of the Reticulo-Endothelial System, 422
  Effect of Three Compounds related to Diethylstilboestrol on the Phagocytic Activity of the Reticulo-Endothelial System, 1032
Drugs known to affect Adrenergic Mechanisms: Parallelism of Changes produced by Cooling and by (Prof. Eleanor Zaimis), 213
Drugs for the Treatment of Hypertension (Manchester and District Section of the Royal Institute of Chemistry, and the Manchester Section and Fine Chemicals Group of the Society of Chemical Industry Symposium on), 743
Drugs (Ataractic): Effects of, on the Blood-Pressure and Heart-Rate of Dogs (L. W. Hall and D. E. Stevenson), 696
Drummond, Dr. R.: Identification of Blood-Group Antigens, *review*, 357
Dry Soils (Wet and): Potash in, *review* by Dr. P. W. Arnold, 976
Drying of Biological Materials: Freezing and (Dr. Harold T. Meryman, and 12 other Authors), 748
Drying (Freeze-) of Plant Viruses (M. Hollings and R. A. Lelliott), 1078
Dubos, Dr. René: Mirage of Health, *review* by Prof. E. Maurice Backett, 633
Ductility of Beryllium at High Temperatures: An Improvement in the (A. Brown, F. Morrow and A. J. Martin), 494
Ductility (Work-Hardening and), of Rhenium and their relation to the Behaviours of other Metals having a Hexagonal Structure (R. A. Jeffery and E. Smith), 52
Duddell Medal Address to the Physical Society (Prof. R. V. Jones), 905

Duddell Medal Addresses to the Physical Society (G. G. Scarrott and G. W. Hutchinson), 854
Dudel, Dr. Josef, and Kuffler, Prof. Stephen W.: Excitation at the Crayfish Neuromuscular Junction with Decreased Membrane Conductance, 246
  A Second Mechanism of Inhibition at the Crayfish Neuromuscular Junction, 247
Dugger, C. L. : Combustion and Propulsion—High Mach Number Air-breathing Engines (The Ram Jet as an Entity), 20
Duguid, Dr. J. P. : Appointed reader in bacteriology at the University of Edinburgh, 465
Duhig, James T. : Bone Marrow Depression in Murine Leukaemia, 71
Dullien, F. A. L., and Shemilt, Prof. L. W. : Equations for Determining Diffusion Coefficients in Liquid Systems by the Diaphragm-Cell Technique, 767
Duncton, P. J. A Plain Man's Guide to Atomic Energy, 1076
Dunsford, Dr. I., and Grant, Jean : The Anti-Globulin (Coombs) Test in Laboratory Practice, *review* by Dr. R. Drummond, 357
Dunwoody, Dr N. T. : Appointed lecturer in engineering mathematics at the Queen's University, Belfast, 465
Durieux, M., and others : The Helium-4 Scale of Temperature, 1077
Dust Flames : Control of Reaction Rate in (J. M. Beér and Dr. R. H. Essenhigh), 1106
Duwez, Prof. P. : Combustion and Propulsion—High Mach Number Air-breathing Engines (Materials Problems raised by the Very High Temperatures of Hypersonic Air-breathing Engines), 21
Duwez, Prof. Pol, and others . Non-crystalline Structure in Solidified Gold–Silicon Alloys, 869
Dwight, Dr. A. E. Positions of Thorium and Uranium in the Periodic Table, 505
Dwyer, Dr. F. P., and Sargeson, Dr A. M · Catalytic Racemization of *tris*(Ethylenediamine) Cobalt (III) Ion, 1022
Dye-sensitized Photo-reactivation of X-Ray Damage in Diploid Yeast (Dr David Freifelder and Prof. Robert B Uretz), 953
Dye (Azo-) Method for Histochemical Demonstration of Acid Phosphatase : A Simple (Dr. Tibor Barka), 248
Dyes (Protein-bound Aminoazo) : Distribution of, in the Rat Liver Microsome (Dr T. Yamada, M. Matsumoto, S. Kanda and Prof. H. Terayama), 943
Dyestuffs (Azo) : Use of, for the Polarographic Determination of the Lanthanides (T. M. Florence and L. E. Smythe), 771
Dynamics of Flight—Stability and Control (Prof. Bernard Etkin), *review*, 444
Dyring, Eric, and others : Dependence on Latitude of the Amplitude of the Diurnal Variation of Cosmic Rays, 1099
Dzibilchaltun in Yucatan : Excavations at, 742

EAMES, F. E , and others . The American Oligocene, 679
Early History of the Earth : Nuclear Fission in the (Prof. P. K. Kuroda), 36
Early India and Pakistan to Ashoka (Sir Mortimer Wheeler), *review* by M C. Burkitt, 94
Earth : Geomagnetic Storms and the Space around the (Prof. Sydney Chapman), 824
  Nuclear Fission in the Early History of the (Prof. P. K. Kuroda), 36
  Physics and Chemistry of the (edited by Prof. L. H. Ahrens, Frank Press, Kalervo Rankama and Prof. S K. Runcorn), Vol 3, *review* by B. E. Leake, 544
Earth beneath the Sea (Prof. Francis P. Shepard), *review* by Dr. G. E. R. Deacon, 629
Earth Satellite 1960λ : The Russian, 830
Earth's Gravitational Potential : Evaluation of the Second, Fourth and Sixth Harmonics in the (D. G King-Hele), 490
Earth's Magnetic Field : Longitude Effect in Temperate Zone Sporadic *E* and the (L. H. Heisler and Dr J. D. Whitehead), 676
Earth (Rare) Groups : Products of the (Johnson, Matthey and Co Ltd.), 832
Earthworm : Occurrence of Free D-Serine in the (Dr. H. Rosenberg and Prof. A. H. Ennor), 617
Earthworm Population Studies—a Comparison of Sampling Methods (F. Raw), 257
East, K : Awarded a Nature Conservancy Diploma Course in Conservation and Ecology at University College, London, 742
East Africa . Scientific Research in, 206
East Africa High Commission : Annual Report for 1959, 206
  Annual Report for 1959 of the East African Fisheries Research Organization, 469
East African Fisheries Research Organization : Annual Report 1959 (East Africa High Commission), 469
East African Virus Research Institute : Report for 1958-59 (J. D. Gillett), 565
East Anglia : Nature and Conservation in (Council for Nature), 649
Easterbrook, J. A. : Cybernetics and Management, *review*, 269
Eastern Atlantic Ocean · Magnetization of Sediment Cores from the (M J. Keen), 220
Eastoe, J E. Organic Matrix of Tooth Enamel, 411
Eccles, Sir John . The Chemistry of Natural Products, 1080
Echinoderm Fauna of the Central North Sea · A Quantitative Investigation of the (Dr. Erik Ursin), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 24), *review* by Dr. A. J. Southward, 360
Echo I (1960ι) : The Satellite, 741
  Reflection of Signals from Satellite, 901
Echo Sounding Experiments in the Barents Sea (I. D. Richardson, D. H. Cushing, F R. Harden Jones, R. J. H Beverton and R. W. Blacker), 855
F Echoes (Spread), at Low Latitudes : Possibility of Detecting Ionospheric Drifts from the Occurrence of (R. W. Knecht), 927
Ecklonia radiata . Carbohydrates of (C. M. Stewart and H. G. Higgins), 511
Ecological Processes (Dr. Alan Mozley), *review* by W. H. Dowdeswell, 451
Ecology : Research Studentships for postgraduate training in (Nature Conservancy Awards for 1960), 742
Ecology in Australia : Biogeography and (edited by A. Keast, R. L Crocker and C. S. Christian), *review* by Prof. A. J. Marshall, 543
Economic Progress : The Conditions of (Colin Clark), 537
Ectromelia. Effect of a Primary Tuberculous Infection on the Resistance of Male and Female Mice to (Dr. A. W. Gledhill and Dr. R. J. W. Rees), 703
'Eddy' Diffusion in Chromatography (A. Klinkenberg and F. Sjenitzer), 1023 ; (J. Calvin Giddings), 1023
Editors : Influence of (Scientific Publications Council Discussion on), 120
Edmonds, Dr. D. T. : Appointed by the Royal Society to a Mackinnon Research Studentship at the Clarendon Laboratory, Oxford, 291
Edmondson, Prof. W. T. (edited by) : Fresh-Water Biology (Henry Baldwin Ward and George Chandler Whipple), second edition, *review* by Dr. T. T. Macan, 6
Education : Studies in the History of, 1780-1870 (Brian Simon), *review* by Dr. James L. Henderson, 357
Education in Britain : Science and, 906
Education, Central Advisory Council for—England : Report, Vol. 2, Surveys, 883
Education, Illinois Department of Registration and : Biological Notes No. 41, Population Trends among Hawks and Owls in Illinois (Richard R. Graber and Jack S. Golden), 999
Education, United States Office of (prepared by) : Technical and Vocational Education in the U.S.A.—a Bibliographical Survey (Unesco, Educational Studies and Documents No. 36), 741
Education (Adult), Universities Council for : Report on the Year 1958-1959, 906
Education (Comparative) : Essays in, *review* by Brian Holmes, 635
Education (Engineering), in Russia (S. P. Timoshenko), 537
Education (English) : Sixty Years of Progress in (Prof. H C Dent), 848
Education (Further) : Part-Time Courses in (J. Heywood), 189
Education (Health) : Training of Teachers for (United Nations, World Health Organization, Technical Report Series No. 193), 638
Education (Modern) : Evolution of, *review* by Dr. James L. Henderson, 357
Education (Technical and Vocational), in the U.S A.—a Bibliographical Survey prepared by the United States Office of Education (Unesco, Educational Studies and Documents No. 36), 741
Education (University), in Britain, 719
Education (University), in New Zealand (Prof. V. J. Chapman), 107
Education (University) : The Place of Physiology in (Prof. J. A. B. Gray), 719
Education and Industry, 470
Education and Training of Professional Radio and Electronics Engineers (British Institution of Radio Engineers Report on), 115
Educational Co-operation : Commonwealth (Commonwealth Relations Office, Colonial Office), 441
Educational Co-operation in the Commonwealth, 113, 441
Educational Publications, Ltd , Wakefield : New Filmstrips, 832
Educational Research The Need for, 883
Edvarson, K. (Low, Kerstin, and) Content of Caesium-137 and (Zirconium + Niobium)-95 in Swedish Soils, 736
Edwards, Prof. J. : Nuclear Training Facilities at the Royal Naval College, Greenwich, 545
Effect of Acridine Orange in Living Bull Spermatozoa (C. van Duijn, jun.), 1006
Effect of Anti-Diuretic Hormone and Calcium on the Equivalent Pore Radius of Kidney Slices from *Necturus* (G. Whittembury, N. Sugino and Dr. A. K. Solomon), 699
Effect of some Aromatic Hydroxy Compounds on the Phagocytic Activity of the Reticulo-Endothelial System (Prof. T. Nicol, C. Druce and C. C. Ware), 422
Effect of Autumn Applications of Potassium Gibberellate on Fruit Production of the Strawberry (Prof. Carter R. Smith), 620
Effect of *Candida albicans* on the Evolution of Experimental Tuberculosis (Dr. E. Mankiewicz and Dr. M. Liivak), 250
Effect of the Cations of the Lyotropic Series on the Tension of Vascular Muscle (Prof. L. Laszt), 329
Effect of Cocaine on the Disposition of Noradrenaline labelled with Tritium (Dr. L. G. Whitby, G. Hertting and Dr. J. Axelrod), 604
Effect of Cortisone on Degenerating Nerve Fibres in Birds (Dr. P. Glees), 327
Effect of Electric Fields on Hydrogen-like Excitons (J. W. Allen), 51
Effect of Electronarcosis on Oxygen Consumption and Carbon Dioxide Output (Dr Jaroslav Strmiska and Dr. Antonín Vacek), 151
Effect on Forest Management : The Development of Pulp and Particle Board Industries and their (Society of Foresters of Great Britain Discussion on), 32
Effect of Glutathione and Alloxan on the Photoperiodic Response of *Xanthium* (J. Nitsan), 81
Effect of Glycerine on the X-Ray Sensitivity of *Serratia marcescens* (Dr. D. L. Dewey), 1008
Effect of Heat on the Serum Factors Gm^{a}, Gm^{b} Gm^{x} and Gm-like (Prof. Arthur G. Steinberg and Rachel Stauffer), 791
Effect of Heavy Water on Respiratory-chain Enzymes (Dr H. Laser and Prof. E C. Slater), 1115
Effect of Hydration on Hexobarbitone-induced Sleep in Mice (Dr. N. K. Bhide), 1030
Effect of Lysergic Acid Diethylamide on Larval Growth (Dr D. V. Siva Sankar, Arthur Kopelman, Peter Schilder and Eleanor Gold), 153
Effect of 6-Mercaptopurine on the Net *in vitro* Gas Production of Sensitive and Resistant *L*1210 Mouse Leukaemia Cells (Dr. H. J. Woodliff), 156
Effect of Nitrate Ion on the Distribution of Sucrose in the Rat's Ventricle (S. T. Takata, C. G Alexander and Prof. G A. Feigen) 419
Effect of Penicillin on the Maintenance of Rumen Oligotrich Protozoa (G. S. Coleman), 518
Effect of the Peritoneal Fluid of the Guinea Pig on Strains of Enteric Bacilli (Prof. R. J. Roantree and L. R. Collis), 1045
Effect of Potassium Cyanide Poisoning on the γ-Aminobutyric Acid-Level in the Brain (Dr. T Tursky), 322
Effect of a Primary Tuberculous Infection on the Resistance of Male and Female Mice to Ectromelia (Dr. A. W. Gledhill and Dr. R. J. W. Rees), 703
Effect of Pyruvate upon Nucleated and Enucleated Fragments of *Amoeba proteus* (Dr Edmund Guttes and Sophie Guttes), 432
Effect of Reserpine on the Nucleotide and Catecholamine Content of the Denervated Adrenal Medulla of the Rat (Prof. Nils-Åke Hillarp), 1032
Effect of a Resisting Couple on the Rotational Motion of a Rigid Body (T. Nonweiler), 311

Effect of Ribonuclease on Erythrocyte Antigens (Prof. Emanuel Hackel and Robert E. Smolker), 1036
Effect of Specular Reflexions on the Radiation Flux from a Heated Tube (Sir K. S. Krishnan), 135
Effect of Size of Pupil on Visual Acuity (Dr. F. W. Campbell and Dr. A. H. Gregory), 1121
Effect of Surface Density of Charge on the Physical Swelling of Lithium Montmorillonite (Dr. J. P. Quirk and B. K. G. Theng), 967
Effect of Temperature on the Expansion on Setting of Gypsum Plaster (P. J. Sereda), 929
Effect of Testicular Hyaluronidase on the Permeability of Human Arterial Tissue (Jørgen Matzke), 873
Effect of Three Compounds related to Diethylstilboestrol on the Phagocytic Activity of the Reticulo-Endothelial System (Prof. T. Nicol, G. Brownlee, C. Druce and C. C. Ware), 1032
Effect of Trypan Blue on Rat Embryos (F. Beck, Dr. B. Spencer and Prof. J. S. Baxter), 605
Effect of Upper Atmosphere Wind on the Rotation of Satellite 1958δ1 (Dr. C. R. Faulkner), 926
Effect of Variations in Temperature on Meiosis in *Gagea reticulata* Schultes (Dr. C. P. Malik), 805
Effect of Vasoconstrictor Amines : Influence on the, by Pretreatment with Reserpine (H. C. Sabelli), 784
Effect of Wheat Gluten on the Peristaltic Reflex (Dr. R. Schneider, H. Bishop, Dr. B. Shaw and Prof. A. C. Frazer), 516
Effect (Bacterial), and Radiophosphorus Assimilation in Organic and Inorganic Forms in Salmon (Dr. P. N. Srivastava), 83
Effect (Borrmann), observed in an Aluminium Single Crystal (Koichi Nakajima and Prof Shigeyasu Koda), 53
Effect (Cage), in the Liquid-Phase Photolysis of Fluorinated Ketones (R. Bowles, Dr. J. R. Majer and Prof. J. C. Robb), 314,
Effect (Eosinophil Leucocyte-attracting), of Histamine in Skin (Dr. R. K. Archer), 155
Effect (Geoelectric), in Coleoptiles : Electrostatic Measurement of the (Carl Hellmuth Hertz), 320
Effect (Longitude), in Temperate Zone Sporadic E and the Earth's Magnetic Field (L. H. Hessler and Dr. J. D. Whitehead), 676
Effect (An Ortho), influencing Fungitoxicity, Electronic Absorption Spectra, and Chemical Reactivity with Mercaptalbumin (Dr. H. P. Burchfield and Eleanor E. Storrs), 593
Effect (Protective), of Cysteine against Retinal Degeneration induced by Iodate and Iodoacetate (Prof. Arnold Sorsby and Ronald Harding), 608
Effect (A Suggested), on Levels of Catecholamine in Brain produced by Small Doses of Reserpine (F. Barbara Orlans and Dr. Bernard B. Brodie), 1034 ; (Herbert Sheppard and Joseph H. Zimmerman), 1035
Effect (Tumour-promoting), of Excessively Large Doses of Oral Griseofulvin on Tumours induced in Mice by Methylcholanthrene (Louis L. Barich, Takashi Nakai, Jan Schwarz and Donna Jean Barich), 335
Effective (More) Organization and Administration of Materials Research and Development for National Security (United States National Academy of Sciences—National Research Council, Publication No. 718), 470
Effectiveness in Industry (W. E. Bargett), 378
Effects : The Marangoni (L. E. Scriven and C. V. Sternling), 186
Effects of Ataractic Drugs on the Blood-Pressure and Heart-Rate of Dogs (L. W. Hall and D. E. Stevenson), 696
Effects of Cysteine and of Anoxia on the Rate of Mitosis in Lens Epithelium : Comparison between the (Dr. Antoinette Pirie and Dr. Ruth van Heyningen), 947
Effects of Light and Darkness on the Rhythm of Output of Carbon Dioxide of Excised *Bryophyllum* Leaves (Dr. Malcolm B. Wilkins), 523
Effects of Linear Energy Transfer on the Radiolysis of Water and Heavy Water (Dr. E. Collinson, Prof. F. S. Dainton and J. Kroh), 475
Effects of Medial Temporal Lesions on Taste Preference in the Monkey (Dr. L. Weiskrantz), 879
Effects of pH and the Nature of the Primary Species in the Radiolysis of Aqueous Solutions (J. T. Allan and Dr. G. Scholes), 218
Effects of Pollution on Living Material (edited by W. B. Yapp), *review* by Dr. G. C. Ware, 1061
Effects of Whole-body Irradiation on the Breeding Plumage of the Weaver Finch, *Quelea quelea* (Dr. B. Lofts, Prof. A. J. Marshall and Prof. J. Rotblat), 615
Effects (Biological), of Atomic Radiation—Summary Reports from a Study by the National Academy of Sciences (United States National Academy of Sciences—National Research Council), 380
Effects (Biological), of Exposure to Intense Radiation, 910
Effects (Chemical), of Ionizing Radiations on Nucleic Acids and Nucleoproteins (P. Emmerson, Dr. G. Scholes, D. H. Thomson, J. F. Ward and Prof. J. Weiss), 319
Effects (Delayed 'Primary'), in *Chara vulgaris* L. subjected to X-Rays (C. M. Gillet), 874
Effects (Orienting), in Octahedral Aquation (Sir Christopher Ingold, Prof. R. S. Nyholm and Dr. M. L. Tobe), 477
Effluent Liaison : Special Assistance for (British Leather Manufacturers' Research Association), 992
Egg-Yolk Reactions of *Pseudomonas* Species (Dr. A. T. Willis and Dr. G. Gowland), 432
Eggs (De-embryonated) : Physical Incompleteness of Influenza Virus propagated in (Martin Hanig and Joseph M. Stern), 40
Eggs (Mouse) : Development of, beneath the Kidney Capsule (D. R. S. Kirby), 707
Ehmert, Prof. Alfred : Elected a member of the Geophysics section of the Leopoldina Academy of Natural Sciences, 1079
Eighteenth-Century Science : The Transits of Venus—a Study of (Prof. Harry Woolf), *review* by Dr. David S. Evans, 636
Eisenschitz, Prof. R. : Reference Book of Theoretical Physics, *review*, 445
Elasmobranchs : Presence of a Pituitary Portal System in (Patrick Meurling), 336
Elateridae : Pathogenicity of *Metarrhizium anisopliae* (Metch.) Sor. and *Beauveria bassiana* (Bals.) Vuill. to Two Species of (Dr. R. D. Tinline and R. Y. Zacharuk), 794
Elderfield, Prof. Robert C. : Appointed chairman of the Division of Chemistry and Chemical Technology of the United States National Academy of Sciences—National Research Council, 647
Electric Fields : Effect of, on Hydrogen-like Excitons (J. W. Allen), 51
Electric and Magnetic Field : Michael Faraday and the Evolution of the Concept of the (Prof. L. Pearce Williams), 730
Electrical Discharges in the Solar Atmosphere : Temperatures reached in (Dr. C. E. R. Bruce), 865
Electrical Engineering in the Imperial College of Science and Technology, London, 463
Electrical Power Convention (British) : Presidential Address, Electricity—the New Horizon (Viscount Chandos), 557, 831
Electrical Resistivity of Thermosetting Polymers : Dependence on Temperature of the (R. W. Warfield and M. C. Petree), 316
Electrical Sensitivity of the Ampullae of Lorenzini (Dr. R. W. Murray), 957
Electricity—the New Horizon (Viscount Chandos), 557, 831
Electricity and Gas Industries (Coal,) : Capital Investment in the (Ministry of Power), 1055
Electrokinetic Parameters at Metal Surfaces : Simultaneous Measurement of Adsorption and (A. M. Peers), 503 ; (Dr. E. A. Blomgren and Dr. J. O'M. Bockris), 504
Electro-deposit (Chromium) : Hexagonal Modification of Black (Hideya Okada and Takeo Ishida), 496
Electrolysis (The Fusion), of Titanium (Dr. W. J. Kroll), 994
Electrolyte Solutions (Aqueous) : Ultrasonic Velocities in (Dr. C. G. Balachandran), 136
Electromagnetic Standing Waves and Ball Lightning (Dr. Lewi Tonks), 1013
Electromagnetic Waves : Ionospheric Propagation of, *review* by Sir Harrie Massey, 810
Electron Linear Accelerators : Pulse-shortening in (M. G. Kelliher and R. Beadle), 1099
Electron (Exo-) Emission in Plastically Deformed Metals : A Possible Origin of (Dr. A. H. Meleka and W. Barr), 232
Electron Microscope Images of Dislocations (Dr. Hatsujiro Hashimoto and Dr. Kazuo Fujita), 51
Electron Microscopy (Nederlandse Vereniging voor Electronenmicroscopie European Regional Conference on), 29
Electron Microscopy : Use of Ferritin-conjugated Antibody to Localize Antigen by (Richard A. Rifkind, Konrad C. Hsu, Councilman Morgan, Beatrice C. Seegal, Alice W. Knox and Harry M. Rose), 1094
Electron Microscopy of Ultra-thin Sections : A Vacuolar System in Cells of *Agrobacterium tumefaciens* as shown by (Miguel Rubio-Huertos and Paul R. Desjardins), 1043
Electronarcosis : Effect of, on Oxygen Consumption and Carbon Dioxide Output (Dr. Jaroslav Strmiska and Dr Antonín Vacek), 151
Electronenmicroscopie, Nederlandse Vereniging voor : European Regional Conference on Electron Microscopy, 29
Electronic Absorption Spectra, and Chemical Reactivity with Mercaptalbumin : An Ortho Effect influencing Fungitoxicity, (Dr. H. P. Burchfield and Eleanor E. Storrs), 593
Electronic Computers : Research in the Use of (Unesco Fellowships for), 465
Electronic Engineering Association : Awards for articles on Electronics, 116
Electronic Engineering Society (Hull), (Institution of Electronics, with the co-operation of the) : Electronics and Instruments Exhibition and Convention, 650
Electronic Equipment used in the Nuclear Energy Industry in France (P. Desneiges, M. Doireau, L. Koch and J. Weill), 1076
Electronic Figure Reader, 28
Electronic States (Excited), of Lithium and Sodium Molecules (Dr. R. F. Barrow, N. Travis and C. V. Wright), 141
Electronics : Awards for articles on (Electronic Engineering Association), 116
Electronics, Institution of, with the co-operation of the Hull Electronic Engineering Society : Electronics and Instruments Exhibition and Convention, 650
Electronics Dictionaries : Communications and, *review* by Dr. R. L. Smith-Rose, 1059
Electronics Engineers (Radio and) : Education and Training of Professional (British Institution of Radio Engineers Report on), 115
Electronics and Instruments Exhibition and Convention (Institution of Electronics, with the co-operation of the Hull Electronic Engineering Society), 650
Electronics and Waveguides : Swedish Supplement to Elsevier's Dictionary of (W. E. Clason), *review* by Dr. R. L. Smith-Rose, 1059
Électroniques : Les Semiconducteurs (Dr. E. Spenke), traduit par L. Godefroy, *review* by Dr. J. R. Tillman, 1058
Electrophoresis (Starch-Gel), of Wheat Proteins (Dr. G. A. H. Elton and J. A. D. Ewart), 600
Electrophoresis (Zone), of Anthocyanins (Prof. P. Markakis), 1092
Electrophoretic Pattern during Amphibian Development (H. Denis), 62
Electrophoretic Separation of certain *in vitro* and *in vivo* Reactions of Rabbit Anti-Mouse Erythrocyte Serum (Chang-Ling Lee, Tamon Takahashi and Israel Davidsohn), 157
Electrophoretic (Immuno-) Differentiation, of Haptoglobins from another Group-Specific Inheritable System in Normal Human Sera (Dr. Jan Hirschfeld), 126
Electrophysiological Observations on a Sound-producing Fish (A. Packard), 63
Electro-shock Seizure Threshold of Metacorticoid Hypertensive Rats (Dr. F. M. Sturtevant), 874
Electrostatic Forces : The Physics of, and their Applications (Centre National de la Recherche Scientifique International Colloquium on), 466
Electrostatic Measurement of the Geoelectric Effect in Coleoptiles (Carl Hellmuth Hertz), 320
Element Relationships (Major), in Tektites (R. D. Cherry, Dr. S. R. Taylor and Maureen Sachs), 680
Elements (Minor), in Soils, *review* by A. H. Debnam, 629
Elements (Rare and Dispersed Chemical), in Soils : The Geochemistry of (A. P. Vinogradov), second edition, (translated from the Russian), *review* by A. H. Debnam, 629
Elements and Compounds of Group IVA (Harold P. Klug and Prof. Robert C. Brasted), (Comprehensive Inorganic Chemistry, edited by Prof. M. Cannon Sneed and Prof. Robert C. Brasted, Vol. 7), *review* by Dr. K. W. Bagnall, 185
Ellem, K. A. O., and others : Reversible Dissociation of Ribonucleic Acid, 509
Ellenbogen, Dr. Eric : *Obituary* by Prof. Robert E. Olson, 554

Elliot, Dr. H. E.: Title of professor of physics in the University of London (at the Imperial College of Science and Technology) conferred on, 466
  Grants for Space Research—£7,275 (for satellite measurements of the primary cosmic-ray energy spectrum), and £1,500 (for an investigation into cosmic-ray intensity variations at rocket altitudes), 744
Elliott, Dr. A., and others: Screw Sense of the α-Helix in Poly-β-benzyl-L-aspartate, 321
Ellison, Prof. M. A., and others: The Solar Flare of June 1, 1960, 926
Elsevier's Dictionary of Electronics and Waveguides: Swedish Supplement to (W. E. Clason), *review* by Dr. R. L. Smith-Rose, 1059
Elsevier's Telecommunication Dictionary in Six Languages—English/American, French, Spanish, Italian, German, Dutch (compiled and arranged on an English alphabetical base by A. Visser), *review* by Dr. R. L. Smith-Rose, 1059
Elson, N.: Has joined Cossor Communications, Ltd., as technical director, 832; work of, 832
Elson and Morgan Method: Glucosamine Values of Muramic Acid and other Amino-Sugars by the (R. E. Strange), 38
Elton, C. S.: Evolutionary Divergence, *review*, 446
Elton, Dr. G. A. H., and Ewart, J. A. D.: Starch-Gel Electrophoresis of Wheat Proteins, 600
Elution (Absorption-) Grouping of Dried Blood-stains on Fabrics (S. S. Kind), 789
Embassy (British), at Buenos Aires: Appointment of A. G. Mill as agricultural and food attaché, 1075
Emberger, Prof. L. (Lemée, Prof. G., and): Problems of the Arid Zones (Plant Ecology), 295
Embryo: The Avian (Prof. Alexis L. Romanoff), *review* by Prof. C. H. Waddington, 814
Embryo (Chick): Assay of Corticosteroids in the (Sir Macfarlane Burnet and N. L. Warner), 938
Embryo (Chick) Fibroblast Cells: An Interferon-like Substance released from Tick-borne Encephalitis Virus-infected (Dr. J. Vilček), 73
Embryonic Cuticle (Provisional), of a Lepidopteran: Occurrence and Function of the (Dr. R. K. Sharan), 1040
Embryonic Plant Tissue: Stabilization by Manganous Ions of Ribosomes from (Dr. J. W. Lyttleton), 1026
Embryos of Birds, *review* by Prof. C. H. Waddington, 814
Embryos (Guinea Pig): Development of Delayed-type Hypersensitivity in (Jonathan W. Uhr), 957
Embryos (Rat): Effect of Trypan Blue on (F. Beck, Dr. B. Spencer and Prof. J. S. Baxter), 605
Emeléus, Prof. H. J.: Elected a member of the Chemistry section of the Leopoldina Academy of Natural Sciences, 1079
Emergence of Civilization: Africa's Place in the (Prof. Raymond A. Dart), *review* by M. C. Burkitt, 891
Emery, Dr. V. J.: Appointed lecturer in mathematical physics at the University of Birmingham, 465
EMI Co., Ltd.: Figure Reading Electronic Device (*Fred*), 28
Emigration Overseas: Welsh (Prof. E. G. Bowen), 843
Emission (Exo-Electron), in Plastically Deformed Metals: A Possible Origin of (Dr. A. H. Meleka and W. Barr), 232
Emission (Radio), from Jupiter: Ionospheric Modification of the (Prof. Alex G. Smith, T. D. Carr, H. Bollhagen, N. Chatterton and F. Six), 568
Emmelot, P., and Bennedetti, E. L.: Cytoplasmic Particles and their Role in Protein Synthesis (Inhibition of the Ability of whole Microsomes to Incorporate Amino-Acids in Rats injected with Dimethyl-nitrosamine), 645
Emmerson, P., and others: Chemical Effects of Ionizing Radiations on Nucleic Acids and Nucleoproteins, 319
Enamel (Tooth): Organic Matrix of (J. E. Eastoe), 411
Encephalitis (Tick-borne): Virus and Antibodies in the Lymph and Blood of Sheep infected experimentally with the Virus of (Doubravka Málková), 716
Encephalitis Virus-infected Chick Embryo Fibroblast Cells: An Interferon-like Substance released from Tick-borne (Dr. J. Vilček), 73
Encyclopedia: Man-Made Textile (edited by J. J. Press), *review* by Prof. C. S. Whewell, 2
Endocrinology of Reproduction, *review* by Prof. P. L. Krohn, 5
Endocrinology of Reproduction: Recent Progress in the—Proceedings of the Conference held in Syracuse, 1958, *review* by Prof. P. L. Krohn, 5
Enemies and Allies: Parasites as (Dr. J. Mahon), 203; (Prof. T. H. Davey), 203
Energies of Activation for Self-diffusion of Alkali Metal Ions in Analcite (Prof. R. M. Barrer and L. V. C. Rees), 768
Energy for the Atmosphere, *review* by Prof. P. A. Sheppard, 974
Energy (Dissociation), of S_2: Mass Spectrometric Investigation of the Vaporization of Sulphides and the (R. Colin, Prof. P. Goldfinger and M. Jeunehomme), 408
Energy (High-) Bound Phosphate and Diabetes Mellitus (Dr. Yoshio Goto, Isao Ito, Akihiko Kuwano and Yukio Ujiie), 702
Energy (High-) Oxygen Ions in Carbon Dioxide Mass Spectra (R. M. S. Hall), 683
Energy (High-) Phosphate Requirement for Succinate Oxidation in Uncoupled Rat Liver Mitochondria (Dr. Giovanni Felice Azzone and Dr. Lars Ernster), 65
Energy (High-) Physics (Commission on High Energy Physics of the International Union of Pure and Applied Physics Tenth Annual International Conference on), 29
Energy Transfer (Linear): Effects of, on the Radiolysis of Water and Heavy Water (Dr. E. Collinson, Prof. F. S. Dainton and J. Kroh), 475
Engelberg, Hanna, and Artman, Dr. M.: Absence of Carbon Monoxide-sensitive Respiration in a Streptomycin-dependent Mutant of *Escherichia coli* grown in Limited Amount of Streptomycin, 801
Engine (Steam) to Satellite: Science as History—the Story of Man's Technological Progress from (Heinz Gartmann), translated from the German by Alan G. Readett, *review* by J. L. Stollery, 8
Engineer: Statics and the (Sir Alfred Pugsley), 844
Engineering: Radio and Electronics, 115
  Television (S. W. Amos and D. C. Birkinshaw), Vol. 1, Fundamentals, Camera Tubes, Television Optics, Electron Optics (written in collaboration with J. L. Bliss); Vol. 2, Video-Frequency Amplification; Vol. 3, Wave-form Generation; Vol. 4, General Circuit Techniques, *review* by Dr. R. L. Smith-Rose, 358
Engineering Laboratory (National): Open Days (R. I. Lithgow), 899
  Symposium on Flow Measurement in Closed Conduits, 905
Engineering Personnel (Scientific and): Direction and Supervision of (Northampton College of Advanced Technology, London, Advanced Course on), 905
Engineering (Chemical) Practice (edited by Herbert W. Cremer and Sidney B. Watkins), Vol. 11, Works Design, etc., *review* by Prof. J. M. Coulson, 887
Engineering (Electrical), in the Imperial College of Science and Technology, London, 463
Engineering (Electronic) Association: Awards for articles on Electronics, 116
Engineering (Electronic) Society (Hull), (Institution of Electronics, with the co-operation of the): Electronics and Instruments Exhibition and Convention, 650
Engineering (Mechanical), at Cardiff, 555
Engineering (Nuclear) Abstracts, Vol. 1, No. 1, 993
Engineering (Soil): Laboratory Testing in (T. N. W. Akroyd), *review* by Dr. H. L. Penman, 891
Engineering (Television): Principles and Practice of, *review* by Dr. R. L. Smith-Rose, 358
Engineering Corporation (High Voltage): Second Accelerator Conference, 743
Engineering Education in Russia (S. P. Timoshenko), 537
Engineering Invention: History of, *review* by J. L. Stollery, 8
Engineering Problems: Unification of Analytical Approaches to, *review* by Prof. J. Greig, 359
Engineering Sciences, Royal Swedish Academy of, and the Swedish Association of Technical Physicists: Fifth International Instruments and Measurements Conference and Exhibition, 374
Engineering Systems Analyses (Prof. Robert L. Sutherland), *review* by Prof. J. Greig, 359
Engineers, Royal Institute of, and others: International Congress on the Technology of Plastics Processing, 559
Engineers (Chemical), Institution of (Constructors John Brown, Ltd., and the): A CJB Scholarship awarded to M. D. Taylor, 650
Engineers (Corrosion), British Association of: Elected a member of the European Federation of Corrosion, 25
Engineers (Gas), Institution of, and the Corrosion Group (Birmingham and Midlands Section) of the Society of Chemical Industry: Symposium on the Protection of Gas Plant and Equipment from Corrosion, 466
Engineers (Radio), British Institution of: Report on the Education and Training of Professional Radio and Electronics Engineers, 115
Engineers (Radio), Institute of (Benelux Section), in co-operation with others: International Symposium on Data Transmission, 290
Engineers (Radio), Institute of (Group on Communications Systems), and others: International Symposium on Data Transmission, 290
Engineers (Radio and Electronics): Education and Training of Professional (British Institution of Radio Engineers Report on), 115
Engineers (Women): Travel Awards for (Caroline Haslett Memorial Trust), 116
Engines (Air-breathing): High Mach Number (AGARD fourth Colloquium on Combustion and Propulsion), 18
England: Monetary Thought and Monetary Policy in (Prof. R. S. Sayers), 844
England (Rural), Council for the Preservation of: Twenty-first National Conference for the Preservation of the Countryside, 559
Englert, F. (Aigrain, Prof. P., et): Les Conducteurs, *review* by Dr. J. R. Tillman, 1058
English Blood Donors: MNSS Gene Frequencies in (Dr. T. E. Cleghorn), 701
English Catalogue: Soviet Science in, 1960 (Program for Science Translations, Jerusalem), 832
English Education: Sixty Years of Progress in (Prof. H. C. Dent), 848
English Newspaper since 1900: The (F. Atkinson), 116
English Rural Life, Museum of: Report for 1959, 26
Enkomi Silver Cup (Dr. G. F. Claringbull and A. A. Moss), 1051; (Dr. Harold J. Plenderleith), 1052
Ennor, Prof. A. H. (Rosenberg, Dr. H., and): Occurrence of Free D-Serine in the Earthworm, 617
Enough: Chemistry is Not (Dr. James Taylor), 841
Enriched (Highly) Oxygen-18 Water Solutions containing Hydrogen Peroxide-16,16: Radiolysis of (Dr. Michael Anbar, Shmuel Guttmann and Prof. Gabriel Stein), 57
Ensete berryi—Revised Name for *Musa ensetiformis* Berry (R. K. Jain), 342
Enteric Bacilli: Effect of the Peritoneal Fluid of the Guinea Pig on Strains o (Prof. R. J. Roantree and L. R. Collis), 1045
'Enthalpy Titrations' and Thermochemistry in Molten Salts (Prof. Joseph Jordan, Jurg Meier, Edward J. Billingham, jun., and James Pendergrast), 318
Entomology: Annual Review of (edited by Edward A. Steinhaus and Ray F. Smith), Vol. 5, *review* by Prof. V. B. Wigglesworth, 542
Enucleated Fragments (Nucleated and), of *Amoeba proteus*: Effect of Pyruvate upon (Dr. Edmund Guttes and Sophie Guttes), 432
Envelopes (Moving), of Stars (Prof. V. V. Sobolev), translated by Sergei Gaposchkin, *review* by Prof. W. H. McCrea, 538
Environment: Cells and their, *review* by Dr. E. N. Willmer, 450
Environment (Geological), in West-Central New Mexico: Anomalous Leads from a Selected (William F. Slawson and Carl F. Austin), 400
Environment (Human): Mode of Formation of 3,4-Benzopyrene in (Prof. G. M. Badger, R. W. L. Kimber and T. M. Spotswood), 663
Environment and Culture in Southern Rhodesia (Roger Summers), 993
Enzymatic Activation of a Hormone-like Response in *Hydra* by Proteases (Dr. Howard M. Lenhoff and John Bovaird), 671
Enzymatic Hydrolysis: Formation of 6-Aminopenicillanic Acid from Penicillin by (Dr. G. N. Rolinson, F. R. Batchelor, D. Butterworth, J. Cameron-Wood, Dr. M. Cole, G. C. Eustace, Marian V. Hart, Dr. M. Richards and Prof. E. B. Chain), 236
Enzymatic Synthesis of Formylglutamic Acid by a Plant Protein (Ernest H. Byers, Jun., and T. J. Bond), 416
Enzyme: A Genetically Determined, in the Pig (Dr. K.-B. Augustinsson and Dr. B. Olsson), 924
Enzyme (Proteolytic), from *Bacillus subtilis*: Amino-Acid Sequence about the Reactive Serine of a (Dr. F. Sanger and D. C. Shaw), 872
Enzymes: Intracellular Localization of (Centre Inter-Universitaire de Recherches Enzymologiques Colloquium on), 836

Enzymes (Respiratory-chain) : Effect of Heavy Water on (Dr. H. Laser and Prof. E. C. Slater), 1115
Enzymic De-iodination of Thyroxine : Transiodination of Proteins during (Dr. J. R. Tata), 1025
Eosinophil Leucocyte-attracting Effect of Histamine in Skin (Dr. R. K. Archer), 155
Epidemiology of Cancer of the Lung (United Nations, World Health Organization, Technical Report Series No. 192), 115
Epidermal Cell in an Insect : The Control of Growth and Form—a Study of the (Prof. V. B. Wigglesworth), *review* by Prof. R. Dennell, 631
Epidote Minerals : Stability of (Prof. W. S. Fyfe), 497
Epinephrine and Norepinephrine in Liver and Kidney : Formation of a New Metabolite of (Dr. Goldstein and Dr. S. B. Gertner), 147
Epithelium (Lens) : Comparison between the Effects of Cysteine and of Anoxia on the Rate of Mitosis in (Dr. Antoinette Pirie and Dr. Ruth van Heyningen), 947
Epstein, Dr. M. A., and Holt, Dr. S. J. : Site and Nature of Adenovirus Nucleic Acid, 1050
Epstein, Dr. Samuel S., and Weiss, Jacqueline B. : Measuring the Size of Isolated Cells, 461
Equations for Determining Diffusion Coefficients in Liquid Systems by the Diaphragm-Cell Technique (F. A. L. Dullien and Prof. L. W. Shemilt), 767
Equations (Differential) : Boundary Problems in—Proceedings of a Symposium conducted by the Mathematics Research Center of the United States Army at the University of Wisconsin, 1959 (edited by Prof. Rudolph E. Langer), *review* by Prof. E. T. Copson, 451
Equatorial Spread-*F* and *F*-Layer Heights (Dr. A. J. Lyon, Dr. N. J. Skinner and Prof. R. W. Wright), 1086
Equipment (Electronic), used in the Nuclear Energy Industry in France (P. Desneiges, M. Doireau, L. Koch and J. Weill), 1076
Equipment (Gas Plant and) : Protection of, from Corrosion (Institution of Gas Engineers and the Corrosion Group of the Birmingham and Midlands Section of the Society of Chemical Industry Symposium on), 466
Equipment Exhibit (Research) : Tenth Annual Instrument Symposium and (United States National Institutes of Health), 559
Equivalent Pore Radius of Kidney Slices from *Necturus* : Effect of Anti-Diuretic Hormone and Calcium on the (G. Whittembury, N. Sugino and Dr. A. K. Solomon), 699
Ergonomics in Industry (Department of Scientific and Industrial Research Conference on), 117
Ergun, Sabri, and others : Absorption of Ultra-violet and Visible Light by Ultra-thin Sections of Vitrinite from a High-volatile Bituminous Coal, 1014
Ernster, Dr. Lars (Azzone, Dr. Giovanni Felice, and) : A High-Energy Phosphate Requirement for Succinate Oxidation in Uncoupled Rat Liver Mitochondria, 65
Error (Inborn), of Metabolism : Reversibility of an Inherited Metabolic Block (Dr. Herman Zondek, Dr. Hannah E. Leszynsky and Dr. Joseph A. Stein), 515
Ershov, A. P. : Programming Programme for the BESM Computer (translated from the Russian by M. Nadler, edited by J. P. Cleave), *review* by R. J. Ord Smith, 92
Erythrocyte Antigens : Effect of Ribonuclease on (Prof. Emanuel Hackel and Robert E. Smolker), 1036
Erythrocyte Serum (Rabbit Anti-Mouse) : Electrophoretic Separation of certain *in vitro* and *in vivo* Reactions of (Chang-Ling Lee, Tamon Takahashi and Israel Davidsohn), 157
Erythocytes of Blood Group A : Substance from (J. Koscielak and K. Zakrzewski), 516
Erythrocytes and Leucocytes of Blood of Normal and Leukaemic Subjects : Zinc Content of (E. Dennes, R. Tupper and Prof. A. Wormall), 302
Escherichia coli grown in Limited Amount of Streptomycin : Absence of Carbon Monoxide-sensitive Respiration in a Streptomycin-dependent Mutant of (Hanna Engelberg and Dr. M. Artman), 801
Escherichia coli B (H) Irradiated with Ultra-violet Light : Recovery in the Presence of Chloramphenicol of (Kenshi Suzuki and Yukiko Iwama), 347
Escherichia coli (Prestarved) : Capacity of Extracts from, to Incorporate Thymidine into Deoxyribonucleic Acid (Dr. Daniel Billen), 1044
ESP : Experimental Evidence for (Dr. S. G. Soal), 171 ; (C. E. M. Hansel), 172
Espenshade, jun., Prof. Edward P : Appointed chairman of the Division of Earth Sciences of the United States National Academy of Sciences—National Research Council, 647
Essays in Comparative Education, *review* by Brian Holmes, 635
Essen, Dr. L. : The International Co-ordination of Time Signals and Standard Frequency Transmissions, 452
Essenhigh, Dr. R. H. (Beér, J. M., and) : Control of Reaction Rate in Dust Flames, 1106
Ester (Cori's), and Phosphorylated Glucides (First International Symposium on), 117, 290
Esterase Activity during Intracellular Digestion in a Histophagous Ciliate : Increase of (Dr. Miklós Muller, József Tóth and Prof. Imre Tóro), 65
Esters (Betaine), in Brain Metabolism : Isolation and Probable Functions of (Prof. E. A. Hosein and Peter Proulx), 321
Esters (Phosphate), produced by Mammalian Skin from 2-Deoxy-D-glucose (Dr. S. A. Brooks, Dr. J. C. Lawrence and Dr. C. R. Ricketts), 1028
Estimating Late Larval and Pupal Mortality in the Wild : Radioactive Labelling of Lepidopterous Larvae—a Method of (L. M. Cook and Dr. H. B. D. Kettlewell), 301
Estuary and Offshore Waters of the Sierra Leone River : Plankton of the (V. Bainbridge), 557
Ethers (Cyclic) A New Method for the Synthesis of (L. F. Schmoyer and L. C. Case), 592
Ethionine and Plant Growth Systems (R. L. Lowther and W. G. Boll), 832
tris(Ethylenediamine), Carbon (III) Ion : Catalytic Racemization of (Dr. F. P. Dwyer and Dr. A. M. Sargeson), 1022
Ethylenediamine Tetraacetic Acid Chelates : Differential Thermal Analysis of some Transition Metal (Prof. Wesley W. Wendlandt and G. Robert Horton), 769
Ethylester (DL-Methionine-) : Damage to Liver Induced by (L. Fehér, F. V. Selmeczi, K. Szaby and Dr. T. Kemény), 421
Etkin, Prof. Bernard : Dynamics of Flight—Stability and Control, *review*, 444
Euglena gracilis : A Bleached Variant of, showing a Doubling of the Content of Deoxyribonucleic Acid (Dr. George Brawerman, Carole A. Rebman and Prof. Erwin Chargaff), 1036
Europe : Prehistoric Man in (Frank C. Hibben), *review* by Miles Burkitt, 729
Europe and North America : Sap-Transmissible Viruses associated with Diseases of Grape Vines in (C. H. Cadman, H. F. Dias and B. D. Harrison), 577
European Association for Potato Research : Series of Triennial Conferences, 466
European Countries in Process of Development : Shortages of Scientific Personnel in, 565
European Economic Co-operation, Organization for (European Productivity Agency) : Discussion on Scientific Research into Road Safety, 116
European Economic Co-operation, Organization for (European Productivity Agency), and the Centre d'Études Nucléaires : International Information Centre for Food Irradiation, 741
European Federation of Corrosion : Election of the British Association of Corrosion Engineers as a member, 25
European Information Centre for Food Irradiation (European Productivity Agency of the Organization for European Economic Co-operation and the Centre d'Études Nucléaires), 741
  Appointment of Pierre Lévêque as director, 741
European Productivity Agency of the Organization for European Economic Co-operation : Discussion on Scientific Research into Road Safety, 116
European Productivity Agency of the Organization for European Economic Co-operation and the Centre d'Études Nucléaires : International Information Centre for Food Irradiation, 741
European Regional Conference on Electron Microscopy (Nederlandse Vereniging voor Electronenmicroscopie), 29
Euryhaline Diptera : Osmotic Regulation in the Larvae of some (D. W. Sutcliffe), 331
Eustace, G. C., and others : Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis, 236
Évacuation et Récupération de la Chaleur des Réacteurs Nucléaires (Richard Alami et Paul Ageron), *review* by R. J. Syme, 636
Evaluation of the Second, Fourth and Sixth Harmonics in the Earth's Gravitational Potential (D. G. King-Hele), 490
Evenari, Prof. M. : Problems of the Arid Zones (Plant Physiology), 295
Evans, Dr. David S. : The Transits of Venus—a Study of Eighteenth-Century Science, *review*, 636
Evans, Prof. Estyn : The Peasant and the Past (Presidential Address to Section H (Anthropology) of the British Association for the Advancement of Science), 844
Evans, I. G. : Appointed lecturer in pure mathematics at University College, Swansea, 117
Evans, Dr. Titus (edited by Dr. Wendell G. Scott and) : Genetics, Radiobiology and Radiology Proceedings, Mid-Western Conference, *review* by Dr. Lorna J. Lilly, 97
Evans, Dr. Ulick R. : The Corrosion and Oxidation of Metals, *review* by Dr. J. M. West, 182
Evaporated Metal Films : Hydrocracking of Neopentane and Neohexane over (Dr. J. R. Anderson and B. G. Baker), 937
Evaporation (Water) : New Compounds for the Control of (A. V. Deo, N. R. Sanjana, S. B. Kulkarni, M. K. Gharpurey and A. B. Biswas), 870
Evaporation and Droplet Growth in Gaseous Media (N. A. Fuchs), translated from the Russian by J. M. Pratt ; edited by Dr. R. S. Bradley, *review* by Prof. F. H. Garner, 451
Evidence for the Identity of Natriferin, the Frog Water-Balance Principle and Arginine Vasotocin (Prof. Wilbur H. Sawyer), 1030
Evidence for Internal Organization of Nucleic Acid in T_2 Bacteriophage (Irwin J. Bendet, David A. Goldstein and Max A. Lauffer), 781
Evidence for Multiple Nature of Cellulase of *Myrothecium verrucaria* (P. Y. F. Prins-van der Meulen and G. J. Schuringa), 695
Evidence (Cytochemical), of the Origin of Lipid Bodies (so-called Golgi Bodies) from Mitochondria (H. C. Chopra), 713
Evidence (Experimental), for Extra-Sensory Perception (Dr. S. G. Soal), 171 ; (C. E. M. Hansel), 172
Evison, Dr. F. F. : Appointed superintendent of the Seismological Observatory, Wellington, New Zealand, 830 ; work of, 830
Evolution of the Concept of the Electric and Magnetic Field : Michael Faraday and the (Prof. L. Pearce Williams), 730
Evolution of Experimental Tuberculosis : Effect of *Candida albicans* on the (Dr. E. Mankiewicz and Dr. M. Livak), 250
Evolution of Modern Education, *review* by Dr. James L. Henderson, 357
Evolution of Nuclear Power Plant Design (Sir Christopher Hinton), 1064
Evolution of the Rural Land Use Pattern in Cyprus (Dr. Demetrious Christodoulou), *review* by Prof. M. J. Wise, 628
Evolution above the Species Level (Prof. Bernhard Rensch), *review* by C. S. Elton, 446
Evolutionary Divergence, *review* by C. S. Elton, 446
Evolutionary Theory after Mendel, *review* by Dr. H. Kalmus, 726
Evolutionary Theory and Christian Belief : The Conflict between (Dr. David Lack), 98
Ewart, J. A. D. (Elton, Dr. G. A. H., and) : Starch-Gel Electrophoresis of Wheat Proteins, 600
Ewer, Prof. T. K. : Appointed to the newly established chair of animal husbandry in the Veterinary School of the University of Bristol, 465, 647 ; work of, 647
Ewing, Dr. Maurice : Awarded the John Fleming Medal of the American Institute of Geonomy and Natural Resources, 905
Examination (Infra-red), of the Association of Cornea Proteins with Water (Dr. S. Bakerman and C. Mitchell), 1033
Excavation of La Grotte de Rochereil, 903
Excavations at Dzibilchaltun in Yucatan, 742
Excessively Large Doses of Oral Griseofulvin : Tumour-promoting Effect of, on Tumours induced in Mice by Methylcholanthrene (Louis L. Barich, Takashi Nakai, Jan Schwarz and Donna Jean Barich), 335
Exchange (Covalent Super-), in Solid State Physics (Prof. W. S. Fyfe and Prof. J. Verhoogen), 1108
Exchanger (Cellulose Ion) : Non-specific Haemagglutinin from Cellulose and (Prof. B. Schmidt, Dr. K. Grossgebauer and D. Hartmann), 790
Excised *Bryophyllum* Leaves : Effects of Light and Darkness on the Rhythm of Output of Carbon Dioxide of (Dr. Malcolm B. Wilkins), 523

Excitability (Membrane), of Calcium-deficient Muscles : Restoration of, by Anodal Polarization (Prof. K. Koketsu and K Noda), 243
Excitation at the Crayfish Neuromuscular Junction with Decreased Membrane Conductance (Dr. Josef Dudel and Prof. Stephen W. Kuffler), 246
Excited Electronic States of Lithium and Sodium Molecules (Dr. R. F. Barrow, N. Travis and C. V. Wright), 141
Excitons (Hydrogen-like) : Effect of Electric Fields on (J. W. Allen), 51
Exclusion of Inulin from Solutions of Hyaluronic Acid (Dr. A. G. Ogston and C. F. Phelps), 1024
Excretion of Catechol after Ingestion of Quinic and Shikimic Acids (Dr. A. N. Booth, D. J. Robbins, M. S. Masri and F. DeEds), 691
Excretion of Sodium : Critical Energy Barriers in the (Prof. E. J. Conway), 394
Excretion (Urinary), of *β*-Amino-isobutyric Acid after Injection of Thymidine labelled with Tritium (Dr. Georg B. Gerber, Gisela Gerber and Kurt I Altman), 956
Excretion (Urinary), of Œstrogens in Cases of Chronic Prostato-vesiculitis (Prof. Gunnar Nylander), 154
Executive : The Red (David Granick), 537
Executives : Selection of (T. H. Hawkins), 31
Exell, A. W., and Wild, H. (edited by) : Flora Zambesiaca, Vol. 1, Part 1, *review* by A. A. Bullock, 449
Exhibition : Second International Plastics, 559
Exhibition of 1851, Royal Commission for the : Studentship and Scholarship Awards for 1960, 116
Exhibition and Convention : Electronics and Instruments (Institution of Electronics, with the co-operation of the Hull Electronic Engineering Society), 650
Existential Psychiatry, *review* by Dr. Clifford Allen, 1062
Exo-Electron Emission in Plastically Deformed Metals : A Possible Origin of (Dr. A. H. Meleka and W. Barr), 232
Expanded Ilio-Sacral Joint in the Toad *Xenopus laevis* (Margaret Palmer), 797
Expanding Pulp and Board Industries in Britain : Scope for (J. J. MacGregor), 32
Expansion on Setting of Gypsum Plaster . Effect of Temperature on the (P. J. Sereda), 929
Expansion (Thermal), at Low Temperatures (Guy K. White), 927
Expedition · The Galathea, *review* by Dr. N. B. Marshall, 443
  The Indian Ocean (Dr. G. E R Deacon), 561
Experiment' : The 'GBR—a Trans-Atlantic Frequency Comparison between Caesium-controlled Oscillators (J. A. Pierce, G. M. R. Winkler and R. L. Corke), 914
Experiment in Psychology—a Centenary and an Outlook (Prof. R. C. Oldfield), 846
Experiment (Animal) : Achievement—some Contributions of, to the Conquest of Disease (Dr. Geoffrey Lapage), *review* by Dr. W. Lane-Petter, 977
Experiment (Skylark Rocket Sodium) : Upper-Atmosphere Wind Studies by (Dr. G. V. Groves), 1001
Experimental Biology, Society for : Symposia No. 13, Utilization of Nitrogen and its Compounds by Plants (edited by H. K. Porter), *review* by Prof. Walter Stiles, 815
Experimental Breeding of *Anopheles gambiae* Giles in Papyrus Swamps (L. K. H Goma), 1137
Experimental Evidence for Extra-Sensory Perception (Dr. S. G. Soal), 171 ; (C. E. M Hansel), 172
Experimental Fish . An Improved Feed for (D. R. Swift), 1133
Experimental Husbandry Farms (Terrington and Kirton), King's Lynn : Appointment of F. E. Shotton as director, 905
Experimental Mechanics : International Congress on, 559
Experimental Poisoning by Cadmium and other Metals : An Abnormal Serum Protein in (D. J. Lawford), 946
Experimental Tuberculosis : Effect of *Candida albicans* on the Evolution of (Dr. E. Mankiewicz and Dr M. Liivak), 250
Experiments on the Nutrition of Sows (Dr. G. A. Lodge), 115
Experiments (Animal), in Research, *review* by Dr. W. Lane-Petter, 977
Experiments (Archaeological Field) : Research Committee on, 289
Experiments (Echo Sounding), in the Barents Sea (I. D. Richardson, D. H. Cushing, F. R. Harden Jones, R. J. H. Beverley and R W. Blacker), 855
Experiments (Small) : Analysis of (P. Sprent), 437
Exploding Wire Phenomenon, *review* by Dr. B. A. Thrush, 726
Exploding Wires—Based on Conference on the Exploding Wire Phenomenon, 1959, conducted by Geophysics Research Directorate, Air Force Cambridge Research Center, with the co-operation of Lowell Technological Institute Research Foundation (edited by William G. Chace and Howard K. Moore), *review* by Dr. B. A. Thrush, 726
Exploration of the Solar System (Felix Godwin), *review* by D. G. King-Hele, 811
Exploration (Petroleum), in Britain by the British Petroleum Company during the Years 1945-57 : Geological Results of (N. L. Falcon and P. E. Kent), 1078
Exploring Vector Space, *review* by Dr. J. W. Jeffery, 975
Explosives (High) : The Science of (Prof. Melvin A. Cook), *review* by Dr. W. L. Murray, 539
  Theory of, *review* by Dr W. L Murray, 539
Exposure to Intense Radiation : Biological Effects of, 910
Exposure (Short-Time), to Ultra-violet Irradiation : Delayed Recovery of Airborne *Serratia marcescens* after (Dr. R L. Dimmick), 251
Expression of Concentrations of Solutions (E. H. Leach), 350
Extinction (Interstellar), and Polarization (R. Wilson), 288
Extracorporeal Circulation : Influence of 5-Hydroxytryptamine on Renal Function in (Dr. M. H Frick), 609
Extraction of Metals and the Chemistry of Metals (Prof. F. D. Richardson), 466
Extracts from Prestarved *Escherichia coli* : Capacity of, to Incorporate Thymidine into Deoxyribonucleic Acid (Dr. Daniel Billen), 1044
Extra-Sensory Perception : Experimental Evidence for (Dr. S. G. Soal), 171 ; (C. E. M. Hansel), 172
Extremely Low Temperatures : Survival of Woody Plants at (Johnson Parker), 1133 ; (Dr. Akira Sakai), 1134
Eye (Lateral), of the Horseshoe Crab : Summative Action of Acetycholine with Physiological Stimulus on the Generator Potential in the (R. Kikuchi, K. Naito and S. Minagawa), 1118

F ECHOES (Spread), at Low Latitudes : Possibility of Detecting Ionospheric Drifts from the Occurrence of (R. W. Knecht), 927
F-Layer Heights : Equatorial Spread-*F* and (Dr. A. J. Lyon, Dr N. J. Skinner and Prof. R. W. Wright), 1086
Fabrication des Colles des Glutinants et Matiéres d'Apprêts : Traité Général de la (Dr. Maurice de Keghel), nouvelle édition, *review* by Prof. A G. Ward, 890
Fabrics : Absorption-Elution Grouping of Dried Blood-stains on (S. S. Kind), 789
Facilities (Nuclear Training) at the Royal Naval College, Greenwich (Prof. J. Edwards), 545
Fact and Opinion, *review* by Prof. O. L. Zangwill, 817
'Factor' from a Pregnant Rabbit for Ovarian Maturation · Breeding of the Rabbit Flea, *Spilopsyllus cuniculi* (Dale)—Requirement of a (A. R. Mead-Briggs and A. J. B. Rudge), 1136
Factor (Bradykinin-releasing) from *Bothrops jararaca* Venom (Dr. Olga B. Henriques, Mina Fichman and W. T Beraldo), 414
Factor (Growth), for *Haemophilus* Species secreted by a Pseudomonad (Moshe Shifrine and Prof. Ernst L. Biberstein), 623
Factor C (The Rh), in South African Bantu (Dr. A. Zoutendyk and Dr. H. Teodorczuk), 790
Factories : Noise in (A. G. Aldersey-Williams), 1085
Factors (Particle Shape), in the Sieve Range : A Method for the Routine Measurement of (Dr. Colin C. Harris), 401 , (D. Howitt), 403
Factors (Serum) Gm^a, Gm^b, Gm^x and Gm-like : Effect of Heat on the (Prof Arthur G Steinberg and Rachael Stauffer), 791
Factors (Steric), affecting the Specificity of Polyglycosidases (F. W. Parrish and A. S. Perlin), 1110
Faith : Questions of Science and (Dr. Hawthorne), 28
1063
Faith of a Physicist (Dr. H. E. Huntley), *review* by Dr. H. D. Anthony,
Falcon, N. L., and Kent, P. E. : Geological Results of Petroleum Exploration in Britain by the British Petroleum Company during the Years 1945-57, 1078
Falconer, Dr. D. S. : Introduction to Quantitative Genetics, *review* by Prof. Kenneth Mather, 813
Fall III : The Wish to—a Study of Psychoanalysis and Medicine (Dr. Karin Stephen), *review* by Dr Clifford Allen, 978
Fall-out Caesium in Surface Sea Water off the California Coast (1959-60) by Gamma-Ray Measurements (Dr. Theodore R. Folsom, Dr. G. J. Mohanrao and Perrin Winchell), 480
Fall-out (Radioactive), in Ghana (Dr. A. H. Ward and J. D Marr), 299
Family : Science for the, *review* by Dr. D. R. Dickinson, 978
Family Contacts : Tuberculosis—Risk to, 1084
Family and Home . Social Development through the (Report of the Conference on), 567
Fan, C. Y. : Penetration of Charged Particles in Matter (Spectroscopic Study of Electron-capture Processes), 1086
Fano, U. : Penetration of Charged Particles in Matter (Energy-loss Distributions), 1086
Faraday (Michael), and the Evolution of the Concept of the Electric and Magnetic Field (Prof L. Pearce Williams), 730
Faraday Society : General Discussion on the Physical Chemistry of Aerosols, 201
Faraday Society (Colloid and Biophysics Committee) · Informal Discussion on Cytoplasmic Particles and their Role in Protein Synthesis, 643
  Symposium on the Physico-chemical, Biological and Applied Aspects of Autoxidation, 746
  Discussion on Ultracentrifugation of Biological Macromolecules, 905
Farkas, Dr. G. S., and others . Lipaemic Clearing Action of Artificial Anticoagulants, 782
Farrington, Prof B. : Francis Bacon without his Background, *review*, 817
Fast Transfer Reactions : Physiological Role of (Massachusetts Institute of Technology Seminar Lectures on), 904
Fat Diet : An Inverse Relation between the Liver Glycogen and the Blood Glucose in the Rat adapted to a (Dr. P. A. Mayes), 325
Fate of Homologous Adult Spleen Cells Injected into New-born Mice (A. J. S. Davies and Sheila M. A. Doak), 610
Fate of Transforming Deoxyribonucleate following fixation by Transformable Bacteria, I (Dr. Maurice S. Fox and Dr Rollin D. Hotchkiss), 1002 ; 2 (Dr. Maurice S. Fox), 1004
Fatigue Crack in Mild Steel : Correlation of the Alternating Stresses required to Initiate and Propagate a (N. E. Frost), 233
Fatty Acid Composition of the Lipids of Pasture Grasses (Dr. G. A. Garton), 511
Fatty Acids of Lower Molecular Weight : Determination of, by Gas Chromatography (Marie L. Vorbeck, Leonard R Mattick, Frank A. Lee and Carl S Pederson), 689
Fatty Acids (Conjugated) : Gas Liquid Chromatography of (Dr. N. W. R. Daniels and J. Wendy Richmond), 55
Faulkner, Dr C R . Effect of Upper Atmosphere Wind on the Rotation of Satellite $1958\delta 1$, 926
Fauna (Echinoderm), of the Central North Sea : A Quantitative Investigation of the (Dr. Erik Ursin), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 24), *review* by Dr. A. J. Southward, 360
Fauna (Oligochaeta), of Three Danish Brackish Water Areas (Ingerlise Dahl), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 26), *review* by Dr. A. J Southward, 360
Fauna (Polychaeta), of South Africa (Prof J. H. Day), Part 5, 199
Fayalite : Formation of, in Roast Reduced Jaspilite (J. B. Lean, K. J. Tucker, B. O. Holland and T. R. Thomson), 683
Feather, Prof. Norman : An Introduction to the Physics of Mass, Length and Time, *review* by G. R. Noakes, 183
Fedorov, V. D., and others : A New Species of Green Sulphur Bacteria, 167
Feed (An Improved), for Experimental Fish (D. R. Swift), 1133
Feeding Grounds (Whale), in the Antarctic : Southern Atmospheric Cyclones and the (Dr. C. W. Beklemishev), 530
Feeding-Stuffs : Nigeria's (V. A. Oyenuga), second edition, *review* by Dr. Richard Mellanby, 637
Fehér, I., and others : Damage to Liver induced by DL-Methionine-Ethyl-ester, 421
Fehér, Dr. T , and Matkovics, Dr. Béla : Chemical Constitution of the Red Blood Cell Membrane, 701

Feigen, Prof. G. A., and others Effect of Nitrate Ion on the Distribution of Sucrose in the Rat's Ventricle, 419
Feingold, Dr. David S. : Appointed assistant professor of bacteriology in the University of Pittsburgh, 905
Feldman-Muhsam, Dr. B., and Havivi, Y. : Accessory Glands of Gene's Organ in Ticks, 964
Fellowship (Armourers and Brasiers' Research) awarded to Dr. J. H. Brunton, 291
Fellowship (Foulerton Gift Research) awarded by the Royal Society to Dr. J. Seed, 291
Fellowships in Chemistry (Ramsay Memorial Fellowship Trust Awards for 1960-61), 832
Fellowships for Research in the Use of Electronic Computers (Unesco), 465
Fellowships (Travelling), in Medicine, 994
Female Mice (Resistance of Male and), to Ectromelia : Effect of a Primary Tuberculous Infection on the (Dr. A. W. Gledhill and Dr. R. J. W. Rees), 703
Feng, Dr. Yu Sheng Louise (Wase, Prof. Arthur W., and) : Sialoadenectomy and the Distribution of Thyrotrophin labelled with Iodine-131, 778
Fernández-Morán, Dr. H. : Freezing and Drying of Biological Materials, 749
Ferretti, A., and others : Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture, 238
Ferri, Prof. A. : Combustion and Propulsion (High Mach Number Air-breathing Engines), 19
Ferricyanide Reduction Method for Reducing Sugars (Dr. Richard I. Mateles), 241
Ferrimagnetism in Theory and Practice, *review* by Dr. G. E. Bacon, 974
Ferrites (Dr. J. Smit and Dr. H. P. J. Wijn), *review* by Dr. G. E. Bacon, 974
Ferritin-conjugated Antibody : Use of, to Localize Antigen by Electron Microscopy (Richard A. Rifkind, Konrad C. Hsu, Councilman Morgan, Beatrice C. Seegal, Alice W. Knox and Harry M. Rose), 1094
Ferromagnetic and Antiferromagnetic Behaviour in the Second Transition Group (Dr. B. R. Coles and D. Griffiths), 226
Ferrous Solutions : Radiolytic Oxidation of, with Standardized Internal Sources of Phosphorus-32 (Dr. M. Pessach and J. Steyn), 58
Fertility of Mice treated with Phosphorus-32 (E. A. D. Holmberg, Dr. A. Pavlovsky, C. D. de Pasqualini and S. L. Rabasa), 876
Fertility and Population Policy : Population Growth, (Prof. D. V. Glass), 849
Fertility (Anti-) Action of a Monoamine Oxidase Inhibitor (W. G. Spector), 514
Fertilization (Self-) in the Calyptraeidae : Protandry and (Dr. H. V. Wyatt), 520
Feulgen-stained Somatic Cell Nuclei : Absorbance of (Dr. Simon Iversen), 86
Fibres : Man-made, *review* by Prof. C. S. Whewell, 2
Fibrinogen-Fibrin Transition : Some Aspects of the (K. Laki, Jules A. Gladner and J. E. Folk), 758
Fibroblast Cells (Chick Embryo) : An Interferon-like Substance released from Tick-borne Encephalitis Virus-infected (Dr. J. Vilček), 73
Fichman, Mina, and others : Bradykinin-releasing Factor from *Bothrops jararaca* Venom, 414
Fiction (Science) : Beyond, *review* by Dr. D. J. West, 270
Field Experiments (Archaeological) : Research Committee on, 289
Field Studies Association (Scottish) : Annual Report for 1959, 200
Figure Reading Electronic Device (*Fred*), (E.M.I. Co. Ltd.), 28
Figures of Celestial Bodies : Theories of (Wenceslas S. Jardetzky), *review* by Prof. L. S. Goddard, 890
Figures (Preparing) : Oceanography of Long Island Sound—Guide for (Y. H. Olsen and James E. Morrow, Jr.), 123
Film Archive (National) : Catalogue, Part 2, Silent Non-Fiction Films (1895-1934), 199
Film Institute (British) : National Film Archive Catalogue, Part 2, Silent Non-Fiction Films (1895-1934), 199
Films of Historical Value : Preservation of, 199
Films (Evaporated Metal) : Hydrocracking of Neopentane and Neohexane over (Dr. J. R. Anderson and B. G. Baker), 937
Films (Sulphide), on Steel : Growth of (R. B. Campbell, L. Grunberg and H. M. Scott), 588
Films (Tin) : Speed of the Superconducting-Normal Transition in (D. J. Oliver, M. J. Rayner and E. H. Rhoderick), 492
Filmstrips : New (Educational Publications, Ltd., Wakefield), 832
Filon, S. P. L. : Book-buying Policy of the National Central Library, 992
Filters (Membrane) : Radioactive Labelling of, for the Assay of Air-borne Material (Dr. G. Kubie and Dr. K. Spurny), 930
Final Months and Descent of Satellite *Sputnik* 3 (B. R. May and D. E. Smith), 456
Financing of Research in Biochemistry and Allied Sciences : Organization and (Biochemical Society and the British Association for the Advancement of Science Colloquium on), 650
Finch, J. T., and others : Cytoplasmic Particles and their Role in Protein Synthesis (Pattern of Ribosomal Ribonucleic Acid in X-Ray Diffraction Photographs compared to that given by Extracted Ribonucleic Acid), 644
Finch (Weaver), *Quelea quelea* : Effects of Whole-body Irradiation on the Breeding Plumage of the (Dr. B. Lofts, Prof. A. J. Marshall and Prof. J. Rotblat), 615
Findlay, Dorothy, and others : Activity of Bovine Pancreatic Ribonuclease A in Mixed Solvent Systems, 601
Findlay, W. P. K. (Cartwright, K. St. G., and) : Decay of Timber and its Prevention, *review* by Prof. F. W. Jane, 977
Fine, Dr. J. M., and others : Haptoglobin Types in 398 Blood Donors from Dakar (Senegal), 517
Finland, Prof. Maxwell (edited by Dr. Henry Welch and) : Antibiotic Therapy and Staphylococcal Diseases, *review* by Prof. R. Knox, 637
Fire (Greek) and Gunpowder : A History of (Prof. J. R. Partington), *review* by Prof. R. J. Forbes, 272
Firearms : Incendiaries, Fireworks and, *review* by Prof. R. J. Forbes, 272
Fireworks and Firearms : Incendiaries, *review* by Prof. R. J. Forbes, 272
First Decade of DDT, *review* by Prof. D. S. Bertram, 271
First Statesman of Science : Francis Bacon, the (J. G. Crowther), *review* by Prof. B. Farrington, 817
Firth, Prof. Raymond : Social Change in Tikopia, *review* by Sir Harry Luke, 816
Fischer, Dr. E., and others : Synergetic Action of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia, *erratum*, 559
Fischer, Prof. Roland (Griffin, Frances, and) : Differential Reactivity of Saliva from 'Tasters' and 'Non-Tasters' of 6-n-Propylthiouracil, 417
Fish (Experimental) : An Improved Feed for (D. R. Swift), 1333
Fish (Sound-producing) : Electrophysiological Observations on a (A. Packard), 63
Fisher, James, and Huxley, Sir Julian (editorial board : Dr. J. Bronowski, with Sir Gerald Barry,) : Science—Chemistry, Physics, Astronomy, *review* by Dr. D. R. Dickinson, 978
Fisheries Research (Oceanographic and), by the Submarine *Severyanka* (V. P. Zaitzev), 559
Fishes (Non-Cichlid), in Lake Victoria Breeding Sites of (Dr. Philip S. Corbet), 616
Fisica, Società Italiana di : International Summer Course on Solid State Physics, 201
Fission (Nuclear), in the Early History of the Earth (Prof. P. K. Kuroda), 36
Fission (Spontaneous), of Californium-252 ; Rare Modes in the (Prof. E. W. Titterton and T. A. Brinkley), 228
Fission Product and Beryllium-7 Concentrations in the Atmosphere : Comparison of (W. Anderson, R. E. Bentley, R. P. Parker, J. O. Crookall and L. K. Burton), 550
Fitch, Coy D., and Dinning, Prof. James S. : Production of Muscular Weakness in Rats by a Creatine Analogue, 421
Fitzpatrick (Percy) Institute of African Ornithology, Cape Town : Appointment of Dr. J. M. Winterbottom as director, 201
Fitzpatrick, Prof. T. B., and others : Melanin Granules and Mitochondria, 392
Fiume, Dr. L. : Inhibition of Aerobic Glycolysis in Yoshida Ascites Hepatoma by Tartronic Acid, 792
Five Co-ordinated Titanium in $K_2Ti_2O_5$ (Dr. Sten Andersson and Dr. A. D. Wadsley), 499
Fixation by Transformable Bacteria : Fate of Transforming Deoxyribonucleate following, 1 (Dr. Maurice S. Fox and Dr. Rollin D. Hotchkiss), 1002 ; 2 (Dr. Maurice S. Fox), 1004
Fixation (Acetone), for the Cytochemical Demonstration of Dehydrogenases in Blood and Bone Marrow Cells (Dennis Quaglino and Dr. F. G. J. Hayhoe), 85
Fixation (Nitrogen) : Copper and Cobalt in (Prof. E. G. Hallsworth, S. B. Wilson and E. A. N. Greenwood), 79
Fixation (Osmium) : Induced Fluorescence with Acridine Orange, after (W. J. Randles), 964
Flames (Dust) : Control of Reaction Rate in (J. M. Beér and Dr. R. H. Essenhigh), 1106
Flare (The Solar), of June 1, 1960 (Prof. M. A. Ellison, Susan M. P. McKenna and J. H. Reid), 926
Flares (Chromospheric) : Measurement of Magnetic Fields in (M. Blaha, M. Kopecky and Z. Svestka), 224
Flat Rolled Products—Rolling and Treatment (edited by T. E. Dancy and E. L. Robinson), *review* by Prof. F. C. Thompson, 273
Flavonoid Pigments of *Lathyrus odoratus* (J. B. Harborne), 240
Flea (Rabbit), *Spilopsyllus cuniculi* (Dale) : Breeding of the—Requirement of a 'Factor' from a Pregnant Rabbit for Ovarian Maturation (A. R. Mead-Briggs and A. J. B. Rudge), 1136
Fleming (John) Medal of the American Institute of Geonomy and Natural Resources awarded to Dr. Maurice Ewing, 905
Fletcher, Prof. W. W. : Herbicides and the Soil (Effects of Herbicides on Soil Micro-organisms), 377
Flies (Dragon-), (Dr. Philip S. Corbet, Cynthia Longfield and Dr. N. W. Moore), *review* by Dr. D. E. Kimmins, 631
Flight : Dynamics of—Stability and Control (Prof. Bernard Etkin), *review*, 444
  Stability and Control of, *review*, 444
Flight by Man-Power (Dr. E. Guerra and Dr. B. Gunther), 419
Flight (Space) : Proposals for, *review* by D. G. King-Hele, 811
Flood Barrier (Thames) : Technical Possibilities of a, 294
Floodgate, Dr. G. D. : Microbial Systematics, 191
Flooding (Tidal), in London : Protection against (N. B. Webber), 293
Flora of the Zambesi Basin, *review* by A. A. Bullock, 449
Flora Zambesiaca (edited by A. W. Exell and H. Wild), Vol. 1, Part 1, *review* by A. A. Bullock, 449
Florence, T. M., and Smythe, L. E. : Use of Azo Dyestuffs for the Polarographic Determination of the Lanthanides, 771
Florensov, N. A. (Selonenko, V. P., and) : Tectonics of the Gobi Mountains, 373
Flow (Plastic) : The Physical Nature of (Dr. J. J. Gilman), 374
Flow Coefficients of Permeable Solids : Measurement of Slip (*Ko*) and Viscous (*Bo*), (J. G. Berum), 865
Flow Measurement in Closed Conduits (National Engineering Laboratory Symposium on), 905
Fluctuations (Periodic Magnetic Field), in the *Sceptre* Discharge (Dr. N. L. Allen), 279
Fluid (Bingham) : Yield Stress exerted on a Body Immersed in a (G. Boardman and Dr. R. L. Whitmore), 50
Fluid (Peritoneal), of the Guinea Pig : Effect of the, on Strains of Enteric Bacilli (Prof. R. J. Roantree and L. R. Collis), 1045
Fluids, Physics of : To be published monthly starting in 1961 (American Institute of Physics), 832
Fluids (Pump), for Higher Vacuums (Kenneth Hickman), 405
Fluorescence (Induced), with Acridine Orange, after Osmium Fixation (W. J. Randles), 964
Fluorinated Ketones : Cage Effect in the Liquid-Phase Photolysis of (R. Bowles, Dr. J. R. Majer and Prof. J. C. Robb), 314
Fluorine Compounds in Nature—the Distribution of Carbon-Fluorine Compounds in some Species of *Dichapetalum* (Sir Rudolph Peters and R. J. Hall), 573
Flux (High), of Thermal Neutrons—Localization by Autoradiography at -195° C. of Radioactive Areas in Rats exposed to a—Importance of Phosphorus-32 in Consecutive Internal Irradiation (Jean Chanteur and Pierre Pellerin), 472
Flux (Radiation), from a Heated Tube : Effect of Specular Reflexions on the (Sir K. S. Krishnan), 135
Fly (Black-) Larvae : Bacteria as a Source of Food for (F. J. H. Fredeen), 963

Fly (Tsetse), *Glossina* : Free Amino-Acids of the (E. Bursell), 778
Fock, V. : The Theory of Space, Time and Gravitation (translated from the Russian by N. Kemmer), *review* by Dr. D W. Sciama, 4
Foetal Liver : Pattern of Haemopoiesis in the (D Brynmor Thomas, P M. Russell and Prof. J M. Yoffey), 876
Fogg, Prof G. E. : Appointed to the chair of botany in Westfield College, London, 362 ; work of, 362
Foliar Application of Nutrients and Rhizosphere Microflora of *Camellia sinensis* (Dr C S. Venkata Ram), 621
Folk, J E , and others : Some Aspects of the Fibrinogen–Fibrin Transition, 758
Follicle Remains in some British Parchments (Dr M. L Ryder), 130
Following Rapid Rates of Crystallization A New Technique for (J. H Magill), 770
Folsom, Dr. Theodore R , and others Fall-out Caesium in Surface Sea Water off the California Coast (1959-60) by Gamma-Ray Measurements, 480
Food for Black-Fly Larvae . Bacteria as a Source of (F. J. H. Fredeen), 963
Food (Artificial) : Silkworm Raising on (Toshifumi Fukuda, Mitsumasa Suto and Yoshikichi Higuchi), 669
Food Consumption (Daily), by South African University Students (Sonia E. Walker), 381
Food Habits in Britain (Scottish Group of the Nutrition Society Symposium on), 905
Food Irradiation : International Information Centre for (European Productivity Agency of the Organization for European Economic Co-operation and the Centre d'Études Nucléaires), 741
  Appointment of Pierre Lévêque as director, 741
Food Science and Technology International Congress of, 905
Food Storage : Use of Toxic Chemicals in Agriculture and (Request from the Research Study Group for evidence), 290
Food Supplies (World) : Pastoral Systems in relation to (Dr. William Davies), 849
Food and Agriculture Organization (United Nations) : Problems of the Arid Zones (Nomadism in relation to Grazing Resources—Nomadic Pastoralism), 296
  Appointment of Dr. Marcel Autret as director of the Nutrition Division, 743
Food and Animal Production Overseas (British Association for the Advancement of Science, Section M (Agriculture), Discussion on), 1070
Forbes, Prof. R. J. : The Royal Society and the Progress of Science Abroad, 100
  Incendiaries, Fireworks and Firearms, *review*, 272
Forces (Electrostatic) : The Physics of, and their Applications (Centre National de la Recherche Scientifique International Colloquium on), 466
Forces (Mechanical) : Initiation of Chemical Reactions by (Dr. Robert Schnurmann and Ivor S. Stringer), 587
Ford Motor Co., Ltd. : Contribution of £5,000 to the 1962 Centenary Appeal Fund of the University of Southampton, 290
Foreign (British and) School Society : Grant of £75,000 towards the general expansion of the Borough Road College, Isleworth, 371
Forest (Natural) : The Dangerous Concept of the (T. R. Peace), 848
Forestry Congress : Fifth World, 29
Forest Management : The Development of Pulp and Particle Board Industries and their Effect on (Society of Foresters of Great Britain Discussion on), 32
Foresters of Great Britain, Society of : Discussion on the Development of Pulp and Particle Board Industries and their Effect on Forest Management, 32
Form : The Control of Growth and—a Study of the Epidermal Cell in an Insect (Prof. V. B. Wigglesworth), *review* by Prof R Dennell, 631
Form in an Insect : Growth and, *review* by Prof. R. Dennell, 631
Formaldehyde : Mechanism of Formaldehyde-induced Mutagenesis—the Uniqueness of Adenylic Acid in the Mediation of the Mutagenic Activity of (Dr Thomas Alderson), 485
Formaldehyde-induced Mutagenesis : Mechanism of—the Uniqueness of Adenylic Acid in the Mediation of the Mutagenic Activity of Formaldehyde (Dr Thomas Alderson), 485
Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis (Dr. G N. Rolinson, F. R. Batchelor, D Butterworth, J. Cameron-Wood, Dr M Cole, G C Eustace, Marian V. Hart, Dr. M. Richards and Prof. E B Chain), 236
Formation of Antarctic Snows : Isotopic Composition and Temperature of (Prof. E. Picciotto, X. de Maere and Dr. I. Friedman), 857
Formation of 3,4-Benzopyrene in Human Environment : Mode of (Prof. G. M. Badger, R. W L. Kimber and T. M. Spotswood), 663
Formation of Fayalite in Roast Reduced Jaspilite (J. B. Lean, K. J. Tucker, B O Holland and T R Thomson), 683
Formation of a New Metabolite of Epinephrine and Norepinephrine in Liver and Kidney (Dr. M Goldstein and Dr. S B Gerner), 147
Formation of D-Penicillamine–Cysteine Mixed Disulphide by Reaction of D-Benzylpenicilloic Acid with Cystine (Dr. Bernard B. Levine), 940
Formation (Photochemical), and Stability of the CF_2 Radical (Dr. J. P. Simons and A. J. Yarwood), 316
Formation (Tumour) : Polyoma Virus Mutant with a Reduction in (Dr. Leo Sachs and Dan Medina), 715
Formylglutamic Acid : Enzymatic Synthesis of, by a Plant Protein (Ernest H. Byers, jun., and T J Bond), 416
Fortes, Prof. Meyer : Oedipus and Job in West African Religion, *review* by Michael Argyle, 96
Fossil Meteorites (B. I Vronsky), 648
Fossiles (Madréporaires) . Contribution à la Systématique des (James Alloiteau), *review* by Dr. H. Dighton Thomas, 95
Fossils (Prof H H. Swinnerton), *review* by Prof S Simpson, 271
Fossils for the Naturalist, *review* by Prof. S Simpson, 271
Foster, K. : Appointed lecturer in mechanical engineering at the University of Birmingham, 465
Foster, Dr. W. N. M : Awarded a Research Training Scholarship by the Animal Health Trust, 904
Foulerton Gift Research Fellowship awarded by the Royal Society to Dr. J Seed, 291
Foundation of Plant Geography, 904
Fourfold Helical Fracture in Titanium Oxide : A Symmetrical (J. S. Jackson), 1104
Fowl (Domestic) : Antibody Responses of the, to Two Soluble Bacterial Antigens (Dr. G. Gowland), 624
Fowler, Dr. P. H : Appointed to a Research Fellowship in physics at the University of Bristol, 465
Fox, Dr. L. : The British Computer Society—Harrogate Meeting, 655
Fox, Dr. Maurice S . Fate of Transforming Deoxyribonucleate following Fixation by Transformable Bacteria (2), 1004
Fox, Dr. Maurice S , and Hotchkiss, Dr. Rollin D Fate of Transforming Deoxyribonucleate following Fixation by Transformable Bacteria (1), 1002
Fractionation of Nuclear Weapon Debris (Prof. C Sharp Cook, R L. Mather, R F Johnson and F. M. Tomnovec), 1100
Fractions (Mitochondrial Membrane): Sodium and Potassium in (Dr Frank Ulrich), 949
Fracture in Titanium Oxide . A Symmetrical Fourfold Helical (J S Jackson), 1104
Fracture (Chain), during the Cross-linking of Rubber : Analysis of Solubility Data to estimate Small Amounts of (L. Mullins and D T. Turner), 145
Fragments (Nucleated and Enucleated), of *Amoeba proteus* : Effect of Pyruvate upon (Dr Edmund Guttes and Sophie Guttes), 432
Frameworks (Statically Indeterminate) . A Historical Note on the Reciprocal Theorem and Theory of (T. M. Charlton), 231
France : Electronic Equipment used in the Nuclear Energy Industry in (P. Desneiges, M. Doireau, L. Koch and J. Weill), 1075
Franceschini, J , and others : Antileukaemic Activity of Glycyrrhetinic Acid, 607
Francis, C. J. : Promoted to Deputy Chief Scientific Officer in the Ministry of Aviation and appointed counsellor (Defence Research and Supply) to the United Kingdom High Commission, Canada, 646 ; work of, 646
Francis, Dr. G H : *Obituary* by Dr A. J Charig, 284
Francois, Dr. P. E. (Doniach, Dr. I., and) . Comparison of Iodine-124 and Iodine-131 in Inhibition of Goitrogenesis in the Rat, 704
Frankel, Dr T. H : The Development of Pulp and Particle Board Industries and their Effect on Forest Management, 32
Franklin, Prof. Kenneth J. : *Obituary* of Prof John F Fulton, 110
Fraser, Dr. M. J : Optimal Protein Synthesis by Ascites Tumour Cells *in vitro*, 1114
Fraser, Prof. T. Russell, and others : Staining for Iodine in Chromatograms of Human Plasma—an Artefact due to Thiourea or Thiouracils, 691 ; *erratum*, 1079
Frasson, E , and others : Structure of $AgSCN.P(n\text{-}C_3H_7)_3$, 772
Frazer, Prof A. C., and others : Effect of Wheat Gluten on the Peristaltic Reflex, 516
Fredeen, F. J. H. . Bacteria as a Source of Food for Black-Fly Larvae, 963
Free Amino-Acids of the Tsetse Fly (*Glossina*), (E Bursell), 778
Free D-Serine in the Earthworm : Occurrence of (Dr H. Rosenberg and Prof. A H Ennor), 617
Freeze-drying of Plant Viruses (M. Hollings and R A. Lelliot), 1078
Freezing and Drying of Biological Materials (Dr. Harold T. Meryman, and 12 others Authors), 748
Freifelder, Dr. David, and Uretz, Prof. Robert B : Dye-sensitized Photoreactivation of X-Ray Damage in Diploid Yeast, 953
French Science News : No. 1, January–March 1960, Special article on Medical Research in the Paris Hospitals, 26
Frequencies (MNSs Gene), in English Blood Donors (Dr. T. E. Cleghorn), 701
Frequency of Quadrivalents in Autotetraploid Plants (Dr. J. W. Morrison and Dr. T Rajhathy), 528
Frequency Comparison between Caesium-controlled Oscillators The 'GBR Experiment'—a Trans-Atlantic (J. A. Pierce, G. M. R. Winkler and R. L. Corke), 914
Frequency Advisory Committee, General Post Office : Appointment of Dr. R. L. Smith-Rose as chairman, 466
Frequency Control (Radio), in Space Telecommunications (Edward Wenk, jun.), 373
Frequency Shifts : Infra-Red (R. S Norrish), 142
Frequency Standards (Atomic Beam) . A Comparison of (R. E. Beehler, R C Mockler and C. S. Snider), 681
Frequency Transmissions : The International Co-ordination of Time Signals and Standard (Dr L. Essen), 452
Frequency (Very Low-) Hiss observed at Byrd Station, Antarctica : Association between Aurora and (Dr. L H. Martin, Dr R A. Helliwell and K. R. Marks), 751
Fresh-Water Biology (Henry Baldwin Ward and George Chandler Whipple), second edition, edited by Prof. W T. Edmonson, *review* by Dr. T. T Macan, 6
Fresh-Water Biology : North American, *review* by Dr T. T. Macan, 6
Frick, Dr. M H. : Influence of 5-Hydroxytryptamine on Renal Function in Extracorporeal Circulation, 609
Frieden, Edward H. Analyses of Relaxin, 200
Friedlander, Dr. P H. (Sayre, Dr. D , and) : Crystal Structure of 9 10-Dimethyl-1·2-benzanthracene, 139
Friedman, Dr. I., and others : Isotopic Composition and Temperature of Formation of Antarctic Snows, 857
  Comparison of the Chemical Composition and Magnetic Properties of Tektites and Glasses formed by Fusion of Terrestrial Rocks, 1089
Friend, Dr. J : Physico-chemical, Biological and Applied Aspects of Autoxidation (Some Aspects of the Biologically Catalysed Aerobic Oxidation of Carotenoids), 747
Friend, Dr. J. A. : Given an Award under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme, 291
Fries, Prof. Nils : Nonanal as a Growth Factor for Wood-rotting Fungi, 166
Frisch, Prof O. R. : Are the Laws of Nature Symmetrical ?, 638
Frisch, Prof. O. R. (consulting editor) : The Nuclear Handbook, *review* by K. E. B. Jay, 273
Frisco, L. F. (edited by R. A. Sodermann and) : Digest of Literature on Dielectrics, Vol 22, 1958 (United States National Academy of Sciences—National Research Council, Publication No. 713), *review* by S Weintroub, 728
Frog (Common), *Rana temporaria* : Cyclical Changes in the Distribution of the Testis Lipids in the (Dr. B. Lofts and C. Boswell), 708
Frog Water-Balance Principle and Arginine Vasotocin : Evidence for the Identity of Natriferin, the (Prof Wilbur H Sawyer), 1030
Frontiers (New), in Optics and Spectroscopy (Pittsburgh Conference and the Optical Society of America Symposium on), 289

Frost, N. E.: Correlation of the Alternating Stresses required to Initiate and Propagate a Fatigue Crack in Mild Steel, 233
Frost-point Temperature and Wind: Airborne Measurements of Latitudinal Variation of (N. C. Helliwell), 993
Fructose-1,6-diphosphatase: Alkaline C-1—Evidence for its Participation in Photosynthesis (Dr. Robert Smillie), 1024
Fruit: Biological Function of (Dr. I. Gindel), 42
Fruit Breeding and Genetics to 1955: Abstract Bibliography of—*Rubus* and *Ribes*, a Survey (Dr. R. L. Knight and Elizabeth Keep), *review* by Dr. G. Haskell, 184
Fruit Juice (Passion): An Acid-tolerant and Non-sporulating Yeast from (B. A. S. Rao and J. S. Pruthi), 342
Fruit Production of the Strawberry: Effect of Autumn Applications of Potassium Gibberellate on (Prof. Carter R. Smith), 620
Fruit-spot (Banana) ('Speckle') caused by *Deightoniella torulosa* (Syd.) Ell. (Dr. D. S. Meredith), 961
Fuchs, N. A. Evaporation and Droplet Growth in Gaseous Media (translated from the Russian by J. M. Pratt; edited by Dr. R. S. Bradley), *review* by Prof. F. H. Garner, 451
β-D-Fucosidase Activity of Mammalian Tissues and its relation to other Glycosidases (Dr. G. A. Levvy), 1027
Fuel and Power: Advisory Council for Research and Development in, 286
Fuel Cell: Low-Temperature (Shell Research Centre), 994
Fujita, Dr. Kazuo (Hashimoto, Dr. Hatsujiro, and): Electron Microscope Images of Dislocations, 51
Fujita, Toshio, and others: Plant-Growth Activity of α-Alkylphenylacetic Acids and 1,2-Benzo-1-cycloalkene-3-carboxylic Acids, 694
Fukuda, Toshifumi, and others: Silkworm Raising on Artificial Food, 669
Fukuhara, H. (Nisman, B., and): Cytoplasmic Particles and their Role in Protein Synthesis (Mechanism of Protein Synthesis in Micro-organisms), 645
Fulton, Dr. J. D.: Treatment of *Leishmania donovani* Infections with Surface-active Agents, 1129
Fulton, Prof. John F.: *Obituary* by Prof. Kenneth J. Franklin, 110
Function: Biological Structure and (International Union of Biochemistry and the International Union of Biological Sciences Symposium on), 905
Function of the Corpus Allatum in 'Dauer-pupa' of the Silkworm, *Bombyx mori* (Dr. Masatoshi Kobayashi), 346
Function of Deoxyribonucleic Acid: Structure, Synthesis and (Société de Chimie Physique Meeting on), 1079
Function of the Provisional Embryonic Cuticle of a Lepidopteran: Occurrence and (Dr. R. K. Sharan), 1040
Function (Antigonadotropic), of the Pineal Gland and the Oxytocin of the Neurosecretory Hypothalamic System (Prof. S.-M. Milcou and S. Pavel), 950
Function (Biological), of Fruit (Dr. I. Gindel), 42
Function (Renal), in Extracorporeal Circulation: Influence of 5-Hydroxytryptamine in (Dr. M. H. Frick), 609
Functions: Confluent Hypergeometric (Dr. L. J. Slater), *review* by Prof. W. N. Bailey, 93
Functions (Probable), of Betaine Esters in Brain Metabolism: Isolation and (Prof. E. A. Hosein and Peter Proulx), 321
Fungi (Obligately Parasitic and Saprophytic): Incorporation of Acetate into Protein by (Dr. Richard C. Staples and Dr. H. P. Burchfield), 1040
Fungi (Wood-rotting): Nonanal as a Growth Factor for (Prof. Nils Fries), 166
Fungitoxicity of Metal Ions (Dr. E. Somers), 427
Fungitoxicity, Electronic Absorption Spectra, and Chemical Reactivity with Mercaptalbumin: An Ortho Effect influencing (Dr. H. P. Burchfield and Eleanor E. Storrs), 593
Furnaces: High-Temperature (A. Gallenkamp and Co., Ltd., Catalogue No. 620), 1077
Further Education: Part-Time Courses in (J. Heywood), 189
Fusion of Terrestrial Rocks: Comparison of the Chemical Composition and Magnetic Properties of Tektites and Glasses formed by (Dr. Irving Friedman, Dr. Arthur Thorpe and Dr. Frank E. Senftle), 1089
Fusion Electrolysis of Titanium (Dr. W. J. Kroll), 994
Future of British Agriculture, *review* by Sir John Russell, 721
Future of Broadcasting in Great Britain, 1076
Future of Man (Prof. P. B. Medawar), *review* by Dr. J. D. Nisbet, 446
Fyfe, Prof. W. S.: Stability of Epidote Minerals, 497
Fyfe, Prof. W. S., and Verhoogen, Prof. J.: Covalent Super-Exchange in Solid State Physics, 1108

GAGEA *reticulata* Schultes: Effect of Variations in Temperature on Meiosis in (Dr. C. P. Malik), 805
Galactic Gravitational Potential: Gravitational Red Shift of Hydrogen 21-cm. Radiation as a Method to measure (L. F. Landovitz and L. Marshall), 223
Galactic Magnetic Field: A New Limit to the, set by Measurements of the Zeeman Splitting of the Hydrogen Line (Dr. R. D. Davies, C. H. Slater, W. L. H. Shuter and P. A. T. Wild), 1088
Galathea Report—Scientific Results of the Danish Deep-Sea Expedition round the World, 1950-52 (edited by Dr. Anton Bruun, Capt. Sv. Greve and Prof. R. Spärck), *review* by Dr. N. B. Marshall, 443
Gall Disease of Cocoa. Transmission of a (A. L. Wharton and A. A. Brunt), 80
Gallagher, Dr. C. H.: Ageing of Mitochondria, 162
Gallagher, Dr. C. H., and Rees, Dr. K. R.: Levels of Pyridine Nucleotides in Liver Poisoning, 148
Gallenkamp and Co., Ltd., A.: Catalogue No. 620, High-Temperature Furnaces, 1077
Gallium Arsenide as a Semi-insulator (J. W. Allen), 403
Gallium Arsenide for γ-Ray Spectroscopy (W. R. Harding, C. Hilsum, M. E. Moncaster, D. C. Northrop and Dr. O. Simpson), 405
Gamarekian, S. Edward: Appointed Editor of *Discovery*, 741; work of, 741
Game Control. Translocation of Wild Animals as a Means of (Dr. A. M. Harthoorn, J. A. Lock and J. MacKinnon), 518
Games (Optimal): Theory of (Prof. Alan S. C. Ross), 968
γ-Aminobutyric Acid-Level in the Brain: Effect of Potassium Cyanide Poisoning on the (Dr. T. Tursky), 322
γ-Chain Haemoglobin (Haemoglobin 'Bart's'): Sedimentation Characteristics of the (Dr. R. A. Kekwick and Dr. H. Lehmann), 158
γ-Globulin (Human): Cleavage of (Dr. Rose Augustin and Barbara J. Hayward), 129
Presence of Immunologically Active Fragments after Proteolytic Degradation of (L. A. Hanson and B. G. Johansson), 599
γ-Irradiation of Lead Silicate Glass (R. S. Barker, D. A. Richardson, E. A. G. McConkey and R. Rimmer), 135
γ-Radiation Sources: Use of, for the Sterilization of Pharmaceutical Products (Report of the Association of the British Pharmaceutical Industry), 903
γ-Ray Measurements: Fall-out Caesium in Surface Sea Water off the California Coast (1959-60) by (Dr. Theodore R. Folsom, Dr. G. J. Mohanrao and Perrin Winchell), 480
γ-Ray Spectrometry. Non-destructive Analysis of Selenium by Neutron Activation followed by (Dr. Minoru Okada), 594
γ-Ray Spectroscopy: Gallium Arsenide for (W. R. Harding, C. Hilsum, M. E. Moncaster, D. C. Northrop and Dr. O. Simpson), 405
Gap between Science and Christianity: Bridging the, *review* by R. Brightman, 818
Gardens Bulletin: Vol. 17, Part 2, Special issue to commemorate the hundredth anniversary of the founding of the Singapore Botanic Gardens, 1000
Gardens (Home) Australian Native Plants for (A. E. Brooks), *review* by Dr. R. Melville, 637
Garlick, Prof. G. F. J.: A Source-Book of Semiconductor Physics, *review*, 865
Garner, Prof. F. H.: Evaporation and Droplet Growth in Gaseous Media, *review*, 451
Garnham, Prof. P. C. C.: *Obituary* of Prof. Eduard Reichenow, 554
Garrett, P. A.: Nomenclature of the Keuper Series, 868
Garth Area: The Geography of the—the Central Highlands in Miniature (Dr. Joy Tivy), 200
Gartmann, Heinz: Science as History—the Story of Man's Technological Progress from Steam Engine to Satellite (translated from the German by Alan G. Readett), *review* by J. L. Stollery, 8
Garton, Dr. G. A.: Lipid Research at the Rowett Institute (1951-59), 115
Fatty Acid Composition of the Lipids of Pasture Grasses, 511
Gas Chromatography: Determination of Fatty Acids of Lower Molecular Weight by (Marie L. Vorbeck, Leonard R. Mattick, Frank A. Lee and Carl S. Pederson), 689
Microanalytical Separation of Steroids by (C. C. Sweeley and Dr. E. C. Horning), 144
Gas Chromatography Research Center: A New (Barber-Colman Company, Houston), 289
Gas Council: Retirement of Dr. R. H. Griffith as director of research, 992
Gas Engineers, Institution of, and the Corrosion Group (Birmingham and Midlands Section) of the Society of Chemical Industry: Symposium on the Protection of Gas Plant and Equipment from Corrosion, 466
Gas Industries (Coal, Electricity and): Capital Investment in the (Ministry of Power), 1055
Gas Phase: Recombination of Oxygen Atoms in the (P. G. Dickens, R. D. Gould, Prof. J. W. Linnett and A. Richmond), 686
Gas Plant and Equipment: Protection of, from Corrosion (Institution of Gas Engineers and the Corrosion Group of the Birmingham and Midlands Section of the Society of Chemical Industry Symposium on), 466
Gas Production of Sensitive and Resistant *L*1210 Mouse Leukaemia Cells: Effect of 6-Mercaptopurine on the Net *in vitro* (Dr. H. J. Woodliff), 156
Gas-Liquid Chromatography of Conjugated Fatty Acids (Dr. N. W. R. Daniels and J. Wendy Richmond), 55
Gas-Liquid Chromatography Analyses of C_6-C_8 Hydrocarbons: Two Highly Selective Solvents for (Dr. A. van der Wiel), 142
Gas-Solid Chromatographic Separation of Hydrocarbons of High Molecular Weight (C. G. Scott and D. A. Rowell), 143
Gascoigne, Dr. J. A. (Brown, Dr. A. M., and): Biosynthesis of Cellulose by *Acetobacter acetigenum*, 1010
Gaseous Media: Evaporation and Droplet Growth in (N. A. Fuchs), translated from the Russian by J. M. Pratt; edited by Dr. R. S. Bradley, *review* by Prof. F. H. Garner, 451
Gaseous Plasmas: Diamagnetic Moment of, measured by Spin Resonance Techniques (T. C. Marshall, R. A. Kawcyn and Prof. L. Goldstein), 584
Gases (*n*-Alkyl Chloride): Ionization and Attachment Coefficients in (J. C. Devins and O. H. LeBlanc, jun.), 409
Gases (Permanent): An Ionization Detector for (Dr. J. E. Lovelock), 49
Gastro-Intestinal Mucosa: Action of some Surface-active Compounds on the (Dr. J. A. Nissim), 305
Gastropoda (Marine): 'Water Rigour' as an Aid when Operating on (Prof. B. J. Krijgsman and A. C. Brown), 69
Gastropods: Australian Bivalve (Robert Burn), 44
Gatenby, Prof. J. Bronte: International Cytology, *review*, 632
Obituary by Prof. J. N. R. Grainger, 990
Gates (Dr. Ruggles), and the Aboriginal Australian (Prof. A. A. Abbie), 375
Gautheret, Prof. R. J.: La Culture des Tissus Végétaux, *review* by A. Allsopp, 976
Gavosto, Dr. Felice, and others: Proliferative Capacity of Acute Leukaemia Cells, 611
'GBR Experiment': The—a Trans-Atlantic Frequency Comparison between Caesium-controlled Oscillators (H. A. Pierce, G. M. R. Winkler and R. L. Corke), 914
Gebbie, Dr. H. A., and others: Pure Rotational Absorption of Ozone in the Region 125-500 Microns, 765
Geddes, Dr. I. C.: Appointed to a senior lectureship in anaesthesia in the University of Liverpool, 117
Gee, Prof. G.: Awarded the Swinburne Medal of the Plastics Institute, 740
Gel (Starch-) Electrophoresis of Wheat Proteins (Dr. G. A. H. Elton and J. A. D. Ewart), 600
Gelatine and Glue Research Association (British): Nineteenth Meeting of the Research Panel, 998
Gemzell, Carl-Axel, and others: Immunoelectrophoretic Studies on Purified Human Growth Hormone, 64
MNSs Gene Frequencies in English Blood Donors (Dr. T. E. Cleghorn), 701
Gene's Organ in Ticks: Accessory Glands of (Dr. B. Feldman-Muhsam and Y. Havivi), 964

General Circuit Theory (Prof. Gordon Newstead), *review* by Prof A. H. M Arnold, 811
General Microbiology, Society of : Formation of a Microbial Systematics Group, 190
General Post Office : Appointment of Dr R L. Smith-Rose as chairman of the Frequency Advisory Committee, 466
General and Linear Circuit Theory, *review* by Prof. A H. M Arnold, 811
Generation of Aerosols by Vapour-Phase Polymerization of Methyl Acrylate (R. Pearson and G. Langer), 235
Generator Potential in the Lateral Eye of the Horseshoe Crab : Summative Action of Acetylcholine with Physiological Stimulus on the (R. Kikuchi, K. Naito and S. Minagawa), 1118
Genesis of Tektites, and Petrogenesis . Average Composition of Granites, the (Prof E H Timothy Whitten), 867
Genetic Recombination in *Salmonella typhimurium* occurring during Transmission of Colicinogeny (Dr Ozeki and Dr. Howarth), 649
Genetically Determined Enzyme in the Pig (Dr K-B Augustinsson and Dr. B Olsson), 924
Genetico-Statistical Study (A Clinical and), of Schizophrenia and Low-Grade Mental Deficiency in a Large Swedish Rural Population (Bertil Hallgren and Torsten Sjogren), 298
Genetics . Abstract Bibliography of Fruit Breeding and, to 1955—*Rubus* and *Ribes*, a Survey (Dr R. L. Knight and Elizabeth Keep), *review* by Dr. G Haskell, 184
  An Introduction to (Dr. C. M. M. Begg), *review* by Wilma George, 357
Genetics for Beginners, *review* by Wilma George, 357
Genetics of Continuous Variation, *review* by Prof Kenneth Mather, 813
Genetics (Cell Culture), of Man : Cytology and (Symposium published by the *American Journal of Human Genetics*), 116
Genetics (Human), American Journal of Symposium on Cytology and Cell Culture Genetics of Man, 116
Genetics (Quantitative) . Introduction to (Dr. D. S Falconer), *review* by Prof. Kenneth Mather, 813
Genetics, Radiobiology and Radiology Proceedings, Mid-Western Conference (edited by Dr Wendell G. Scott and Dr. Titus Evans), *review* by Dr. Lorna J. Lilly, 97
Genetics and Twentieth Century Darwinism (Cold Spring Harbor Symposia on Quantitative Biology, Vol. 24), *review* by Dr H. Kalmus, 726
Geochemistry of Rare and Dispersed Chemical Elements in Soils (A P. Vinogradov), second edition (translated from the Russian), *review* by A H. Debnam, 629
Geoelectric Effect in Coleoptiles : Electrostatic Measurement of the (Carl Hellmuth Hertz), 320
Geographical Society (Royal) : Research Series No. 3, The Making of the Broads (Dr. J. M. Lambert, J. N Jennings, C T. Smith, Charles Green and J N. Hutchinson), *review* by Miles Burkitt, 636
Géographie des Plantes (Alexander von Humboldt et A. Bonpland), facsimile edition (Society for the Bibliography of Natural History), 904
Geography of the Garth Area—the Central Highlands in Miniature (Dr. Joy Tivy), 200
Geography (Plant) : Foundation of, 904
Geological Environment in West-Central New Mexico : Anomalous Leads from a Selected (William F. Slawson and Carl F Austin), 400
Geological Research in the Northern Highlands of Scotland, 831
Geological Results of Petroleum Exploration in Britain by the British Petroleum Company during the Years 1945-57 (N. L. Falcon and P. E. Kent), 1078
Geological Society : Memoir No. 2, Geological Results of Petroleum Exploration in Britain by the British Petroleum Company during the Years 1945-57 (N. L Falcon and P. E Kent), 1078
Geological Time-Scale : A Revised (Prof. Arthur Holmes), 27
Geology : Submarine, *review* by Dr. G E. R Deacon, 629
Geology (Regional) : Handbook of—Scotland, the Northern Highlands (Dr. J. Phemister), third edition, 831
Geology (Structural) : The Use of Stereographic Projection in (Dr. F. C. Phillips), second edition, *review* by John Sutton, 729
Geomagnetic Noise at 230 kc./s (R. L. Dowden), 677
Geomagnetic Storms and the Space around the Earth (Prof. Sydney Chapman), 824
Geometry : Molecular, *review* by Dr. J. W. Cook, 812
  A New Plasma Confinement (James L. Tuck), 863
Geonomy and Natural Resources, American Institute of : John Fleming Medal awarded to Dr. Maurice Ewing, 905
Geophysical Co-operation (International), 1959 : Recent Scientific Activities at Halley Bay— (M. J. Blackwell), 982
Geophysical Year (International) . I.G Y., Year of Discovery—the Story of the (Prof Sydney Chapman), *review* by Prof S K. Runcorn, 185
Geophysical Year (International) Observations : Distribution of Atmospheric Ozone—a Preliminary Analysis of some (J. MacDowall), 382
Geophysics : Advances in (edited by H. E Landsberg and Prof. J. van Mieghem), Vols. 4 and 5, *review* by Dr S H Hall, 1060
George, Dr. E. P , and others : Lipaemic Clearing Action of Artificial Anticoagulants, 782
George, Wilma : Genetics for Beginners, *review*, 357
Gerber, Gisela, and others : Urinary Excretion of β-Amino-isobutyric Acid after Injection of Thymidine labelled with Tritium, 956
Gerber, Dr. Georg B , and others : Urinary Excretion of β-Amino-isobutyric Acid after Injection of Thymidine labelled with Tritium, 956
Gerber, Dr. J. H : Appointed director of the Center for Aging Research of the National Institutes of Health, United States Department of Health, Education and Welfare, 374
Gergely, Dr J., and others : Role of Mucoid Substances of the Aorta in the Deposition of Lipids, 152
Germination (Pollen), in some Gramineae— *Pennisetum typhoideum* (Dr. I. K. Vasil), 1134
Germination Inhibitor of the Seed of Rice . Viability and (Prof. S. M. Sircar and Manjula Biswas), 620
Gero, Dr. S., and others : Role of Mucoid Substances of the Aorta in the Deposition of Lipids, 152
Gertner, Dr. S. B. (Goldstein, Dr. M., and) : Formation of a New Metabolite of Epinephrine and Norepinephrine in Liver and Kidney, 147
Geschwind, Dr. Irving I. : Viscosity of Concentrated Urea–Lithium Bromide Solutions, 324
Ghana : Radioactive Fall-out in (Dr. A. H. Ward and J. D. Marr), 299
Gharpurey, M. K., and others : New Compounds for the Control of Water Evaporation, 870
Gherzi, Father E. : Atmospherics on 20 kc./s. at the Time of Local Aurorae, 225
Giant Amoeba *Chaos chaos* : Streaming in Cytoplasm dissociated from the (Prof. R. D. Allen, J W. Cooledge and P. J. Hall), 896
Gibberellate (Potassium) : Effect of Autumn Applications of, on Fruit Production of the Strawberry (Prof Carter R. Smith), 620
Gibberellin Toxicity of, to Seedless and Seeded Varieties of *Vitis vinifera* (Dr. Robert J Weaver), 1135
Gibbons, Dr D F : Appointed lecturer in physical metallurgy at the University of Birmingham, 117
Gibbs, P. E : Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Botany), 742
Gibson, Dr. Alan F , and others (edited by) : Progress in Semiconductors, Vol. 4, *review* by Dr J R. Tillman, 185
Giddings, J. Calvin : "Eddy" Diffusion in Chromatography, 1023
Gilchrist, A O : Elected to a Junior Research Fellowship (Sydney Harvey Fellowship) of Churchill College, Cambridge, 742
Gill, S. : At the second Annual Conference of the British Computer Society (Advances in the United States), 656
Gillespie, Dr. R. J., and others : Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives—Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy, 662
Gillet, C. M. . Delayed 'Primary' Effects in *Chara vulgaris* L subjected to X-Rays, 874
Gillett, J D . Report for 1958-59 of the East African Virus Research Institute, 565
Gillie, A. C : Transistors, *review* by Dr. J. R. Tillman, 1058
Gilman, Dr. J. J : The Physical Nature of Plastic Flow, 374
Gilmour, A E , and others : Ocean Currents in McMurdo Sound, 867
Gilmour, J. S L. : Microbial Systematics, 191
Gilson, H. C. : East African Fisheries Research Organization, 469
Gindel, Dr I Biological Function of Fruit, 42
Giolitti, G , and others . An Antibiotic Complex derived from a *Streptomyces* and Active against Gram-positive Bacteria, 1029
Gladish, Y. C., and others New Inhibitor of Monoamine Oxidase, 941
Gladner, Jules A., and others : Some Aspects of the Fibrinogen–Fibrin Transition, 758
Gland (Pineal) Antigonadotropic Function of the, and the Oxytocin of the Neurosecretory Hypothalamic System (Prof. S -M. Milcou and S Pavel), 950
Glands (Accessory), of Gene's Organ in Ticks (Dr. B. Feldman-Muhsam and Y. Havivi), 964
Glands (Adrenal), of Litter-mate Cats Proportion of Noradrenaline to Adrenaline in the (Dr. K. R. Butterworth and Dr. Monica Mann), 785
Glass, Prof D V Population Growth, Fertility and Population Policy (Presidential Address to Section N (Sociology) of the British Association for the Advancement of Science), 849
Glass (Lead Silicate) Gamma Irradiation of (R. S Barker, D A. Richardson, E. A. G McConkey and R. Rimmer), 135
Glass Rods . Strengths of Acid-etched (B. A. Proctor), 492
Glasses formed by Fusion of Terrestrial Rocks : Comparison of the Chemical Composition and Magnetic Properties of Tektites and (Dr Irving Friedman, Dr. Arthur Thorpe and Dr. Frank E. Senftle), 1089
Glasshouse Crops Research Institute : Open Day (F W. Toovey), 204
  Appointment of Sir William Slater as chairman of the governing body, 1079
Glasziou, K. T : The David North Plant Research Centre, 745
Gledhill, Dr. A W., and Rees, Dr. R. J. W. : Effect of a Primary Tuberculous Infection on the Resistance of Male and Female Mice to Ectromelia, 703
Glees, Dr. P. : Effect of Cortisone on Degenerating Nerve Fibres in Birds, 327
Glendinning, D R Selfing of Self-Incompatible Cocoa, 170
Glenner, Dr. George G. (Kellogg, Dr. Donald A., and) : Histochemical Localization of Human, Term Placental 17β-Œstradiol Dehydrogenases—Implications for the Transhydrogenase Reaction, 763
γ-Globulin (Human) Cleavage of (Dr. Rosa Augustin and Barbara J. Hayward), 129
  Presence of Immunologically Active Fragments after Proteolytic Degradation of (L. A. Hanson and B G Johansson), 599
β-Globulin Polymorphism in Chimpanzees (Prof. Samuel H. Boyer and Dr. William J. Young), 1035
Glomerulus (Rat), and Nephritogenic Streptococci : Immunological Relationships between the (A S Markowitz, S Howard Armstrong, jun , and Daniel S. Kushner), 1095
Glossina (Tsetse Fly) : Free Amino-Acids of the (E Bursell), 778
Glossina palpalis (R-D) in Nigeria : Use of Dieldrin in the Control of (J. B. Davies), 84
Glover, Dr J (Packter, N M , and) : Ubiquinone (50) and Ubichromenol in *Aspergillus fumigatus*, Fresenius, 413
Glover, Dr. R. E : Tuberculosis in Animals, 996
Gloyne, Dr R. W. : Weather Problems in Agriculture (Windbreaks—some Physical Effects), 996
Glucides (Phosphorylated) : Cori's Ester and (First International Symposium on), 117, 290
Glucosamine Values of Muramic Acid and other Amino-Sugars by the Elson and Morgan Method (R. E. Strange), 38
Glucose into the Lateral Ventricle of the Rat : Hunger Reduction produced by Injecting (L. J. Herberg), 245
Glucose, Cellobiose and other Saccharides : Syntheses of, by *Acetobacter acetigenum* in a Lactate-buffered Glycerol Medium (Dr. C. P. Jackson and K. Ramamurti), 942
Glucose (Blood), in the Rat adapted to a Fat Diet . An Inverse Relation between the Liver Glycogen and the (Dr. P. A Mayes), 325
Glucose, Methionine and Sodium Butyrate Reduction of the Intestinal Absorption of, by the Cation Trimethylhexadecylammonium (Dr. J. A. Nissim), 308
Glucuronosyl Transferase : Inhibition of, by Progestational Agents from Serum of Pregnant Women (Dr. David Yi-Yung Hsia, Robert M Dowben, Ralph Shaw and Aaron Grossman), 693
Glue Research Association, British Gelatine and : Nineteenth Meeting of the Research Panel, 998

Glutathione and Alloxan: Effect of, on the Photoperiodic Response of *Xanthium* (J. Nitsan), 81
Gluten (Wheat): Effect of, on the Peristaltic Reflex (Dr. R. Schneider, H. Bishop, Dr. B. Shaw and Prof. A. C. Frazer), 516
Glutinants et Matières d'Apprêts: Traité Général de la Fabrication des Colles des (Dr. Maurice de Keghel), nouvelle édition, *review* by Prof. A. G. Ward, 890
Glycerine: Effect of, on the X-Ray Sensitivity of *Serratia marcescens* (Dr. D. L. Dewey), 1008
Glycerol Medium (Lactate-buffered): Syntheses of Glucose, Cellobiose and other Saccharides by *Acetobacter acetigenum* in a (Dr. C. P. Jackson and K. Ramamurti), 942
Glycogen (Liver), and the Blood Glucose in the Rat adapted to a Fat Diet: An Inverse Relation between the (Dr. P. A. Mayes), 325
Glycolysis (Aerobic): Inhibition of, in Yoshida Ascites Hepatoma by Tartronic Acid (Dr. L. Fiume), 792
Glycosidases: The β-D-Fucosidase Activity of Mammalian Tissues and its relation to other (Dr. G. A. Levvy), 1027
Glycyrrhetinic Acid: Antileukaemic Activity of (Dr. W. Logemann, F. Lauria, G. Cudkowicz and J. Franceschini), 607
Gobi Mountains: Tectonics of the (V. P. Solonenko and N. A. Florensov), 373
God: The Masks of—Primitive Mythology (Dr. Joseph Campbell), *review* by Dr. K. O. L. Burridge, 7
Goddard, C. K.: Physiological Media for Tissues of *Helix*, 68
Goddard, Prof. L. S.: Theories of Figures of Celestial Bodies, *review*, 890
Goddard, Dr. Robert H.: Awarded posthumously the Langley Medal of the Smithsonian Institution, Washington, 201
Godwin, Felix: The Exploration of the Solar System, *review* by D. G. King-Hele, 811
Goitre Conference: The Fourth International (Prof. C. Rimington and Dr. R. A. Miley), 651
Goitrogenesis in the Rat: Comparison of Iodine-124 and Iodine-131 in Inhibition of (Dr. I. Doniach and Dr. P. E. Francois), 704
Gold, Eleanor, and others: Effect of Lysergic Acid Diethylamide on Larval Growth, 153
Gold–Silicon Alloys: Non-crystalline Structure in Solidified (W. Klement, Jun., R. H. Willens and Prof. Pol Duwez), 869
Golden, Jack S. (Graber, Richard R., and): Population Trends among Hawks and Owls in Illinois (Illinois Department of Registration and Education, Biological Notes No. 41, 999
Goldfinger, Prof. P., and others: Mass Spectrometric Investigation of the Vaporization of Sulphides and the Dissociation Energy of S_2, 408
Goldie, Dr. L., and Green, Dr. J. M.: Paradoxical Blocking and Arousal in the Drowsy State, 952
Golding, E. W., and Tabor, Dr.: Problems of the Arid Zones (Local Energy Sources), 295
Golding, R. M.: Ultra-Violet Absorption Spectra of the Molecules H_2O, HDO and D_2O, 139
Goldman, Prof. Leon, and others: Absence of Local Cytotoxic Change in Man from Griseofulvin, 335
Goldsmid, H. J., and Bowley, A. E.: Thermal Conduction in Mica along the Planes of Cleavage, 864
Goldsmiths' College, London: Foundation Oration, The Diffusion of Knowledge (Dr. Michael Grant), 371
Goldstein, David A., and others: Evidence for Internal Organization of Nucleic Acid in T_2 Bacteriophage, 781
Goldstein, Prof. L., and others: Diamagnetic Moment of Gaseous Plasmas measured by Spin Resonance Techniques, 584
Goldstein, Dr. M., and Gertner, Dr. S. B.: Formation of a New Metabolite of Epinephrine and Norepinephrine in Liver and Kidney, 147
Golgi Bodies (so-called): Cytochemical Evidence of the Origin of Lipid Bodies, from Mitochrondria (H. C. Chopra), 713
Golovinsky, Dr. E. V., and others: Adaptive Chain in the Conversion of Antimetabolites into Metabolites, 1041
Goma, L. K. H.: Experimental Breeding of *Anopheles gambiae* Giles in Papyrus Swamps, 1137
Gonads in Parasitic and Non-Parasitic Lampreys: Development of the (M. W. Hardisty), 341
Goodman, C. H. L.: Ionic-Covalent Bonding in Crystals, 590
Gordienko, P. A.: Recent Progress of the work of the Arctic Drift Expeditions, 287
Gorter, C. J.: At the Tenth General Physics Conference of the Swedish National Committee for Physics (Problem of Orienting Atomic Nuclei at Low Temperatures), 557
Goswami, Ajit, and Sadhu, Prof. D. P.: Polyenoic Acid in Hypercholesterolaemia Induced by Pyridoxine Deficiency in Rats, 766
Goto, Dr. Yoshio, and others: High-Energy Bound Phosphate and Diabetes Mellitus, 702
Gould, R. D., and others: Recombination of Oxygen Atoms in the Gas Phase, 686
Gould, R. P.: Sensory Innervation of the Anal Canal, 337
Gourevitch, Dr. A., and others: Bacterial Penicillin Amidase, 237
Government (State): Science and—a Study of the Scientific Activities of State Government Agencies in Six States (Dr. Frederic N. Cleaveland), *review* by R. Brightman, 181
Government Chemist: Report for 1958-59, 1076
Govindachari, Prof. T. R.: The Chemistry of Natural Products (Recent Investigations on some Alkaloids from Indian Plants), 1080
Gowland, Dr. G.: Antibody Responses of the Domestic Fowl to Two Soluble Bacterial Antigens, 624
Gowland, Dr. G. (Willis, Dr. A. T., and): Egg-Yolk Reactions of *Pseudomonas* Species, 432
Graber, Richard R., and Golden, Jack S.: Population Trends among Hawks and Owls in Illinois (Illinois Department of Registration and Education, Biological Notes No. 41), 999
Graddon, Dr. D. P., and Watton, E. C.: Structure of the 1:1-Adducts of Cupric β-Diketone Chelates with Heterocyclic Bases, 1021
Grade (Low-) Mental Deficiency in a Large Swedish Rural Population: A Clinical and Genetico-Statistical Study of Schizophrenia and (Bertil Hallgren and Torsten Sjogren), 298.
Graduate Research Laboratories: Grants for (United States National Science Foundation), 559
Graduate Schools in British Universities (Prof. W. R. Niblett), 560
Graham-Jones, Oliver: Tuberculosis in Animals (Disease in Zoo Animals), 997
Grainger, Prof. J. N. R.: *Obituary* of Prof. J. Bronte Gatenby, 990
Grainger, L.: Appointed assistant director of the Atomic Energy Research Establishment, with special responsibilities for applied research, 536
Gram-positive Bacteria: An Antibiotic Complex derived from a *Streptomyces* and Active against (B. Sgarzi, A. M. Lugli and G. Gioletti), 1029
Gramineae: Pollen Germination in some—*Pennisetum typhoideum* (Dr. I. K. Vasil), 1134
Granick, David: The Red Executive, 537
Granit, Prof. Ragnar: Elected to foreign membership of the Royal Society, 112; work of, 112
Granites: The Average Composition of, the Genesis of Tektites, and Petrogenesis (Prof. E. H. Timothy Whitten), 867
Grant, Jean (Dunsford, Dr. I., and): The Anti-Globulin (Coombs) Test in Laboratory Practice, *review* by Dr. R. Drummond, 357
Grant, Dr. Michael: The Diffusion of Knowledge (Foundation Oration at Goldsmiths' College, London), 371
Grant, Prof. W. F.: Chromosome Numbers in *Amaranthus*, 28
Grants for Graduate Research Laboratories (United States National Science Foundation), 559
Grants for Assistance in Research in any branch of Chemistry (Chemical Society), 466
Grants for Space Research in Britain, 744
Grants and Awards for 1961 (Lalor Foundation), 1078
Grants (Training), in Plastics Technology (Plastics Institute), 28
Granules (Melanin), and Mitochondria (Dr. Ruth V. Baker, M. S. C. Birbeck, Dr. H. Blaschko, Prof. T. B. Fitzpatrick and Dr. M. Seiji), 392
Grape Vines in Europe and North America: Sap-Transmissible Viruses associated with Diseases of (C. H. Cadman, H. F. Dias and B. D. Harrison), 577
Graphitic Perfection (Different): Dependence on Temperature of the Interlayer Spacing in Carbons of (E. G. Steward, B. P. Cook and E. A. Kellett), 1015
Grass: Lead-210 and Polonium-210 in (C. R. Hill), 211
Grasses (Pasture): Fatty Acid Composition of the Lipids of (Dr. G. A. Garton), 511
Grassland Productivity: The Measurement of—Proceedings of the University of Nottingham Sixth Easter School in Agricultural Science, 1959 (edited by Prof. J. D. Ivins), *review* by Dr. G. W. Cooke, 544
Gravitation: The Theory of Space, Time and (V. Fock), translated from the Russian by N. Kemmer, *review* by Dr. D. W. Sciama, 4
Gravitational Potential (Earth's): Evaluation of the Second, Fourth and Sixth Harmonics in the (D. G. King-Hele), 490
Gravitational Potential (Galactic): Gravitational Red Shift of Hydrogen 21-cm. Radiation as a Method to measure (L. F. Landovitz and L. Marshall), 223
Gravitational Red Shift of Hydrogen 21-cm. Radiation as a Method to measure Galactic Gravitational Potential (L. F. Landovitz and L. Marshall), 223
Gray, I., and Millman, Dr. A. P.: Spectral Reflectivity of Ore Minerals, 282
Gray, Prof. J. A. B.: The Place of Physiology in University Education (Inaugural Lecture at University College, London), 719
Great Britain: Future of Broadcasting in, 1076
  Irrigation in, 198
  Output of Power in, 557
  Recruits to Teaching in, 750
  See also under Britain
Greaves, Dr. J. P., and Scott, Dr. Patricia P.: Urinary Amino-Acid Pattern of Cats on Diets of varying Protein Content, 242
Greaves, Dr. R. I. N.: Freezing and Drying of Biological Materials, 749
Grebenik, Prof. E.: Demography, *review*, 97
Greek Fire and Gunpowder: A History of (Prof. J. R. Partington), *review* by Prof. R. J. Forbes, 272
Green, Charles, and others: The Making of the Broads, *review* by Miles Burkitt, 636
Green, Dr. J. M. (Goldie, Dr. L., and): Paradoxical Blocking and Arousal in the Drowsy State, 952
Green Algae (Siphonaceous): Xylan of (Yoshihiko Iriki, Takeo Suzuki, Kazutosi Nisizawa and Tomoo Miwa), 82
Green Plant: Crystallization of a Photosynthetic Reductase from a (Dr. R. Hill and Fay Bendall), 417
Green Sulphur Bacteria: A New Species of (V. V. Shaposhnikov, E. N. Kondratieva and V. D. Federov), 167
Greenhalgh, R., and Riley, Dr. J. P.: Alleged Occurrence of the Perchlorate Ion in Sea-Water, 1107
Greenwich (Royal) Observatories: Integration of the Cape and, 464
Greenwood, E. A. N., and others: Copper and Cobalt in Nitrogen Fixation, 79
Gregoire, M., and others: A Transplantable Spontaneous Osteogenic Sarcoma observed in the Muscle Tissue of an Albino Mouse, 1129
Gregory, Dr. A. H. (Campbell, Dr. F. W., and): Effect of Size of Pupil on Visual Acuity, 1121
Greig, H. B. W., and Cornelius, Elsie M.: Isolation of Material with Pro-activator Activity from Human Serum, 1125
Greig, Prof. J.: Unification of Analytical Approaches to Engineering Problems, *review*, 359
Greve, Capt. Sv., and others (edited by): Galathea Report—Scientific Results of the Danish Deep-Sea Expedition round the World, 1950-52, *review* by Dr. N. B. Marshall, 443
Grew, J. S.: *Obituary* of Dr. O. J. Silberrad, 553
Griffin, Dr. D. M., and Perrin, Helen N.: Anastomoses in the Phycomycetes, 1039
Griffin, Frances, and Fischer, Prof. Roland: Differential Reactivity of Saliva from 'Tasters' and 'Non-Tasters' of 6-*n*-Propylthiouracil, 417
Griffin, R. M.: Awarded a Research Training Scholarship by the Animal Health Trust, 904
Griffith, Dr. R. H.: Retirement as director of research at the London Research Station of the Gas Council, 992; work of, 992
Griffiths, D. (Coles, Dr. B. R., and): Ferromagnetic and Antiferromagnetic Behaviour in the Second Transition Group, 226
Griffiths, D. C.: Immunity of Aphids to Insect Parasites, 346
Grimley, Dr. T. B.: Appointed to a senior lectureship in inorganic and physical chemistry in the University of Liverpool, 117

Griseofulvin : Absence of Local Cytotoxic Change in Man from (Prof Leon Goldman, Amanda Beyer and Jan Schwartz), 335
Griseofulvin (Oral) : Tumour-promoting Effect of Excessively Large Doses of, on Tumours induced in Mice by Methylcholanthrene (Louis L. Barich, Takashi Nakai, Jan Schwarz and Donna Jean Barich), 335
Griseofulvin (Radioactive) : Behaviour of, in Skin (Dr. A Scott), 705
Gros, F · Cytoplasmic Particles and their Role in Protein Synthesis (Alteration in the Composition of Ribonucleic Acid led to Modifications in the Biosynthesis of Proteins), 644
Grossgebauer, Dr K., and others : Non-specific Haemagglutinin from Cellulose and Cellulose Ion Exchanger, 790
Grossman, Aaron, and others · Inhibition of Glucuronosyl Transferase by Progestational Agents from Serum of Pregnant Women, 693
Grossman, Prof. J · Food and Animal Production Overseas (Agricultural Zones in Brazil), 1071
Grotte de Rochereil : La (P. E. Jude), 903
Group-Specific Inheritable System in Normal Human Sera : Immuno-Electrophoretic Differentiation of Haptoglobins from another (Dr. Jan Hirschfeld), 126
Grouping (Absorption-Elution), of Dried Blood-stains on Fabrics (S. S. Kind), 789
Groups (Haem-binding), in Native and Denatured Haemoglobin and Myoglobin : Nature of the (Dr Joan Keilin), 365
Groves, Dr G V : Upper-Atmosphere Wind Studies by *Skylark* Rocket Sodium Experiment, 1001
Growing: Mushroom (Ministry of Agriculture, Fisheries and Food, Bulletin No 34), seventh edition, 902
Growing Demand for Water Second Report of the Sub-Committee on (Central Advisory Water Committee), 198
Growth by Actinomycin of *Neurospora crassa* : Action of Nucleic Acids on the Inhibition of (Dr. W Kersten, Dr. H. Kersten and Prof H. M. Rauen), 60
Growth by Cell Division in Insect Tissue Culture (Dr B. M Jones and I. Cunningham), 1072
Growth of Sulphide Films on Steel (R. B Campbell, L Grunberg and H. M. Scott), 588
Growth, Society for the Study of Development and : Seventeenth Symposium—Cell, Organism and Milieu (edited by Prof Dorothea Rudnick), *review* by Dr E N Willmer, 450
Growth (Crystal), in Paraffin (R. J. Jaccodine), 498
Growth (Dendritic), of Crystals, *review* by A F. Wells, 93
Growth (Droplet), in Gaseous Media . Evaporation and (N A. Fuchs), translated from the Russian by J. M Pratt ; edited by Dr. R. S. Bradley, *review* by Prof. F H Garner, 451
Growth (Hair-) · Potentiation of, by Ultra-Violet Light (B E. Johnson), 159
Growth (Larval) : Effect of Lysergic Acid Diethylamide on (Dr. D. V Siva Sankar, Arthur Kopelman, Peter Schilder and Eleanor Gold), 153
Growth (Plant-) Activity of α-Alkylphenylacetic Acids and 1,2-Benzo-1-cycloalkene-3-carboxylic Acids (Kazuyoshi Kawazu, Toshio Fujita, Tetsuo Mitsui, Jiro Kato and Masayuki Katsumi), 694
Growth (Plant) Systems : Ethionine and (R L Lowther and W. G. Boll), 832
Growth (Population), Fertility and Population Policy (Prof D. V. Glass), 849
Growth (Pre-Natal), in Mammals. Control of (Dr. Anne McLaren and Dr. Donald Michie), 363
Growth Factor for *Haemophilus* Species secreted by a Pseudomonad (Moshe Shifrine and Prof Ernst L. Biberstein), 623
Growth Factor for Wood-rotting Fungi Nonanal as a (Prof. Nils Fries), 166
Growth Hormone (Human) . Immunoelectrophoretic Studies on Purified (Dr Jan Hirschfeld, Carl-Axel Gemzell and Leif Wide), 64
Growth Inhibition · Cell Biology and (Cell Biology Programme of Unesco International Symposium on), 836
Growth and Form : The Control of—a Study of the Epidermal Cell in an Insect (Prof V. B Wigglesworth), *review* by Prof R. Dennell, 631
Growth and Form in an Insect, *review* by Prof. R. Dennell, 631
Grunberg, L , and others : Growth of Sulphide Films on Steel, 588
Grunberger, Dr D., and others Biogenesis of Ascorbigen, 3-Indolylacetonitrile and Indole-3-carboxylic Acid from D,L-Tryptophan-3-^{14}C in *Brassica oleracea* L , 61
Guerra, Dr E , and Gunther, Dr B · Flight by Man-Power, 419
Guggenheim, Prof K (Ilan, Judith, and) : Lack of Haematopoietic Potency of Liver of Mice fed on a Meat Diet, 698
Guide to Reference Material (edited by Dr. A J. Walford, with the assistance of L. M. Payne,) *review* by R. Brightman, 273
Guide (A Plain Man's), to Atomic Energy (P. J Duncton), 1076
Guinea Pig · Effect of the Peritoneal Fluid of the, on Strains of Enteric Bacilli (Prof R. J Roantree and L. R. Collins), 1045
Guinea Pig Embryos Development of Delayed-type Hypersensitivity in (Jonathan W Uhr), 957
Gypsum Plaster . Effect of Temperature on the Expansion on Setting of (P. J. Sereda), 929
Gulbenkian Foundation, Lisbon · Grant of £250 to the Cambridge expedition to British Guiana, 558
  Grant of £250 to the Oxford expedition to the Peruvian Andes, 558
  Grant of £140 to the Oxford Women's expedition to the Azores, 558
  Grant of £100 to the University of Oxford expedition to Cyrenaica, 558
  Grant of £50 to the Wye College Exploration Society expedition to Morocco, 558
  Grant of £10,000 to the Institute of Education, University of Oxford, 558
  Grant of £2,700–£3,400 over two years to the Institute of Education, University of Durham, 558
Gulf Stream · The—a Physical and Dynamical Description (Dr. Henry Stommel), *review* by Dr. G. E R. Deacon, 183
Gunning, B E S. : A Method for the Detection of Inhibition of Auxin Transport, 428
Gunpowder : A History of Greek Fire and (Prof. J. R. Partington), *review* Prof. R. J Forbes, 272
Gunther, Dr B (Guerra, Dr. E., and) : Flight by Man-Power, 419
Gurne, D., and others . Anti-neoplastic Activity of Tetrahydro-1,3-oxazine Derivatives, 426
Guthrie Lecture of the Physical Society (Sir Harrie Massey), 853
Guttes, Dr. Edmund, and Guttes, Sophie : Effect of Pyruvate upon Nucleated and Enucleated Fragments of *Amoeba proteus*, 432
  Suppression of Cytoplasmic Division in *Amoeba proteus*, 520
Guttes, Sophie (Guttes, Dr Edmund, and) : Effect of Pyruvate upon Nucleated and Enucleated Fragments of *Amoeba proteus*, 432
  Suppression of Cytoplasmic Division in *Amoeba proteus*, 520
Güttmann, Shmuel, and others : Radiolysis of Highly Enriched Oxygen-18 Water Solutions containing Hydrogen Peroxide-16,16, 57

HABITS (Food), in Britain (Scottish Group of the Nutrition Society Symposium on), 905
Heckel, Prof Emanuel, and Smolker, Robert E. · Effect of Ribonuclease on Erythrocyte Antigens, 1036
Haem-binding Groups in Native and Denatured Haemoglobin and Myoglobin · Nature of the (Dr. Joan Keilin), 365
Haemagglutinin (Non-specific), from Cellulose and Cellulose Ion Exchanger (Prof B. Schmidt, Dr K Grossgebauer and D Hartmann), 790
Haematology of the Central Australian Aborigine (J. R. Casey-Smith), 903
Haematopoietic Potency of Liver of Mice fed on a Meat Diet · Lack of (Judith Ilan and Prof. K. Guggenheim), 698
Haemodynamic Aspects of Atherogenesis (Wei Young), 425
Haemoglobin Carbon-14 Labelled Hybrids of (Dr. Jerome Vinograd and William D. Hutchinson), 216
Haemoglobin 'Bart's' (γ-Chain Haemoglobin) Sedimentation Characteristics of the (Dr. R A. Kekwick and Dr H Lehmann), 158
Haemoglobin (γ-Chain) (Haemoglobin 'Bart's') : Sedimentation Characteristics of the (Dr R. A Kekwick and Dr H Lehmann), 158
Haemoglobin and Myoglobin · Nature of the Haem-binding Groups in Native and Denatured (Dr. Joan Keilin), 365
Haemophilus Species secreted by a Pseudomonad · A Growth Factor for (Moshe Shifrine and Prof. Ernst L. Biberstein), 623
Haemopoiesis in the Foetal Liver : Pattern of (D. Brynmor Thomas, P. M. Russell and Prof J. M Yoffey), 876
Hagen, Dr. Ulrich . Labilization of Deoxyribonucleic Acid in Thymus Nucleoprotein after Whole-body Irradiation, 1123
Hägg, Prof. Gunnar : Elected a member of the Chemistry section of the Leopoldina Academy of Natural Sciences, 1079
Hair-Growth : Potentiation of, by Ultra-Violet Light (B. E. Johnson), 159
Halberstadt, B. Epstein (Laron, Dr. Z., and) · Total and l(+) Tartaric Acid Inhibited Rat Serum Acid Phosphatase, 67
Haldane, Prof. J B S. · The Scientific Work of J S. Haldane (1860-1936), 102
  'Dex' or 'Order of Magnitude' ?, 879
Haldane, J S. : The Scientific Work of (1860-1936), (Prof. J. B. S. Haldane), 102
Haldane, J. S (Bayliss, W. M., and) Joint Meeting of the U.S.S R.-Great Britain Society and the Moscow Physiological Society to celebrate the centenary of the births of (D A. Sakharov), 912
Hall, Dr. D A., and Saxl, H : Human and other Animal Cellulose, 547
Hall, Dr. G V., and others · Lipaemic Clearing Action of Artificial Anticoagulants, 782
Hall, L W., and Stevenson, D E. : Effects of Ataractic Drugs on the Blood-Pressure and Heart-Rate of Dogs, 696
Hall, P J., and others: Streaming in Cytoplasm dissociated from the Giant Amoeba, *Chaos chaos*, 896
Hall, R. J. (Peters, Sir Rudolph, and) : Fluorine Compounds in Nature—the Distribution of Carbon-Fluorine Compounds in some Species of *Dichapetalum*, 573
Hall, R. M. S : High-Energy Oxygen Ions in Carbon Dioxide Mass Spectra, 683
Hall, Dr. S. H. . Grant of £7,935 for Space Research (for geomagnetic field measurements in the Earth's upper atmosphere), 744
  Advances in Geophysics, *review*, 1060
Halley Bay : Recent Scientific Activities at—International Geophysical Co-operation, 1959 (M. J. Blackwell), 982
Hallgren, Bertil, and Sjogren, Torsten : A Clinical and Genetico-Statistical Study of Schizophrenia and Low-Grade Mental Deficiency in a Large Swedish Rural Population, 298
Hallsworth, Prof E G (edited by) Nutrition of the Legumes—Proceedings of the University of Nottingham Fifth Easter School in Agricultural Science, 1958, *review* by Prof Walter Stiles, 815
Hallsworth, Prof. E G., and others . Copper and Cobalt in Nitrogen Fixation, 79
Halogenated Porphyrin in Mouse Tumours · Localization of a (K. I. Altman and Prof. K Salomon), 1124
Halpern, Dr. B N., and others : Influence of the Ionic Strength of the Medium on the Anaphylactic Sensitization of Isolated Tissues *in vitro*, 697
Hama, Tadao, and Obika, Masataka : Pterin Synthesis in the Amphibian Neural Crest Cell, 326
Hamann, Dr. S. D. : Appointed chief of the Division of Physical Chemistry of the Australian Commonwealth Scientific and Industrial Research Organization, 901 ; work of, 901
Hamdy, Dr A. R. . Modification of the Neurocranium in *Zygaena malleus* and the Nature of the Optic Stalk in Selachii, 257
Hamilton, Dr J. : Appointed to the newly created second chair of physics in University College, London, 466, 555 ; work of, 555
Hammond, Sir John : Food and Animal Production, 1070
Hampton, Dr. W. M : Retirement as managing director of Chance Brothers, Ltd., Smethwick, 905
Hamster (Syrian) Occurrence of a Brown Mutation in the (Roy Robinson), 170
Hanby, W. E., and others : Screw Sense of the α-Helix in Poly-β-benzyl-L-aspartate, 321
Hancock Medal for 1960 of the Institution of the Rubber Industry awarded to C B Copeman, 464
Handbook for Chemical Society Authors (Chemical Society, Special Publication No. 14), 832
Handloser, John S : Health Physics Instrumentation, *review* by B S. Smith, 9
Hanig, Martin, and Stein, Joseph, M. . Physical Incompleteness of Influenza Virus propagated in De-embryonated Eggs, 40
Hanna, C H (Marshall, Dr. L. H., and) Dextran and Insulin in Rats, 1118
Hansel, C E. M. : Experimental Evidence for Extra-Sensory Perception, 172
Hansen, V K. : Investigations on the Quantitative and Qualitative Distribution of Zooplankton in the Southern Part of the Norwegian Sea (Meddelelser fra Danmarks Fiskeri- og Havundersogelser, Ny Serie, Bind 2, Nr. 23), *review* by Dr. A. J. Southward, 360

Hanson, L. A., and Johansson, B. G. : Presence of Immunologically Active Fragments after Proteolytic Degradation of Human γ-Globulin, 599
Hanstrom, Bertil, and others (edited by) : South African Animal Life—Results of the Lund University Expedition in 1950-1951, Vol. 6, review by H. Oldroyd, 1063
Hanzon, V. : Cytoplasmic Particles and their Role in Protein Synthesis (Particles having a Diameter of 15 $m\mu$ as the Structural Basis of Microsomal Nucleo-Protein), 644
Haptoglobin Types in 398 Blood Donors from Dakar (Senegal), (Dr. J. Moullec, Dr. J. M. Fine and J. Linhard), 517
Haptoglobins : Immuno-Electrophoretic Differentiation of, from another Group-Specific Inheritable System in Normal Human Sera (Dr. Jan Hirschfeld), 126
Harbison, Frederick, and Myers, Charles S. : Management in the Industrial World—an International Analysis, 537
Harborne, J. B. : Flavonoid Pigments of *Lathyrus odoratus*, 240
Hard Spheres : Packing of Mixtures of (Prof. Paul C. Mangelsdorf, Jun., and Elmer L. Washington), 930
Harden, Dr. D. B. : Elected president of the Museums Association, 657
Hardening (Work-) and Ductility of Rhenium and their relation to the Behaviours of other Metals having a Hexagonal Structure (R. A. Jeffery and E. Smith), 52
Harding, Ronald (Sorsby, Prof. Arnold, and): Protective Effect of Cysteine against Retinal Degeneration Induced by Iodate and Iodoacetate, 608
Harding, W. R., and others : Gallium Arsenide for γ-Ray Spectroscopy, 405
Hardisty, M. W. : Sex Ratio of Ammocoetes, *erratum*, 29
 Development of the Gonads in Parasitic and Non-Parasitic Lampreys, 341
Hardung, V., and Laszt, Prof. L. : Viscoelastic Behaviour of Blood Vessels of the Muscular Type, 330
Hare, Rt. Hon John : New Buildings of the Plant Pathology Laboratory, Harpenden, opened by, 21
Harmonics in the Earth's Gravitational Potential : Evaluation of the Second, Fourth and Sixth (D. G. King-Hele), 490
Harré, Dr. H. R. . Appointed lecturer in the philosophy of science at the University of Oxford, 117
Harris, Dr. Colm C. : A Method for the Routine Measurement of Particle Shape Factors in the Sieve Range, 401
Harris, Eugene, and others : Oceanography of Long Island Sound, 123
Harris, Dr. H. : Appointed to the University of London chair of biochemistry at King's College, London, 286 ; work of, 286
Harris, Dr. R. J. C. (edited by) : The Relationship between Nucleus and Cytoplasm—Proceedings of the Symposium held at the Université Libre de Bruxelles, 1958, *review* by Dr. E. N. Willmer, 450
Harris, Prof T. M. : Origin of Angiosperms (Presidential Address to Section K (Botany) of the British Association for the Advancement of Science), 847
Harrison, B. D., and others : Sap-Transmissible Viruses associated with Diseases of Grape Vines in Europe and North America, 577
Harrison, B. J. : Autogenous Necroses in an *Antirrhinum* Species Hybrid, 527
Harrison, E. R. : Theory of Auroral Structures, 383
Hart, F. A., and others Some New Hydrides of Iron and Osmium, 55
Hart, Martin V., and others : Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis, 236
Hart, T. John : Oceanography of Long Island Sound, 123
Harthoorn, Dr. A. M., and others : Translocation of Wild Animals as a Means of Game Control, 518
Hartley, Dr. G. S : Herbicides and the Soil (Physico-chemical Aspects of the Availability of Herbicides in Soils), 377
Hartley, Sir Harold (edited by) : The Royal Society, its Origins and Founders, *review* by Dr. William P. D. Wightman, 356
Hartmann, D., and others : Non-specific Haemagglutinin from Cellulose and Cellulose Ion Exchanger, 790
Hashimoto, Dr. Hatsujiro, and Fujita, Dr. Kazuo . Electron Microscope Images of Dislocations, 51
Haskell, Dr. G. : The Two R's of Plant Breeding, *review*, 184
Haslett (Caroline) Memorial Trust : Travel Awards for Women Engineers, 116
Haslewood, Prof. G. A. D. : Spotting Ketosteroids, *review*, 183
Hasted, Dr J. B. : Penetration of Charged Particles in Matter (Coincidence Methods of Studying Inelastic Ionic Collisions), 1086
Hathway, Dr. D. E. : Physico-chemical, Biological and Applied Aspects of Autoxidation (Aerobic Oxidation of Plant Phenols and its Biological Implications), 747
Hatt, Dr. H. H. . Appointed leader of research in the new Sugar Research Laboratory of the Australian Commonwealth Scientific and Industrial Research Organization, 372
Haury, Dr. Emil W. : Appointed chairman of the Division of Anthropology and Psychology of the United States National Academy of Sciences—National Research Council, 647
Havivi, Y. (Feldman-Muhsam, Dr. B., and) · Accessory Glands of Gene's Organ in Ticks, 964
Hawkins, Desmond (edited by) : The Second BBC Naturalist, *review* by B. J. G. Maitland, 728
Hawkins, T. H. : Selection of Executives, 31
 Nature and Man, *review*, 979
Hawks and Owls in Illinois : Population Trends among (Richard R. Graber and Jack S. Golden), 999
Hawthorn, Prof J. : Science and Meat, *review*, 868
Hawthorne, Dr. —. · Questions of Science and Faith, 28
Hayes, R. C : Retirement as superintendent of the Seismological Observatory, Wellington, New Zealand, 24 ; work of, 24
Hayes, Jr , Dr. W. J., and others : DDT—the Insecticide DDT and its Significance (edited by Paul Muller), Vol 2, Human and Veterinary Medicine (edited by Dr. S. W. Simmons), *review* by Prof. D. S. Bertram, 271
Hayhoe, Dr. F. G. J. (Quaglino, Dennis, and) : Acetone Fixation for the Cytochemical Demonstration of Dehydrogenases in Blood and Bone Marrow Cells, 85
Hayter, R. G., and others . Some New Hydrides of Iron and Osmium, 55
Hayward, Barbara J. (Augustin, Dr. Rose, and) : Cleavage of Human γ-Globulin, 129
Hayward, Dr. H. E., and Bernstein, Dr. L. : Problems of the Arid Zones (Salinity Problems of Plants and Soils), 295
Hayward, Admiral J. T. : Combustion and Propulsion (High Mach Number Air-breathing Engines), 19
Hazes (Blue), in the Atmosphere (Dr. F W. Went), 641, *erratum*, 994
HDO and D_2O (Molecules H_2O,) : Ultra-violet Absorption Spectra of the (Dr. Jack Barrett and Dr. A. L. Mansell), 138 ; (R. M. Golding), 139
Healey, V. : Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Zoology), 742
Healing (Wound), in the New-Born Opossum (*Didelphis virginianam*), (Prof. Matthew Block), 340
Health · Culture, Society and (Division of Anthropology of the New York Academy of Sciences and the Research Institute for the Study of Man Conference on), 658
 Mirage of (Dr. René Dubos), *review* by Prof. E. Maurice Backett, 633
 World (Prof. Fraser Brockington), *review* by Christine Cockburn, 722
Health (World) : In Pursuit of, *review* by Christine Cockburn, 722
Health, National Institutes of (United States) : Appointment of Dr. J. H. Gerber as director of the Center for Aging Research, 374
 Tenth Annual Instrument Symposium and Research Equipment Exhibit, 559
Health, Education and Welfare (United States Department of) · Publication No. 739, Highlights of Research Progress in General Medical Sciences (1959), 200
 Appointment of Dr. J. H. Gerber as director of the Center for Aging Research, National Institutes of Health, 374
Health (Industrial), in Britain, 648
Health and Safety (Radiological) : Training in (Prof. J. E. Roberts), 471
Health Education : Training of Teachers for (United Nations, World Health Organization, Technical Report Series No 193), 648
Health Physics Instrumentation (John S. Handloser), *review* by B. S. Smith, 9
Health Service : Local (United Nations, World Health Organization, Report Series No. 194), 465
Health Services in the U.S.S.R. (United Nations, World Health Organization, Public Health Papers No 3), 379
Hearing : The Physiology of (Prof. W. Burns), 845
Heart Muscle of the Rat and some other Mammals : Potentiation of Contractility in the (Dr. V. Kruta and Dr. P Braveny), 327
Heart-Rate of Dogs : Effects of Ataractic Drugs on the Blood-Pressure and (L. W. Hall and D. E. Stevenson), 696
Heart Ventricles (Rabbit Right and Left) : Platelet-Count Differences in Blood of the (Dr. J. George Sharnoff and Dr. Vito Scardino), 334
Heat : Effect of, on the Serum Factors Gm^a Gm^b, Gm^x and Gm-like (Prof. Arthur G. Steinberg and Rachael Stauffer), 791
Heat (Latent), of Vaporization : A Relation between Ultra-sonic Velocity and (Prof. R. Ramachandra Rao and P. R. K L. Padmini), 311
Heat Transfer in Cold-Cathode Arcs : Stepwise Ablation and (Dr. A. von Engel and Dr. K. W. Arnold), 1101
Heat Treatment of Metals and Alloys (Société Française de Métallurgie Meeting on), 559
Heated Tube : Effect of Specular Reflexions on the Radiation Flux from a (Sir K. S. Krishnan), 135
Heating (Domestic), and Thermal Insulation (Building Research Station, Digest 133), 999
Heavy Water : Effect of, on Respiratory-chain Enzymes (Dr. H. Laser and Prof E. C. Slater), 1115
 Effects of Linear Energy Transfer on the Radiolysis of Water and (Dr E. Collinson, Prof. F. S. Dainton and J Kroh), 475
Hector, a New Research Reactor (United Kingdom Atomic Energy Authority), 992
Hehemann, Prof. R. F. (Matas, S., and) : Retained Austenite and the Tempering of Martensite, 685
Heights : Equatorial Spread-*F* and *F*-Layer (Dr. A. J. Lyon, Dr N. J. Skinner and Prof. R W. Wright), 1086
Heisler, L. H , and Whitehead, Dr. J. D. : Longitude Effect in Temperate Zone Sporadic *E* and the Earth's Magnetic Field, 676
Helary, A. (Legrand, J. -P., and) : Local Increase of Intensity of Cosmic Radiation, 397
Helical Fracture in Titanium Oxide : A Symmetrical Fourfold (J. S. Jackson), 1104
Helium-4 Scale of Temperature (F C. Brickwedde, H. van Dijk, M. Durieux, J. R. Clement and J. K. Logan), 1077
Helix : Physiological Media for Tissues of (C. K. Goddard), 68
α-Helix in Poly-β-benzyl-L-aspartate : Screw Sense of the (E. M. Bradbury, A. R. Downie, Dr. A. Elliott and W. E. Hanby), 321
Hell, Elizabeth, and others : Analysis of Metabolic Rates at the Cellular Level, 919
Helliwell, N. C. : Airborne Measurements of Latitudinal Variation of Frost-point Temperature and Wind (Air Ministry, Meteorological Office, Scientific Paper No. 1), 993
Helliwell, Dr. R. A , and others : Association between Aurorae and Very Low-Frequency Hiss observed at Byrd Station, Antarctica, 751
Hellstrom, Prof. Nils · Structure of β-Acylacrylic Acids, 146, *erratum*, 650
Helminthology : Medical (Dr. J. M. Watson), *review* by Dr. G. Lapage, 815
Helminths : Parasitic, *review* by Dr. G. Lapage, 815
Helminthum : Systema (Prof. Satyu Yamaguti), Vol 2, The Cestodes of Vertebrates, *review* by Dr. Ben Dawes, 723
Help of Proton Magnetic Resonance Spectroscopy : Structure Determination with the (Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives), (C F. Blakely, Dr R. J. Gillespie, L. Roubinek, Dr. A Wassermann and R. F. M. White), 662
Hemispheres (Cerebral) : An Unidentified Pharmacologically Active Substance extracted from (P. F. L. Andrews, Shirley A. P. Price and Dr. G. B. West), 420
Hen : Parallel Distribution of Calcium and Citric Acid in the Oviduct of the (Dr. T. G. Taylor and F. Hertelendy), 244
Hen (Laying) : Oxytocin in the Neurohypophysis of the (Katuhide Tanaka and Prof Seiichi Nakajo), 245
Henderson, E. H., and others : Radioactive and Natural Strontium in Human Bone (Atomic Energy Research Establishment, *R*23246), 994
Henderson, J. C. de Courcy : Appointed reader in reinforced concrete structures at the Imperial College of Science and Technology, London, 466
Henderson, Dr. James L. : Evolution of Modern Education, *review*, 357
Hendey, N. Ingram : *Obituary* of Dr. J. H Oliver, 111

Hendler, R. W. · Cytoplasmic Particles and their Role in Protein Synthesis (Possibility that Complexes between Amino-Acids and Lipids might be involved in the Transport of Amino-Acids and in Protein Synthesis), 645
Henriques, Dr Olga B., and others : Bradykinin-releasing Factor from *Bothrops jararaca* Venom, 414
Henrotte, Dr. J G., and others : Potassium Tolerance Tests in South Indian People, 328
Heparin : Uptake of, by Cells (Dr G Csaba and Dr. Eszter Kapa), 711
Hepatitis Virus (Murine) · Protection against Liver Injury due to (Dr. J. D. Judah, G Bjotvedt and T. Vainio), 507
Hepatoma (Yoshida Ascites) : Inhibition of Aerobic Glycolysis in, by Tartronic Acid (Dr L Fiume), 792
Hepatomas induced by Butter Yellow : Vitamin and Coenzyme Content of (M H Briggs), 249
Hepburn, Dr. F. Appointed lecturer in medical physics at the University of Leeds, 465
Herberg, L. J . Hunger Reduction produced by Injecting Glucose into the Lateral Ventricle of the Rat, 245
Herbicides and the Soil (British Weed Control Council Symposium on), 376
Heredities . The Two, *review* by Dr. J D. Nisbet, 446
Heredity Biochemistry and, *review* by Dr. P Cohn, 447
  The Chemistry of (Prof Stephen Zamenhof), *review* by Dr. P. Cohn, 447
  Chromosomes and the Theory of (Prof C. D. Darlington), 892
Herley, P. J. · Awarded an Overseas Scholarship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Herne, R G , and others A Transplantable Spontaneous Osteogenic Sarcoma observed in the Muscle Tissue of an Albino Mouse, 1129
Hertelendy, F (Taylor, Dr T. G , and) · Parallel Distribution of Calcium and Citric Acid in the Oviduct of the Hen, 244
Hertting, G , and others . Effect of Cocaine on the Disposition of Noradrenaline labelled with Tritium, 604
Hertz, Carl Hellmuth · Electrostatic Measurement of the Geoelectric Effect in Coleoptiles, 320
Heterocyclic Bases . Structure of the 1·1-Adducts of Cupric *β*-Diketone Chelates with (Dr. D. P Graddon and E. C. Watton), 1021
Hewer, H. R. Age Determination of Seals, 959
Hexafluorobenzene : A Molecular Complex of Benzene and (Dr. C. R. Patrick and G S. Prosser), 1021
Hexagonal Modification of Black Chromium Electro-deposit (Hideya Okada and Takeo Ishida), 496
Hexagonal Structure Work-Hardening and Ductility of Rhenium and their relation to the Behaviours of other Metals having a (R. A. Jeffery and E. Smith), 52
Hexobarbitone-induced Sleep in Mice Effect of Hydration on (Dr N K. Bhide), 1030
Heywood, J. Part-Time Courses in Further Education, 189
Heywood, Dr V H. · Appointed to a senior lectureship in botany in the University of Liverpool, 117
Hibben, Frank C Prehistoric Man in Europe, *review* by Miles Burkitt, 729
Hickinbottom, Dr W J. : Title of professor of organic chemistry in the University of London (at Queen Mary College) conferred on, 466
Hickman, Kenneth : Pump Fluids for Higher Vacuums, 405
Hidden Mind : The, *review* by Dr. Clifford Allen, 978
Higgins, H G (Stewart, C M., and) . Carbohydrates of *Ecklonia radiata*, 511
High-Energy Bound Phosphate and Diabetes Mellitus (Dr. Yoshio Goto, Isao Ito, Akihiko Kuwano and Yukio Ujiie), 702
High-Energy Oxygen Ions in Carbon Dioxide Mass Spectra (R. M. S. Hall), 683
High-Energy Phosphate Requirement for Succinate Oxidation in Uncoupled Rat Liver Mitochondria (Dr Giovanni Felice Azzone and Dr. Lars Ernster), 65
High-Energy Physics . (Commission on High Energy Physics of the International Union of Pure and Applied Physics Tenth Annual International Conference on), 29
High Explosives The Science of (Prof. Melvin A Cook), *review* by Dr. W. L. Murray, 539
  Theory of, *review* by Dr. W. L Murray, 539
High Flux of Thermal Neutrons Localization by Autoradiography at -195° C of Radioactive Areas in Rats exposed to a—Importance of Phosphorus-32 in Consecutive Internal Irradiation (Jean Chanteur and Pierre Pellerin), 472
High Mach Number Air-breathing Engines (AGARD fourth Colloquium on Combustion and Propulsion), 18
High Molecular Weight Gas-Solid Chromatographic Separation of Hydrocarbons of (C. G. Scott and D. A. Rowell), 143
High Polymer Forum : Tenth Canadian (National Research Council of Canada and the Chemical Institute of Canada), 117
High Pressure Chemical Plant . The Design and Construction of (Harold Tongue), second edition, *review* by Dr. K. E. Bett, 541
High-Pressure Forms of Ice—Ice III : Crystal Structures of the (Prof. W. Barclay Kamb and Sankar K. Datta), 140
High-Pressure Technology, *review* by Dr K E. Bett, 541
High-Resolution Nuclear Magnetic Resonance (J. A Pople, W. G. Schneider and H. J. Bernstein), *review* by Dr. L. M Jackman, 358
High-Temperature Furnaces (A. Gallenkamp and Co , Ltd , Catalogue No. 620), 1077
High-Temperature Resistance and Thermal Degradation of Polymers (Plastics and Polymer Group of the Society of Chemical Industry Symposium on), 466
High Temperatures · An Improvement in the Ductility of Beryllium at (A. Brown, F Morrow and A J. Martin), 494
High-Volatile Bituminous Coal : Absorption of Ultra-violet and Visible Light by Ultra-thin Sections of Vitrinite from a (Sabri Ergun, J. T. McCartney and R E Walline), 1014
High Voltage Engineering Corporation : Second Accelerator Conference, 743
Higher Vacuums : Pump Fluids for (Kenneth Hickman), 405
Highlands (Northern) : Scotland—the (Dr J. Phemister), (Handbook of Regional Geology), third edition, 831
Highlights of Research Progress in General Medical Sciences 1959 (United States Department of Health, Education and Welfare, Publication No. 739), 200
Highly Directive Rotating Array for 16 Mc /s. (Prof. J. A. Thomas and Dr. R. W. E. McNicol), 398
Highly Enriched Oxygen-18 Water Solutions containing Hydrogen Peroxide 16,16 : Radiolysis of (Dr. Michael Anbar, Shmuel Guttmann and Prof. Gabriel Stein), 57
Highly Selective Solvents (Two), for Gas-Liquid Chromatography Analysis of C_6–C_8 Hydrocarbons (Dr. A. van der Wiel), 142
Higman, Dr. Graham . Appointed to the Waynflete chair of pure mathematics in the University of Oxford, 830 ; work of, 830
Higuchi, Yoshikichi, and others : Silkworm Raising on Artificial Food, 669
Hill, A V., and others : Differentiation in *Peronospora tabacina* Adam., 710
Hill, C. R. : Lead-210 and Polonium-210 in Grass, 211
Hill, Dr. D W : *Obituary* of Dr. W. Lawrence Balls, 989
Hill, Dr. R., and Bendall, Fay Crystallization of a Photosynthetic Reductase from a Green Plant, 417
Hillaby, John : Nature and Man, *review* by T H. Hawkins, 979
Hillarp, Prof Nils-Åke : Effect of Reserpine on the Nucleotide and Catecholamine Content of the Denervated Adrenal Medulla of the Rat, 1032
Hilsum, C., and others · Gallium Arsenide for *γ*-Ray Spectroscopy, 405
Hind-Limb Reflexes in the Kitten—Velocity of Conduction and Spinal Transmission of Proprioceptive Hind-Limb Reflexes (Dr. Sten Skoglund), 132 ; Properties of the Two-Neuron Arc (Dr. Sten Skoglund), 134
Hind-Limb Reflexes (Proprioceptive) . Velocity of Conduction and Spinal Transmission of (Hind-Limb Reflexes in the Kitten), (Dr. Sten Skoglund), 132
Hinshelwood, Sir Cyril : Elected a Foreign Associate of the United States National Academy of Sciences, 198
  The Royal Society (Presidential Address at the Formal Opening of the Tercentenary Celebrations), 274
Hinton, Sir Christopher Evolution of Nuclear Power Plant Design (Royal Society Tercentenary Lecture), 1064
Hinton, Dr. J. J. C , and Moran, Dr. T : Plant Hormone Activity—Stilboestrol applied to the Wheat Seedling, 258
Hirsch, Dr. James G. : Promoted to a professor and member of the Rockefeller Institute, 290
Hirschfeld, Dr. Jan . Immunoelectrophoretic Differentiation of Haptoglobins from another Group-Specific Inheritable System in Normal Human Sera, 126
Hirschfeld, Dr Jan, and others : Immunoelectrophoretic Studies on Purified Human Growth Hormone, 64
Hirschfeld, Dr. Jan, and Soderberg, Dr. Ulf . Immunoelectrophoretic Demonstration of Precipitating Components in Sera from Pregnant Women, 332
Hirst, Prof. E. L. : International Commission for Uniform Methods of Sugar Analysis, *review*, 9
Hiss (Very Low-Frequency), observed at Byrd Station, Antarctica : Association between Aurorae and (Dr. L H Martin, Dr. R. A. Helliwell and K. R. Marks), 751
Histamine in Skin : Eosinophil Leucocyte-attracting Effect of (Dr R. K. Archer), 155
Histochemical Demonstration of Acid Phosphatase : A Simple Azo-Dye Method for (Dr. Tibor Barka), 248
Histochemical Localization of Human, Term Placental 17*β*-Œstradiol Dehydrogenase—Implications for the Transhydrogenase Reaction (Dr. Donald A. Kellogg and Dr George G. Glenner), 763
Histochemistry—Theoretical and Applied (Dr. A. G. Everson Pearse), second edition, *review* by Dr. L G. E Bell, 185
Histochemistry and Cytochemistry (Société Française d'Histochimie first International Congress on), 29
d'Histochimie, Société Française : First International Congress of Histochemistry and Cytochemistry, 29
Histology : Softening Chitin for (Dr D. B Carlisle), 1132
Histophagous Ciliate Increase of Esterase Activity during Intracellular Digestion in a (Dr Miklós Muller, József Tóth and Prof. Imre Toro), 65
Historical Note on the Reciprocal Theorem and Theory of Statically Indeterminate Frameworks (T. M. Charlton), 231
Historical Value : Preservation of Films of, 199
History Science as—the Story of Man's Technological Progress from Steam Engine to Satellite (Heinz Gartmann), translated from the German by Alan G. Readett, *review* by J L. Stollery, 8
History of Education, 1780-1870 Studies in the (Brian Simon), *review* by Dr. James L. Henderson, 357
History of Engineering Invention, *review* by J. L. Stollery, 8
History of Greek Fire and Gunpowder (Prof. J. R. Partington), *review* by Prof R. J. Forbes, 272
History of Medicine and Pharmacy (Faculty of the History of Medicine and Pharmacy of the Worshipful Society of Apothecaries of London, in co-operation with the Royal College of Physicians, the Royal College of Surgeons of England and the Royal Society of Medicine First British Congress on), 374
History of Medicine or Pharmacy · Maccabaean Prize and Medal for an essay on a subject connected with the (Worshipful Society of Apothecaries), 650
History and Philosophy of Science, International Union for : International Congress for Logic, Methodology and Philosophy of Science, 201
History (A Brief), of the Royal Society (Prof. E. N. da C. Andrade), *review* by Dr. William P D. Wightman, 356
History (Early), of the Earth · Nuclear Fission in the (Prof. P. K. Kuroda), 36
History (Pleistocene), of the Irish Sea (G. F. Mitchell), 842
Hoare, A H M. · Appointed to a research fellowship in pure mathematics in the University of Birmingham, 117
H_2O, HDO and D_2O (Molecules) . Ultra-Violet Absorption Spectra of the (Dr. Jack Barrett and Dr A. L. Mansell), 138 ; (R. M Golding), 139
Hobbs, D. C., and Celmer, W. D. : Structure of the Antibiotics *PA*148-I and *PA*148-3, 598
Hobden, D. J. : Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Zoology), 742
Hodek, I., and Cerkasov, J. : Prevention and Artificial Induction of the Imaginal Diapause in *Coccinella 7-punctata* L., 345
Hodgkin, Dr. Dorothy C. Appointed the first holder of the Wolfson Research Professorship of the Royal Society, 24 ; work of, 24
Holland, B. O., and others . Formation of Fayalite in Roast Reduced Jaspilite, 683

Hollings, M., and Lelliot, R. A : Freeze-drying of Plant Viruses, 1078
Hollingsworth, B. C. : The Development of Pulp and Particle Board Industries and their Effect on Forest Management (Requirements for the Coal Mining Industry), 33
Hollow Universe : The (Prof. Charles de Koninck), review by F. I. G. Rawlins, 890
Holman, Mollie E (Burnstock, G., and) : Autonomic Nerve—Smooth Muscle Transmission, 951
Holmberg, E. A. D., and others : Fertility of Mice treated with Phosphorus-32, 876
Holmes, Prof Arthur : A Revised Geological Time-Scale, 27
 Age of the Base of the Cambrian, 35
Holmes, Brian : Essays in Comparative Education, review, 635
Holmes, K. C., and others : Cytoplasmic Particles and their Role in Protein Synthesis (Pattern of Ribosomal Ribonucleic Acid in X-Ray Diffraction Photographs compared to that given by Extracted Ribonucleic Acid), 644
Holstein, Dr Theodore : Appointed professor of physics in the University of Pittsburgh, 905
Holt, Dr. S. J. : Intracellular Localization of Enzymes, 836
Holt, Dr S J (Epstein, Dr. M. A., and) : Site and Nature of Adenovirus Nucleic Acid, 1050
Holton, Dr. F. A. : Appointed to the University of London readership in veterinary biochemistry at the Royal Veterinary College, 904
Home Social Development through the Family and (Report of the Conference on), 567
Home Gardens Australian Native Plants for (A. E Brooks), review by Dr. R. Melville, 637
Homogeneous Synthesis of Isotactic Polystyrene using *n*-Butyllithium Initiator (Dr. R. J. Kern), 410
Homologous Adult Spleen Cells injected into New-born Mice : Fate of (A. J. S Davies and Sheila M A Doak), 610
Homologous Radiation Chimaeras : Polyvalent Immunological Tolerance in (Alena Lengerová), 160
Homotransplant Antigens—Preparation of Active Cellular Fractions (L. T. Mann, jun., J M. Corson and Prof. G. J. Dammin), 774
Honer, M. R. : *Diplodiscus* Species Parasitic in the Snail *Paludina vivipara* Lm., 431
Honig, Pieter (edited by): Principles of Sugar Technology, Vol. 2, Crystallization, review by H. C. S. de Whalley, 979
Hookway, Dr H T. : Appointed director of the United Kingdom Scientific Mission in Washington, 24 ; work of, 24
Hopkins, Dr. A. L. : Freezing and Drying of Biological Materials, 749*
Hopkins, L. F. (Ranger, A. E., and) : Behaviour of Paper during Tensile Straining, 1097
C Horizon of the Soil Profile (Dr. S. G. Willimott and D. W. Gilchrist Shirlaw), 966
Horizons (New), in Chemistry (Sir Alexander Todd), 819
Horlock, Prof. J. H. : Combustion and Propulsion—High Mach Number Air-breathing Engines (Research in Turbo-machinery), 21
Hormone (Anti-Diuretic), and Calcium : Effect of, on the Equivalent Pore Radius of Kidney Slices from *Necturus* (G. Whittembury, N. Sugino and Dr. A. K. Solomon), 699
Hormone (Human Growth) : Immunoelectrophoretic Studies on Purified (Dr. Jan Hirschfeld, Carl-Axel Gemzell and Leif Wide), 64
Hormone (Plant) Activity—Stilboestrol applied to the Wheat Seedling (Dr J. J. C. Hinton and Dr. T. Moran), 258
Hormone-like Response in *Hydra* : Enzymatic Activation of a, by Proteases (Dr. Howard M. Lenhoff and John Bovaird), 671
Hormones and Atherosclerosis—Proceedings of the Conference held in Brighton, Utah, 1958 (edited by Gregory Pincus), review by Dr. G. S. Boyd, 634
Horne (Robert) Memorial Lecture of the Society of Chemical Industry (Prof. F D. Richardson), 466
Horning, Dr. E. C. (Sweeley, C. C., and) : Microanalytical Separation of Steroids by Gas Chromatography, 144
Horse, Sheep and Dog (Man,) : Occurrence of Keto-Acids in Blood Serum and Urine of Cattle in comparison with (Dr. C. J. G. van der Horst), 146
Horseshoe Crab : Summative Action of Acetylcholine with Physiological Stimulus on the Generator Potential in the Lateral Eye of the (R. Kikuchi, K. Naito and S. Minagawa), 1118
Horta, Wanda A., and others : Race Differences in the Ability to excrete Beetroot Pigment (Betanin), 806
Horticulture and Plantation Crops, Commonwealth Bureau of : Technical Communication No. 25, Abstract Bibliography of Fruit Breeding and Genetics to 1955—*Rubus* and *Ribes*, a Survey (Dr. R. L. Knight and Elizabeth Keep), review by Dr. G. Haskell, 184
Horton, G. Robert (Wendlandt, Prof. Wesley W., and) : Differential Thermal Analysis of some Transition Metal Ethylenediamine Tetraacetic Acid Chelates, 769
Hosein, Prof. E. A., and Proulx, Peter : Isolation and Probable Functions of Betaine Esters in Brain Metabolism, 321
Hospitals (Paris) : Medical Research in the, 26
Host Plant Crop in Successful Biological Control of Insect Pests : Significance of the Type of (D. C. Lloyd), 430
Host-Range of *Lactobacillus* Bacteriophages (Prof. J. N. Coetzee, H. C. de Klerk and T. G. Sacks), 348
Hotchkiss, Dr. Rollin D. (Fox, Dr. Maurice S., and) : Fate of Transforming Deoxyribonucleate following Fixation by Transformable Bacteria (1), 1002
Houghton, Dr. J T. : Grant of £4,560 for Space Research (for the development of photoconductive material for satellite measurements of infra-red radiation), 744
House of Commons : Second Reading of the International Development Association Bill, 266
 Adjournment Debate on the Overseas Civil Service, 371
 Second reading of the Commonwealth Teachers Bill, 441
 Debates on Science and Education, 906
Howarth, Dr. (Ozeki, Dr., and) : Genetic Recombination in *Salmonella typhimurium* occurring during Transmission of Colicinogeny, 649
Howe, Dr. E. D. : Problems of the Arid Zones (Saline Water Conversion), 295
Howie, A. : Elected to a Junior Research Fellowship of Churchill College, Cambridge, 742
Howitt, D. : A Method for the Routine Measurement of Particle Shape Factors in the Sieve Range, 403
Hoyle, Prof. Fred : Obituary of Walter Baade, 1075
Hsia, Dr. David Yi-Yung, and others : Inhibition of Glucuronosyl Transferase by Progestational Agents from Serum of Pregnant Women, 693
Hsu, Konrad C., and others : Use of Ferritin-conjugated Antibody to Localize Antigen by Electron Microscopy, 1094
Hudson, Jack W., and Taylor, Charles R : Variability in Levels of Blood Uric Acid in Five Species of Birds, 788
Hughes, Dr. R. Elfyn. Appointed director of the Bangor Research Station of the Nature Conservancy, 744
Hull Electronic Engineering Society (Institution of Electronics, with the co-operation of the) : Electronics and Instruments Exhibition and Convention, 650
Hultin, T. (von der Decken, A., and) : Cytoplasmic Particles and their Role in Protein Synthesis, 645
Human Aortic Tissue : Presence of Neutral Carbohydrates in (Dr. Sv. Bertelsen), 411
Human Arterial Tissue : Effect of Testicular Hyaluronidase on the Permeability of (Jørgen Matzke), 873
Human Blood Group Antigen, Sw^a : A 'New' (Dr. T. E Cleghorn), erratum, 743
Human Bone : Radioactive and Natural Strontium in (J. W. Arden, J F. Bryant, E. H. Henderson, G. D. Lloyd and A G. Morton), 994
Human Environment : Mode of Formation of 3,4-Benzopyrene in (Prof. G. M. Badger, R. W L. Kimber and T. M Spotswood), 663
Human Genetics, American Journal of : Symposium on Cytology and Cell Culture Genetics of Man, 116
Human γ-Globulin : Cleavage of (Dr. Rose Augustin and Barbara J. Hayward), 129
 Presence of Immunologically Active Fragments after Proteolytic Degradation of (L. A Hanson and B. G. Johansson), 599
Human Growth Hormone : Immunoelectrophoretic Studies on Purified (Dr. Jan Hirschfeld, Carl-Axel Gemzell and Leif Wide), 64
Human Insulin Amino-Acid Sequence of (Dr. D. S. H. W. Nicol and Dr. L. F. Smith), 483
Human Pituitary. Polypeptides of the, with Direct Action on Metabolism (Dr. J. Bornstein and Deirdre Hyde), 125
Human Placenta : Steroid 11 β-ol Dehydrogenase in (Dr. P. A Osinski), 777
Human Plasma : Staining for Iodine in Chromatograms of—an Artefact due to Thioureas or Thiouracils (A. Dimitriadou, Prof. T. Russell Fraser, Dr. J. D. H. Slater and P. C R Turner), 691 ; erratum, 1079
Human Potentialities (Dr. Gardner Murphy), review by Dr. D. J. West, 270
Human Red Cells : Adenosine Triphosphate and Maintenance of Shape of the (Mahoto Nakao, Toshiko Nakao and Saburo Yamazoe), 945
Human Sera (Normal) : Immuno-Electrophoretic Differentiation of Haptoglobins from another Group-Specific Inheritable System in (Dr. Jan Hirschfeld), 126
Human Serum : Isolation of Material with Proactivator Activity from (H. B. W. Greig and Elsie M. Cornelius), 1125
Human, Term Placental 17β-Œstradiol Dehydrogenases : Histochemical Localization of—Implications for the Transhydrogenase Reaction (Dr. Donald A. Kellogg and Dr. George G. Glenner), 763
Human Tumours : Polyploidy in (N. B. Atkin and Angela J. Ross), 579
Human and other Animal Cellulose (Dr. D. A. Hall and H. Saxl), 547
Human and Veterinary Medicine (Dr. W. J. Hayes, Jr., Dr. S. W. Simmons and Dr. E. F. Knipling), (edited by Dr. S. W. Simmons), (DDT—the Insecticide DDT and its Significance, edited by Paul Müller, Vol. 2), review by Prof. D. S. Bertram, 271
Humans (Premature Neonatal) : Delayed-type Hypersensitivity in (Jonathan W. Uhr, Joseph Dancis and Charlotte Grantz Neumann), 1130
Humpback Whale of Known Age : Marked (Dr. R. G. Chittleborough), 164
Humphrey, Dr. J. H. : Serum Albumin Concentration in Analbuminaemia and its Immunological Significance, 304
Humphreys, J. G., and Owen, Prof. Walter S. : An Iron—Silicon Carbide, 589
Hungate, Dr. F. P. (Uhler, Dr. R. L., and) : Relative Availability of some Strontium-90 Compounds in Soil, 252
Hunger Reduction produced by Injecting Glucose into the Lateral Ventricle of the Rat (L. J. Herberg), 243
Hunter, G. D. : Cytoplasmic Particles and their Role in Protein Synthesis (Complexes between Amino-Acids and Lipids in *Bacillus megaterium*), 643
Huntley, Dr. H. E. : The Faith of a Physicist, review by Dr. H. D. Anthony, 1063
Husbandry (Animal), at Bristol, 647
Husbandry Farms (Terrington and Kirton Experimental), King's Lynn : Appointment of F. E. Shotton as director, 905
Hutchinson, D. W., and others : Oxidative Phosphorylation—Synthesis of Adenosine Diphosphate by the Oxidation of Quinol Phosphates, 59
Hutchinson, G. W. : 'Memories' for Nuclear Physics (Duddell Medal Address to the Physical Society), 854
Hutchinson, J. N., and others : The Making of the Broads, review by Miles Burkitt, 636
Hutchinson, William D. (Vinograd, Dr. Jerome, and) : Carbon-14 Labelled Hybrids of Haemoglobin, 216
Hutchison, Dorris J., and others : Transformation of Resistance to 8-Azaguanine in *Diplococcus pneumoniae*, 800
Hutton, Dr. S. P. : Appointed to the new chair of mechanical engineering in the University College of South Wales and Monmouthshire, Cardiff, 117, 555 ; work of, 555
Huxley, A. F. : Appointed Jodrell professor of physiology at University College, London, 371 ; work of, 371
Huxley, Dr. H. E., and Zubay, G. : Cytoplasmic Particles and their Role in Protein Synthesis (Examination in the Ultracentrifuge of Ribosomes, using *Escherichia coli*), 644
Huxley, Sir Julian (editorial board : Dr. J. Bronowski, with Sir Gerald Barry, James Fisher and) : Science—Chemistry, Physics, Astronomy, review by Dr. D. R. Dickinson, 978
Huxley, Prof. L. G H. : Appointed vice-chancellor of the University of Canberra, 290
Huxley Memorial Medal for 1961 of the Royal Anthropological Institute awarded to Dr. A. E. Mourant, 114
Hyaluronic Acid : Exclusion of Inulin from Solutions of (Dr. A. G. Ogston and C. F. Phelps), 1024

Hyaluronidase (Testicular) : Effect of, on the Permeability of Human Arterial Tissue (Jorgen Matzke), 873
Hybrid (*Antirrhinum* Species) : Autogenous Necrosis in an (B. J. Harrison), 527
Hybrids (Carbon-14 Labelled), of Haemoglobin (Dr Jerome Vinograd and William D Hutchinson), 216
Hybrids (Interspecific), of the Liverwort *Sphaerocarpos* Maternal Inheritance and (Dr. William T. Doyle), 429
Hybrids (Interspecific) of *Tilapia*—*T nigra* x *T zillii* (P. J. Whitehead), 878
Hyde, Deirdre (Bornstein, Dr. J , and) : Polypeptides of the Human Pituitary with Direct Action on Metabolism, 125
Hydra . Enzymatic Activation of a Hormone-like Response in, by Proteases (Dr. Howard M. Lenhoff and John Bovaird), 671
Hydration Effect of, on Hexobarbitone-induced Sleep in Mice (Dr. N. K. Bhide), 1030
Hydrides of Iron and Osmium : Some New (Dr J Chatt, F. A. Hart and R. G Hayter), 55
Hydrocarbons of High Molecular Weight : Gas-Solid Chromatographic Separation of (C. G Scott and D. A. Rowell), 143
Hydrocarbons (Aliphatic) . Radiation-induced Nitration of (Dr. Tyson Rigg), 933
Hydrocarbons (C_4–C_6) : Two Highly Selective Solvents for Gas-Liquid Chromatography Analysis of (Dr A van der Wiel), 142
Hydrocarbons (Terpene) . Radiolysis of—Isomerization and Polymerization of α- and β-Pinene (T. H. Bates and Dr. T. Ffrancon Williams), 665
Hydrocracking of Neopentane and Neohexane over Evaporated Metal Films (Dr. J R. Anderson and B G. Baker), 937
Hydrogen : Stabilization of Austenite by (E. G. Ramachandran and C. Dasarathy), 684
Hydrogen Line : A New Limit to the Galactic Magnetic Field set by Measurements of the Zeeman Splitting of the (Dr. R. D. Davies, C. H. Slater, W. L H. Shuter and P. A. T Wild), 1088
Hydrogen 21-cm Radiation · Gravitational Red Shift of, as a Method to measure Galactic Gravitational Potential (L. F. Landovitz and L. Marshall), 223
Hydrogen-like Excitons . Effect of Electric Fields on (J. W. Allen), 51
Hydrogen 'Peroxide-16,16 : Radiolysis of Highly Enriched Oxygen-18 Water Solutions containing (Dr. Michael Anber, Shmuel Guttmann and Prof. Gabriel Stein), 57
Hydrographic Department (Royal Navy) : Retirement of Rear Admiral K. St B. Collins as hydrographer to the Navy, 285
  Appointment of Rear Admiral E. G. Irving as hydrographer to the Navy, 286
Hydrolysis (Enzymatic) . Formation of 6-Aminopenicillanic Acid from Penicillin by (Dr G. N. Rolinson, F. R. Batchelor, D. Butterworth, J. Cameron-Wood, Dr. M Cole, G C Eustace, Marian V. Hart, Dr. M. Richards and Prof E. B Chain), 236
Hydromechanics Research Association (British) : Twelfth Annual Report (1958-59), 26
Hydroxide (*N* Sodium) : Ammonia released on Treating Soils with, as a Possible Means of Predicting the Nitrogen-supplying Power of Soils (A. H. Cornfield), 260
Hydroxide (Sodium), In Water : Interaction of Picric Acid with (Takehiro Abe), 234
Hydroxy Compounds (Aromatic) : Effect of some, on the Phagocytic Activity of the Reticulo-Endothelial System (Prof. T. Nicol, C. Druce and C. C. Ware), 422
Hydroxylation of α-Pinene · Microbiological Transformation of Terpenes—(P. K. Bhattacharyya, B. R. Prema, B D. Kulkarni and S. K. Pradhan), 689
Hydroxyproline and the Shrinkage Temperature of Collagen (D. J. Rigby and Dr. J. D. Spikes), 150
5-Hydroxytryptamine . Influence of, on Renal Function in Extracorporeal Circulation (Dr. M. H. Frick), 609
  Mast Cells and, in Precancerous Mouse Skin (Dr. R. E. Coupland and Dr. J. F. Riley), 1128
5-Hydroxytryptamine in Cerebrospinal Fluid (A. Akcasu, M. Akcasu and S. B. Tumay), 324
Hygiene and Sanitation In Aviation : Guide to (World Health Organization of the United Nations), 911
Hyland, P. G., and others : Abnormal Crimping In Merino and Polwarth Wools, 960
Hynes, Dr. H. B. N. : The Biology of Polluted Waters, *review* by Dr. G. C. Ware, 1061
Hypercholesterolaemia induced by Pyridoxine Deficiency in Rats : Polyenoic Acid in (Ajit Goswami and Prof. D. P Sadhu), 786
Hyperconjugation Necessary ? Is (C N. R Rao), 913
Hypergeometric Functions Confluent (Dr. L. J. Slater), *review* by Prof W. N. Bailey, 93
Hypersensitivity (Delayed-type), in Guinea Pig Embryos : Development of (Jonathan W. Uhr), 957
Hypersensitivity (Delayed-type), in Premature Neonatal Humans (Jonathan W. Uhr, Joseph Dancis and Charlotte Grantz Neumann), 1130
Hypersensitiveness (Delayed-type Iso) : Natural Occurrence of (Dr. Jack R Battisto), 69
Hypertension : Drugs for the Treatment of (Manchester and District Section of the Royal Institute of Chemistry, and the Manchester Section and Fine Chemicals Group of the Society of Chemical Industry Symposium on), 743
Hypertensive Rats (Metacorticoid) : Electro-shock Seizure Threshold of (Dr F. M. Sturtevant), 874
Hypertrophy (Compensatory) Radiosensitivity of Mouse Kidney undergoing (Lieut. V. J. Rosen, jun., and Dr. L. J. Cole), 612
Hypothalamic System (Neurosecretory) : Antigonadotropic Function of the Pineal Gland and the Oxytocin of the (Prof. S.-M. Milcou and S. Pavel), 950
Hypothesis of Contraction in Striated Muscle (Dr. M. Spencer and Dr. C. R. Worthington), 388

ICE : Crystal Structures of the High-Pressure Forms of—Ice III (Prof. W. Barclay Kamb and Sankar K. Datta), 140
Identification of Blood-Group Antigens, *review* by Dr. R Drummond, 357
Identification of Transplanted Bone Marrow Cells in Radiation Chimaeras (P. Czarski, O Rosiek and J. Sabliński), 955
Identity of Natriferin, the Frog Water-Balance Principle and Arginine Vasotocin : Evidence for the (Prof. Wilbur H. Sawyer), 1030
I.G.Y., Year of Discovery—the Story of the International Geophysical Year (Prof. Sydney Chapman), *review* by Prof. S. K Runcorn, 185
Ikeda, Yonosuke (Kohiyama, Masamichi, and) · Appearance of New Deficient Characters in Streptomycin-resistant Mutants of *Bacillus subtilis*, 168
Ilan, Judith, and Guggenheim, Prof K. : Lack of Haematopoietic Potency of Liver of Mice fed on a Meat Diet, 698
Ilio-Sacral Joint (Expanded), in the Toad *Xenopus laevis* (Margaret Palmer), 797
Ill The Wish to Fall—a Study of Psychoanalysis and Medicine (Dr. Karin Stephen), *review* by Dr. Clifford Allen, 978
Illinois : Population Trends among Hawks and Owls in (Richard R. Graber and Jack S. Golden), 999
Illinois Department of Registration and Education Biological Notes No. 41, Population Trends among Hawks and Owls in Illinois (Richard R Graber and Jack S Golden), 999
Illinois Institute of Technology . International Symposium on Photo-elasticity, 650
Images (Electron Microscope), of Dislocations (Dr. Hatsujiro Hashimoto and Dr. Kazuo Fujita), 51
Imaginal Diapause in *Coccinella 7-punctata* L. Prevention and Artificial Induction of the (I. Hodek and J. Cerkasov), 345
Imaging Systems : Aspheric (Dr. C. R. Burch), 854
Imanishi, M. (Kawamata, Prof. J., and) : Interaction of Actinomycin with Deoxyribonucleic Acid, 1112
Immature Simuliidae : Attachment of, to other Arthropods (Dr D. J Lewis, E T. Reid, R W Crosskey and J. B. Davies), 618
Immunity of Aphids to Insect Parasites (D C Griffiths), 346
Immunoelectrophoretic Demonstration of Precipitating Components in Sera from Pregnant Women (Dr. Jan Hirschfeld and Dr. Ulf Soderberg), 332
Immunoelectrophoretic Differentiation of Haptoglobins from another Group-Specific Inheritable System in Normal Human Sera (Dr. Jan Hirschfeld), 126
Immunoelectrophoretic Studies on Purified Human Growth Hormone (Dr Jan Hirschfeld, Carl-Axel Gemzell and Leif Wide), 64
Immunological Relationships between the Rat Glomerulus and Nephritogenic Streptococci (A. S. Karkovitz, S Howard Armstrong, Jun., and Daniel S. Kushner), 1095
Immunological Responsiveness : 6-Mercaptopurine in (Dr John L. Robinson and Dr. Charles L. Christian), 796
Immunological Significance Serum Albumin Concentration in Analbuminaemia and its (Dr. J H Humphrey), 304
Immunological Tolerance (Polyvalent), in Homologous Radiation Chimaeras (Alena Lengerová), 160
Immunologically Active Fragments · Presence of, after Proteolytic Degradation of Human γ-Globulin (L. A. Hanson and B. G. Johansson), 599
Impaired Potassium Transport : A Bacterial Mutant with (Dr. Stanley G. Schultz and Dr A K Solomon), 802
Imperial College of Science and Technology, London · Appointment of Dr. D. V. Ager as reader in geology, 117
  Appointment of Sir Willis Jackson to the chair of electrical engineering, 463
  Appointment of J. C. de Courcy Henderson to the readership in reinforced concrete structures, 466
  Title of professor of physics in the University of London conferred on Dr. H. Elliot, 466
  Appointment of Dr L. M. Jackman to the University of London readership in organic chemistry, 743
  Grants for Space Research—£7,275 to Dr. H. E. Elliot (for satellite measurements of the primary cosmic-ray energy spectrum), and £1,500 to Dr. H. E Elliot (for an investigation into cosmic-ray intensity variations at rocket altitudes) ; £7,935 to Dr S. H. Hall (for geomagnetic field measurements in the Earth's upper atmosphere), 744
Imperial College of Tropical Agriculture . To be merged into the University College of the West Indies, 374
Implications of Interdependence . NATO in the 1960's—the (Alastair Buchan), 179
Implications for the Transhydrogenase Reaction : Histochemical Localization of Human, Term Placental 17β-Œstradiol Dehydrogenases—(Dr Donald A. Kellogg and Dr George G. Glenner), 763
Importance of Phosphorus-32 In Consecutive Internal Irradiation : Localization by Autoradiography at −195°C. of Radioactive Areas in Rats exposed to a High Flux of Thermal Neutrons— (Jean Chanteur and Pierre Pellerin), 472
Improved Feed for Experimental Fish (D. R. Swift), 1133
Improvement in the Ductility of Beryllium at High Temperatures (A. Brown, F. Morrow and A. J. Martin), 494
Inborn Error of Metabolism : Reversibility of an Inherited Metabolic Block— (Dr. Herman Zondek, Dr. Hannah E. Leszynsky and Dr Joseph A. Stein), 515
Incendiaries, Fireworks and Firearms, *review* by Prof. R. J Forbes, 272
Incompatible (Self-) Cocoa : Selfing in (D. R Glendinning), 170
Incompleteness (Physical), of Influenza Virus propagated in De-embryonated Eggs (Martin Hanig and Joseph M Stein), 40
Incorporate Thymidine into Deoxyribonucleic Acid : Capacity of Extracts from Prestarved *Escherichia coli* to (Dr. Daniel Billen), 1044
Incorporation of Acetate into Protein by Obligately Parasitic and Saprophytic Fungi (Dr Richard C. Staples and Dr. H P. Burchfield), 1040
Incorporation of Adenine-8-^{14}C and D,L-Methionine-^{35}S in *Acetabularia mediterranea* : Influence of Localized Ultra-violet Irradiation on the (Prof. J. Brachet and Dr. J. M. Olszewska), 954
Increase of Esterase Activity during Intracellular Digestion In a Histophagous Ciliate (Dr. Miklós Muller, József Tóth and Prof. Imre Toro), 65
Increase (Local), of Intensity of Cosmic Radiation (J.-P. Legrand and A Helary), 397
Increments (Viscosity), of Non-ionized Molecules (Alfred Polson), 482
Indeterminate Frameworks (Statically) : A Historical Note on the Reciprocal Theorem and Theory of (T. M. Charlton), 231
Index-Catalogue of Medical and Veterinary Zoology (United States Department of Agriculture), Supplements 9 and 10, 559

Index Chemicus (Institute for Scientific Information, Philadelphia), No. 1, 993
Indexes for Scientific and Technical Reports (ASLIB Survey on), 372
India : Prehistoric, *review* by M. C. Burkitt, 94
India (Early), and Pakistan to Ashoka (Sir Mortimer Wheeler), *review* by M. C. Burkitt, 94
India's First Agricultural University, 556
Indian Council of Scientific and Industrial Research : Bibliography of Indian Scientific and Technical Publications, 199
Indian Council of Scientific and Industrial Research (Chemical Research Committee) : Symposium on Redox Processes, 650
Indian Ocean Expedition (Dr. G. E. R. Deacon), 561
Indian Scientific and Technical Publications : Bibliography of (Council of Scientific and Industrial Research, New Delhi), 199
Indian (South) People : Potassium Tolerance Tests in (Dr. G. Henrotte, G. Krishnamurthi and G. Ranganathan), 328
Indole-3-carboxylic Acid from D,L-Tryptophan-3-^{14}C in *Brassica oleracea* L.: Biogenesis of Ascorbigen, 3-Indolylacetonitrile and (Dr. M. Kutáček, Dr. Z. Procházka and Dr. D. Grunberger), 61
Indoles : Non-Enzymic Reactions of, with Coenzyme I (Prof. S. G. A. Alivisatos, G. A. Mourkides and A. Jibril), 374
3-Indolylacetonitrile and Indole-3-carboxylic Acid from D,L-Tryptophan-3-^{14}C in *Brassica oleracea* L. : Biogenesis of Ascorbigen, (Dr. M. Kutáček, Dr. Z. Procházka and Dr. D Grunberger), 61
Induced Fluorescence with Acridine Orange, after Osmium Fixation (W. J. Randles), 964
Induction (Artificial), of the Imaginal Diapause in *Coccinella 7-punctata* L. : Prevention and (I. Hodek and J. Čerkasov), 345
Industrial Health in Britain, 648
Industrial Property, International Association for the Protection of : Twenty-fourth Congress (H. C. Miller), 202
Industrial Research (Scientific and) : Co-operation and, 89
Industrial Uses of Radioisotopes (United Kingdom Atomic Energy Authority Course for Trade Union Officials), 905
Industrial World : Management in the—an International Analysis (Frederick Harbison and Charles S. Myers), 537
Industries (Coal, Electricity and Gas) : Capital Investment in the (Ministry of Power), 1055
Industries (Pulp and Board), in Britain : Scope for Expanding (J. J. MacGregor), 32
Industries (Pulp and Particle Board) : The Development of, and their Effect on Forest Management (Society of Foresters of Great Britain Discussion on), 32
Industry : Education and, 470
  Effectiveness in (W. E. Bargett), 378
  Ergonomics in (Department of Scientific and Industrial Research Conference on), 117
  Research and Development in (Dr. E. J. Solvay), 830
Industry (Chemical), in Basle : The Story of (published by Ciba Limited on the occasion of its 75th Anniversary), *review* by Dr. L. K. Sharp, 540
Industry (Nuclear Energy), in France : Electronic Equipment used in the (P. Desneiges, M Doireau, L. Koch and J. Weill), 1076
Infection (Primary Tuberculous) : Effect of a, on the Resistance of Male and Female Mice to Ectromelia (Dr. A. W. Gledhill and Dr. R. J. W. Rees), 703
Infection Process (Cucumber Mosaic Virus) : Direct Infra-Red Spectral Analysis of the (Prof. G. W. Cochran, G. W. Welkie and J. L. Chidester), 1049
Infections (*Leishmania donovani*) : Treatment of, with Surface-active Agents (Dr. J. D. Fulton), 1129
Infective Ribonucleic Acid from the Viruses of Talfan and Teschen Diseases (F. Brown and Doreen L. Stewart), 714
Inflammatory (Anti-) Activity of Salicylate (Dr. V. Marks and Dr. M. J. H. Smith), 610
Inflorescence (Terminal), in the Genus *Trifolium* : Axial Origin of the (Yvonne Aitken), 622
Influence of Different Types of Malnutrition on the ^{14}-C-Lysine Metabolism in Young Rats (Prof. Kurt Schreier and Corinna Kraeusz), 1117
Influence of Editors (Scientific Publications Council Discussion on), 120
Influence on the Effect of Vasoconstrictor Amines by Pretreatment with Reserpine (H. C. Sabelli), 784
Influence of 5-Hydroxytryptamine on Renal Function in Extracorporeal Circulation (Dr. M. H. Frick), 609
Influence of the Ionic Strength of the Medium on the Anaphylactic Sensitization of Isolated Tissues *in vitro* (R. Binaghi, M. Liacopoulos-Briot, Dr. B. N. Halpern and P. Liacopoulos), 697
Influence of Localized Ultra-violet Irradiation on the Incorporation of Adenine-8-^{14}C and D,L-Methionine-^{35}S in *Acetabularia mediterranea* (Prof. J. Brachet and Dr. M. J. Olszewska), 954
Influenza Virus propagated in De-embryonated Eggs : Physical Incompleteness of (Martin Hanig and Joseph M. Stearn), 40
Information (Ionospheric), from Satellite Signals (Dr. G. H. Munro), 1017
Information (Scientific), Institute for (Philadelphia) : *Index Chemicus*, No. 1, 993
Information Centre for Food Irradiation : International (European Productivity Agency of the Organization for European Economic Co-operation and the Centre d'Études Nucléaires), 741
  Appointment of Pierre Lévêque as director, 741
Information Processing Societies, International Federation of : Formation of an, 655
Information Service (United States) : Title of *Atoms for Peace Digest* changed to *Science Horizons*, 902
Infra-red Examination of the Association of Cornea Proteins with Water (Dr. S. Bakerman and C. Mitchell), 1033
Infra-Red Frequency Shifts (R. S. Norrish), 142
Infra-Red Spectra of Amino-acids and related Substances in Water (Prof. Frank S. Parker and Prof. Donald M. Kirschenbaum), 386
Infra-Red Spectral Analysis (Direct), of the Cucumber Mosaic Virus Infection Process (Prof. G. W. Cochran, G. W. Welkie and J. L. Chidester) 1049
Ingestion of Quinic and Shikimic Acids : Excretion of Catechol after (Dr. A. N. Booth, D. J. Robbins, M. S. Masri and F. DeEds), 691
Ingold, Sir Christopher, and others : Orienting Effects in Octahedral Aquation, 477
Ingram, Dr. M. : Microbial Systematics, 191
Inheritable System (Group-Specific), in Normal Human Sera : Immuno-Electrophoretic Differentiation of Haptoglobins from another (Dr. Jan Hirschfeld), 126
Inheritance (Maternal), and Interspecific Hybrids of the Liverwort *Sphaerocarpos* (Dr. William T. Doyle), 429
Inherited Metabolic Block (Inborn Error of Metabolism) : Reversibility of an (Dr. Herman Zondek, Dr. Hannah E. Leszynsky and Dr. Joseph A. Stein), 515
Inhibited Rat Serum Acid Phosphatase : Total and *l*(+) Tartaric Acid (Dr. Z. Laron and B Epstein Halberstadt), 67
Inhibition of Aerobic Glycolysis in Yoshida Ascites Hepatoma by Tartronic Acid (Dr. L. Hume), 792
Inhibition of Auxin Transport : A Method for the Detection of (B. E. S. Gunning), 428
Inhibition at the Crayfish Neuromuscular Junction : A Second Mechanism of (Dr. Josef Dudel and Prof Stephen W. Kuffler), 247
Inhibition of Glucuronosyl Transferase by Progestational Agents from Serum of Pregnant Women (Dr. David Yi-Yung Hsia, Robert M. Dowden, Ralph Shaw and Aaron Grossman), 693
Inhibition of Goitrogenesis in the Rat · Comparison of Iodine-124 and Iodine-131 in (Dr. L Donach and Dr. P. E. Francois), 704
Inhibition of Growth by Actinomycin of *Neurospora crassa* : Action of Nucleic Acids on the (Dr. W. Kersten, Dr H. Kersten and Prof. H. M. Rauen), 60
Inhibition of Nodule Bacteria by an Antibiotic from Legume Seed Coats (J. A. Thompson), 619
Inhibition (Growth) : Cell Biology and (Cell Biology Programme of Unesco International Symposium on), 836
Inhibitor (Germination), of the Seed of Rice : Viability and (Prof. S. M Sircar and Manjula Biswas), 620
Inhibitor (Monoamine Oxidase) : Anti-Fertility Action of a (W. G. Spector), 514
Inhibitor (New), of Monoamine Oxidase (Dr. J. D. Taylor, A. A. Wykes, Y. C. Gladish and W. B. Martin), 941
Inhibitors (Specific), of the Adrenal Cortex (Prof. J. H. U. Brown), 985
Initial Stages of Oxidation of Coal (S. K. Chakrabartty, B. K. Mazumdar and A. Lahiri), 502
Initial Value of Metabolic Processes : Role of, in Oxygen Consumption Changes in Rats during Irradiation (Dr. A. Vacek), 76
Initiate and Propagate a Fatigue Crack in Mild Steel : Correlation of the Alternating Stresses required to (N. E. Frost), 233
Initiation of Chemical Reactions by Mechanical Forces (Dr. Robert Schourmann and Ivor S. Stringer), 587
Initiator (*n*-Butyllithium). Homogeneous Synthesis of Isotactic Polystyrene using (Dr. R. J. Kern), 410
Injected Chelating Agents : Sustained Action of (Dr. A. Lindenbaum and Dr. J. Schubert), 575
Injecting Glucose into the Lateral Ventricle of the Rat : Hunger Reduction produced by (L. J. Herberg), 245
Injection of Thymidine labelled with Tritium : Urinary Excretion of *β*-Amino-isobutyric Acid after (Dr. Georg B. Gerber, Gisela Gerber and Kurt I. Altman), 956
Injection (Photo-) of Charge into Dielectric Liquids (M. J. Morant), 48
Injury (Liver), due to Murine Hepatitis Virus : Protection against (Dr. J. D. Judah, G. Bjotvedt and T Vainio), 507
Innervation (Sensory), of the Anal Canal (R. P. Gould), 337
Innes, Prof. K. Keith, and others : Ultra-violet Absorption Spectra of the Diazines, 500
Innes (The John) Institute (Dr. K. S. Dodds), 467
Inorganic Chemistry : Annual Reviews on, *review* by Dr. I. R Beattie, 4
  Comprehensive (edited by Prof. M. Cannon Sneed and Prof Robert C. Brasted), Vol. 7, The Elements and Compounds of Group IVA (Harold P. Klug and Prof. Robert C. Brasted), *review* by Dr. K. W. Bagnall, 185
  Progress in (edited by F. Albert Cotton), Vol. 1, *review* by Dr. I. R. Beattie, 4
Inorganic Forms (Organic and) : Bacterial Effect and Radiophosphorus Assimilation in, in Salmon (Dr. P. N. Srivastava), 83
Insect : The Control of Growth and Form—a Study of the Epidermal Cell in an (Prof. V. B. Wigglesworth), *review* by Prof. R. Dennell, 631
  Growth and Form in an, *review* by Prof. R. Dennell, 631
Insect Parasites : Immunity of Aphids to (D. C. Griffiths), 346
Insect Pests : Significance of the Type of Host Plant Crop in Successful Biological Control of (D. C. Lloyd), 430
Insect Suction Traps : Vent-Axia, 559
Insect Tissue Culture : Growth by Cell Division in (Dr. B. M. Jones and L Cunningham), 1072
Insecticides (William O. Negherbon), (Handbook of Toxicology, Vol. 3), *review* by Prof. V. B. Wigglesworth, 544
Insects attacking *Striga* (D. V. Murthy), 959
Instrument Manual, third edition, *review* by S. Weintroub, 97
Instrument Symposium and Research Equipment Exhibit : Tenth Annual (United States National Institutes of Health), 559
Instrumentation : Chemical Plant—some Notes on the Use of Measuring Instruments (Association of British Chemical Manufacturers), 1079
  Health Physics (John S. Handloser), *review* by B. S. Smith, 9
Instruments (Measuring) : Chemical Plant Instrumentation—some Notes on the Use of (Association of British Chemical Manufacturers), 1079
Instruments (Nuclear Physics) : Application of Computer Techniques to (G. G. Scarrott), 854
Instruments and Measurements Conference and Exhibition : Fifth International (Royal Swedish Academy of Engineering Sciences and the Swedish Association of Technical Physicists), 374
Instruments (Electronics and), Exhibition and Convention (Institution of Electronics, with the co-operation of the Hull Electronic Engineering Society), 650
Insulation (Thermal) : Domestic Heating and (Building Research Station, Digest 133), 999
Insulator (Semi-) : Gallium Arsenide as a (J. W. Allen), 403
Insulin in Rats : Dextran and (Dr. L. H. Marshall and C. H. Hanna), 1118
Insulin (Human) : Amino-Acid Sequence of (Dr. D. S. H. W. Nicol and Dr. L. F. Smith), 483
Integrals (Stochastic Path) : A Remark on (Prof. M. S. Bartlett), 968
Integration of the Cape and Royal Greenwich Observatories, 464
Intense Radiation : Biological Effects of Exposure to, 910

Intensity of Cosmic Radiation : Local Increase of (J. -P. Legrand and A. Helary), 397
Inter-Library Communications : 'Telex' and, 558
Interaction of Actinomycin with Deoxyribonucleic Acid (Prof. J. Kawamata and M. Imanishi), 1112
Interaction of Picric Acid with Sodium Hydroxide in Water (Takehiro Abe), 234
Interactions of Science and Technology with Society, 1
Interactions (Solid—Solid), on Active Adsorbents (Dr. Philip Anthony and Prof Harry Zeitlin), 936
Intercomparisons (Precision), of Lead Isotope Ratios—Broken Hill and Mount Isa (F. Kollar, Prof. R. D Russell and T. J Ulrych), 754
Interdependence : NATO in the 1960's—the Implications of (Alastair Buchan), 179
Interference Systems in Virus-infected Plants : Possible Occurrence of (A D. Thomson), 761
Interferometry : Possible Discovery of Ion-Pairs by (Prof. R. N. O'Brien and C. Rosenfield), 935
Interferon-like Substance released from Tick-borne Encephalitis Virus-infected Chick Embryo Fibroblast Cells (Dr J. Vilček), 73
Intergovernmental Conference on Oceanographic Research, 647
Interlayer Spacing in Carbons of Different Graphitic Perfection : Dependence on Temperature of the (E. G. Steward, B. P. Cook and E. A. Kellett), 1015
Interlayers (Aluminium) in Clay Minerals, Montmorillonite and Vermiculite—Laboratory Synthesis (B. L. Sawhney), 261
Internal Irradiation (Consecutive) : Localization by Autoradiography at -195° C. of Radioactive Areas in Rats exposed to a High Flux of Thermal Neutrons—Importance of Phosphorus-32 in (Jean Chanteur and Pierre Pellerin), 472
Internal Organization of Nucleic Acid in T_2 Bacteriophage : Evidence for (Irwin J. Bendet, David A. Goldstein and Max A. Lauffer), 781
Internal Sources (Standardized), of Phosphorus-32 · Radiolytic Oxidation of Ferrous Solutions with (Dr. M. Peisach and J. Steyn), 58
Internally Deposited Americium · Removal of, by Chelating Agents (Dr. F D. Sowby and Dr. D M Taylor), 612
International (Premier Colloque), de Photographie Corpusculaire, Strasbourg, 1957, *review* by D. L. Allan, 636
International Association for the Protection of Industrial Property : Twenty-fourth Congress (H. C. Miller), 202
International Atomic Energy Agency : Review Series No. 3, Electronic Equipment used in the Nuclear Energy Industry in France (P. Desnetges, M. Doireau, L. Koch and J. Weill), 1076
International Bank for Reconstruction and Development : Articles of Agreement of the proposed International Development Association, as approved for submission to Governments by the Executive Directors of the, 266
International Colloquium on the Physics of Electrostatic Forces and their Applications (Centre National de la Recherche Scientifique), 466
International Commission for Uniform Methods of Sugar Analysis—Report of the Proceedings of the Twelfth Session, Washington, D.C., 1958, *review* by Prof. E. L Hirst, 9
International Conference on High-Energy Physics Tenth Annual (Commission on High Energy Physics of the International Union of Pure and Applied Physics), 29
International Conference on Nuclear Structure, 290
International Conference on Semiconductor Physics (Czechoslovak Academy of Science), 29
International Congress of Applied Mechanics . Tenth, 201
International Congress of Blood Transfusion · Eighth (Japanese Red Cross Society), 201
International Congress on Experimental Mechanics, 559
International Congress of Food Science and Technology, 905
International Congress on Histochemistry and Cytochemistry (Société Française d'Histochimie), 29
International Congress for Logic, Methodology and Philosophy of Science (International Union for History and Philosophy of Science), 201
International Congress on Nutrition . Fifth (International Union of Nutritional Sciences, the American Institute of Nutrition and the United States National Committee, and the International Union of Nutritional Sciences of the United States National Academy of Sciences—National Research Council), 201
International Congress of Pure and Applied Chemistry : Seventeenth (International Union of Pure and Applied Chemistry), 29, *erratum*, 117
International Congress on the Technology of Plastics Processing (Association for the Advancement of the Knowledge of Materials, the Royal Institute of Engineers, the Royal Netherlands Chemical Federation and the International Union of Pure and Applied Chemistry), 559
International Co-ordination of Time Signals and Standard Frequency Transmissions (Dr. L. Essen), 452
International Council for Bird Preservation : Annual Report for 1959, 287
International Council of Scientific Unions · Year Book for 1960, 198
International Course on Lyophilization (Association des Cours Internationaux de Lyophilization), 29
International Cytology, *review* by the late Prof. J. Bronte Gatenby, 632
International Development Association : Articles of Agreement as approved for submission to Governments by the Executive Directors of the International Bank for Reconstruction and Development, and Accompanying Report of the Executive Directors, 266
International Federation of Information Processing Societies : Formation of an, 655
International Geophysical Co-operation, 1959 Recent Scientific Activities at Halley Bay— (M. J Blackwell), 982
International Geophysical Year : I.G Y., Year of Discovery—the Story of the (Prof. Sydney Chapman), *review* by Prof. S K. Runcorn, 185
International Geophysical Year Observations : Distribution of Atmospheric Ozone —a Preliminary Analysis of some (J. MacDowall), 382
International Goitre Conference . Fourth (Prof. C. Rimington and Dr. R. A. Miley), 651
International Information Centre for Food Irradiation (European Productivity Agency of the Organization for European Economic Co-operation and the Centre d'Études Nucléaires), 741
  Appointment of Pierre Lévèque as director, 741
International Instruments and Measurements Conference and Exhibition : Fifth (Royal Swedish Academy of Engineering Sciences and the Swedish Association of Technical Physicists), 374
International Meteorological Organization Prize awarded by the World Meteorological Organization to Prof. J. van Mieghem, 740
International Pharmacological Meeting First (Section of Pharmacology of the International Union of Physiological Sciences), 29
International Plastics Exhibition : Second, 559
International Potash Institute : Potassium Symposium, 1958—Twelve Papers read at the Fifth Congress, *review* by Dr. P W. Arnold, 976
International Review of Cytology (edited by Prof G. H. Bourne and Prof, J F. Danielli), Vol 8, *review* by the late Prof. J. Bronte Gatenby, 632
International Review of Neurobiology (edited by Carl C. Pfeiffer and John R. Smythies), Vol. I, *review* by Dr D H. Brinton, 447
International Scientific Radio Union · Thirteenth General Assembly, 902
International Summer Course on Solid State Physics (Società Italiana di Fisica), 201
International Symposium on Cell Biology and Growth Inhibition (Cell Biology Programme of Unesco), 836
International Symposium on Chromatography (Belgisch Genootschap voor Pharmaceutische Wetenschappen), 374
International Symposium on Cori's Ester and Phosphorylated Glucides : First, 117, 290
International Symposium on Data Transmission (Benelux Section of the Institute of Radio Engineers, in co-operation with the Nederlands Radiogenootschap and the Group on Communications Systems of the Institute of Radio Engineers), 290
International Symposium on Photoelasticity (Illinois Institute of Technology), 650
International Union of Biochemistry and the International Union of Biological Sciences . Symposium on Biological Structure and Function, 905
International Union of Biological Sciences (International Union of Biochemistry and the) : Symposium on Biological Structure and Function, 905
International Union for History and Philosophy of Science : International Congress for Logic, Methodology and Philosophy of Science, 201
International Union of Nutritional Sciences of the United States National Academy of Sciences—National Research Council, and others : Fifth International Congress on Nutrition, 201
International Union of Physiological Sciences (Section of Pharmacology) : First International Pharmacological Meeting, 29
International Union of Pure and Applied Chemistry : Seventeenth International Congress of Pure and Applied Chemistry, 29, *erratum*, 117
International Union of Pure and Applied Chemistry (sponsored by the) : Symposium on the Chemistry of Natural Products (organized by the Australian Academy of Science), 1080
International Union of Pure and Applied Chemistry, and others : International Congress on the Technology of Plastics Processing, 559
International Union of Pure and Applied Physics : Tenth Annual International Conference on High-Energy Physics, 29
Interpretation of Cosmology (Dr. W. Davidson), 583 ; (Prof. W. H. McCrea), 583
Interspecific Hybrids of the Liverwort *Sphaerocarpos* : Maternal Inheritance and (Dr. William T. Doyle), 429
Interspecific Hybrids of *Tilapia*—*T. nigra* x *T. zillii* (P. J. Whitehead), 878
Interstellar Extinction and Polarization (R. Wilson), 288
Interval Analyser : A Biological (G K. Smith and Prof. B. Delisle Burns), 512
Intestinal Absorption of Glucose, Methionine and Sodium Butyrate : Reduction of the, by the Cation Trimethylhexadecylammonium (Dr. J. A. Nissim), 308
Intracellular Configuration and Dedifferentiation in *Splachnum ampullaceum* (L.) Hedw. (Prof. Kraft E. von Maltzahn and Mary M. MacNutt), 344
Intracellular Digestion in a Histophagous Ciliate · Increase of Esterase Activity during (Dr. Miklós Muller, József Tóth and Prof. Imre Toro), 65
Intracellular Localization of Enzymes (Centre Inter-universitaire de Recherches Enzymologiques Colloquium on), 836
Introduction to Genetics (Dr. C. M. M. Begg), *review* by Wilma George, 357
Introduction to Quantitative Genetics (Dr. D. S. Falconer), *review* by Prof. Kenneth Mather, 813
Introduction to Rubber Technology (edited by Maurice Morton), *review* by Dr. W. F. Watson, 359
Introduction to Symbolic Logic and its Applications (Rudolf Carnap), translated by William H. Meyer and John Wilkinson, *review* by P. I. G. Rawlins, 729
Inulin : Exclusion of, from Solutions of Hyaluronic Acid (Dr. A. G. Ogston and C. F Phelps), 1024
Invention (Engineering) : History of, *review* by J. L. Stollery, 8
Inverse Relation between the Liver Glycogen and the Blood Glucose in the Rat adapted to a Fat Diet (Dr. P. A. Mayes), 325
Investigating the Creep of Metals under Simple Shear : A Simple Method of (Prof E. N. da C. Andrade), 494
Investigation (Mass Spectrometric), of the Vaporization of Sulphides and the Dissociation Energy of S_2 (R. Colin, Prof. P. Goldfinger and M. Jeunehomme), 408
Investigation (Quantitative), of the Echinoderm Fauna of the Central North Sea (Dr. Erik Ursin), (Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 24), *review* by Dr. A. J. Southward, 360
Investigations on the Quantitative and Qualitative Distribution of Zooplankton in the Southern Part of the Norwegian Sea (V. K. Hansen), (Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 23), *review* by Dr. A J Southward, 360
Investment (Capital), in the Coal, Electricity and Gas Industries (Ministry of Power), 1055
Iodate and Iodoacetate : Protective Effect of Cysteine against Retinal Degeneration induced by (Prof. Arnold Sorsby and Ronald Harding), 608
Iodine in Chromatograms of Human Plasma : Staining for—an Artefact due to Thiourea or Thiouracils (A. Dimitriadou, Prof. T. Russell Fraser, Dr. J. D. H. Slater and P. C. R. Turner), 691 ; *erratum*, 1079
Iodine-124 and Iodine-131 : Comparison of, in Inhibition of Goitrogenesis in the Rat (Dr. I. Doniach and Dr. P. E. Francois), 704

Iodine-131: The Ouchterlony Technique using Antigen or Antiserum labelled with (Joan M. Rhodes), 793
Sialoadenectomy and the Distribution of Thyrotrophin labelled with (Prof. Arthur W. Wase and Dr. Yu Sheng Louise Feng), 778
Iodine-131 (Iodine-124 and): Comparison of, in Inhibition of Goitrogenesis in the Rat (Dr. I. Doniach and Dr. P. E. Francois), 704
Iodoacetate: Protective Effect of Cysteine against Retinal Degeneration induced by Iodate and (Prof. Arnold Sorsby and Ronald Harding), 608
Ion (*tris* (Ethylenediamine) Cobalt (III): Catalytic Racemization of (Dr. F. P. Dwyer and Dr. A. M. Sargeson), 1022
Ion (Nitrate): Effect of, on the Distribution of Sucrose in the Rat's Ventricle (S. T. Taketa, C. G. Alexander and Prof. G. A. Feigen), 419
Ion (Perchlorate), in Sea-Water: Alleged Occurrence of the (R. Greenhalgh and Dr. J. P. Riley), 1107
Ion Exchanger (Cellulose): Non-specific Haemagglutinin from Cellulose and (Prof. B. Schmidt, Dr. K. Grossgebauer and D. Hartmann), 790
Ion-Pairs. Possible Discovery of, by Interferometry (Prof. R. N. O'Brien and C. Rosenfeld), 935
Ionic-Covalent Bonding in Crystals (C. H. L. Goodman), 590
Ionic Strength of the Medium: Influence of the, on the Anaphylactic Sensitization of Isolated Tissues *in vitro* (R. Binaghi, M. Liacopoulos-Briot, Dr. B. N. Halpern and P. Liacopoulos), 697
Ionization Detector for Permanent Gases (Dr. J. E. Lovelock), 49
Ionization and Attachment Coefficients in *n*-Alkyl Chloride Gases (J. C. Devins and O. H. LeBlanc, Jun.), 409
Ionizing Radiations: Chemical Effects of, on Nucleic Acids and Nucleoproteins (P. Emmerson, Dr. G. Scholes, D. H. Thomson, J. F. Ward and Prof. J. Weiss), 319
Role of Oxygen in the Cross-linking and Degradation of Deoxyribonucleic Acid by (Peter Alexander and J. T. Lett), 933
Ionosphere: The Magneto-Ionic Theory and its Applications to the (J. A. Ratcliffe), *review* by Sir Harrie Massey, 810
Recent Trends in the Theory of the (J. A. Ratcliffe), 853
Ionospheric Drifts: Possibility of Detecting, from the Occurrence of Spread *F* Echoes at Low Latitudes (R. W. Knecht), 927
Ionospheric Information from Satellite Signals (Dr. G. H. Munro), 1017
Ionospheric Modification of the Radio Emission from Jupiter (Prof. Alex G. Smith, T. D. Carr, H. Bollhagen, N. Chatterton and F. Six), 568
Ionospheric Propagation of Electromagnetic Waves, *review* by Sir Harrie Massey, 810
Ions (Alkali Metal), in Analcite: Energies of Activation for Self-diffusion of (Prof. R. M. Barrer and L. V. C. Rees), 768
Ions (Bivalent Metal), in Transphosphorylation: Synergism of (Dr. John M. Lowenstein), 570
Ions (High-Energy Oxygen), in Carbon Dioxide Mass Spectra (R. M. S. Hall), 683
Ions (Manganous): Stabilization by, of Ribosomes from Embryonic Plant Tissue (Dr. J. W. Lyttleton), 1026
Ions (Metal). Fungitoxicity of (Dr. E. Somers), 427
Ions (Negative): Isotopic Analysis of Silicon by Solid-Source Mass Spectrometry using (Dr. D. C. Newton, J. Sanders and A. C. Tyrrell), 683
Iriki, Yoshihiko, and others: Xylan of Siphonaceous Green Algae, 82
Irish Sea Pleistocene History of the (G. F. Mitchell), 842
Iron (Serum), and Total Iron-binding Capacity in certain Mammals (Prof. Jose Planas and Sinnio de Castro), 1126
Iron-binding Capacity (Total), in certain Mammals: Serum Iron and (Prof. Jose Planas and Sinnio de Castro), 1126
Iron Meteorites: The Sulphide Phase in some (Dr. H. J. Axon), 406
Iron and Osmium: Some New Hydrides of (Dr. J. Chatt, F. A. Hart and R. G. Hayter), 55
Iron—Silicon Carbide. An (J. G. Humphreys and Prof. Walter S. Owen), 589
Iron and Steel Institute: Establishment of a new Gold Medal Award, 286
First award of the Gold Medal made to the Royal Society, 286
Irradiated with Ultra-violet Light: Recovery in the Presence of Chloramphenicol of *Escherichia coli* B (H), (Kenshi Suzuki and Yukiko Iwama), 347
Irradiated Rats: Synthesis of Diphosphopyridine Nucleotide in (Dr. D. K. Myers), 1124
Irradiation: Role of Initial Value of Metabolic Processes in Oxygen Consumption Changes in Rats during (Dr. A. Vacek), 76
Irradiation (Consecutive Internal). Localization by Autoradiography at -195° C. of Radioactive Areas in Rats exposed to a High Flux of Thermal Neutrons—Importance of Phosphorus-32 in (Jean Chanteur and Pierre Pellerin), 472
Irradiation (Food): International Information Centre for (European Productivity Agency of the Organization for European Economic Co-operation and the Centre d'Études Nucléaires), 741
Appointment of Pierre Lévêque as director, 741
Irradiation (Gamma), of Lead Silicate Glass (R. S. Barker, D. A. Richardson, E. A. G. McConkey and R. Rimmer), 135
Irradiation (Localized Ultra-violet). Influence of, on the Incorporation of Adenine-8-^{14}C and D,L-Methionine-^{35}S in *Acetabularia mediterranea* (Prof. J. Brachet and Dr. M. J. Olszewska), 954
Irradiation (Ultra-violet): Delayed Recovery of Airborne *Serratia marcescens* after Short-Time Exposure to (Dr. R. L. Dimmick), 251
Irradiation (Whole-body): Effects of, on the Breeding Plumage of the Weaver Finch, *Quelea quelea* (Dr. B. Lofts, Prof. A. J. Marshall and Prof. J. Rotblat), 615
Labilization of Deoxyribonucleic Acid in Thymus Nucleoprotein after (Dr. Ulrich Hagen), 1123
Irradiation (X-): Changes in Conductivity of Pure Water caused by (K. Schmidt), 931
Irreversibility. Statistical Mechanics with special reference to (Institute of Physics and the Physical Society Conference on), 1079
Irrigation in Great Britain, 198
Irving, Rear Admiral E. G.: Appointed hydrographer to the Navy, 286; work of, 286
Is Hyperconjugation Necessary? (C. N. R. Rao), 913
Ishida, Takeo (Okada, Hideya, and): Hexagonal Modification of Black Chromium Electro-deposit, 496
Islam, Prof. Ahmad Shamsul: Unproductivity in the Colchicine-induced Tetraploids of *Annona squamosa* L., 343
Island (Pacific): Continuity in a Small, *review* by Sir Harry Luke, 816
Ismen, Hikmet (MacNeill, B. H., and): Virus-Streak Disease of Tomatoes, 903
Iso-hypersensitiveness (Delayed-type): Natural Occurrence of (Dr. Jack R. Battisto), 69
Isolated Cells: Measuring the Size of (Dr. Samuel S. Epstein and Jacqueline B. Weiss), 461
Isolated Tissues *in vitro*: Influence of the Ionic Strength of the Medium on the Anaphylactic Sensitization of (R. Binaghi, M. Liacopoulos-Briot, Dr. B. N. Halpern and P. Liacopoulos), 697
Isolation of a δ-Lactone Compound from the Leaves of *Citona marina* Linn. (Dr. A. Sinha), 149
Isolation of Material with Proactivator Activity from Human Serum (H. B. W. Greig and Elsie M. Cornelius), 1125
Isolation of a Non-pathogenic Tumour-destroying Virus from Mouse Ascites (Dr. J. G. Bennette), 72
Isolation of a Phytoalexin from *Pisum sativum* L. (I. A. M. Cruickshank and Dawn R. Perrin), 799
Isolation of Plant Protoplasts and Vacuoles: A Method for the (Dr. E. C. Cocking), 962
Isolation and Probable Functions of Betaine Esters in Brain Metabolism (Prof. E. A. Hosein and Peter Proulx), 321
Isomerization and Polymerization of α- and β-Pinene: Radiolysis of Terpene Hydrocarbons— (T. H. Bates and Dr. T. Ffrancon Williams), 665
Isotactic Polystyrene: Homogeneous Synthesis of, using *n*-Butyllithium Initiator (Dr. R. J. Kern), 410
Isotope (Lead) Ratios: Precision Intercomparisons of—Broken Hill and Mount Isa (F. Kollar, Prof. R. D. Russell and T. J. Ulrych), 754
Isotopic Analysis of Silicon by Solid-Source Mass Spectrometry using Negative Ions (Dr. D. C. Newton, J. Sanders and A. C. Tyrrell), 683
Isotopic Composition and Temperature of Formation of Antarctic Snows (Prof. E. Picciotto, X. de Maere and Dr. I. Friedman), 857
Israel Programme for Scientific Translations, 832
Ito, Isao, and others: High-Energy Bound Phosphate and Diabetes Mellitus, 702
Ito, Dr. Toshio: Nutritive Values of Carbohydrates for the Silkworm, *Bombyx mori*, 527
Iversen, Dr. Simon: Absorbance of Feulgen-stained Somatic Cell Nuclei, 86
Ivins, Prof. J. D. (edited by): The Measurement of Grassland Productivity—Proceedings of the University of Nottingham Sixth Easter School in Agricultural Science, 1959, *review* by Dr. G. W. Cooke, 544
Iwama, Yukiko (Suzuki, Kenshi, and): Recovery in the Presence of Chloramphenicol of *Escherichia coli* B (H) Irradiated with Ultra-violet Light, 347

JACCODINE, R. J.: Crystal Growth in Paraffin, 498
Jackman, Dr. L. M.: Nuclear Magnetic Resonance, *review*, 358
Appointed to the University of London readership in organic chemistry at the Imperial College of Science and Technology, 743
Jackson, Dr. C. P., and Ramamurti, K.: Syntheses of Glucose, Cellobiose and other Saccharides by *Acetobacter acetigenum* in a Lactate-buffered Glycerol Medium, 942
Jackson, J. S.: A Symmetrical Fourfold Helical Fracture in Titanium Oxide, 1104
Jackson, Sir Willis: Appointed to the chair of electrical engineering at the Imperial College of Science and Technology, London, 463; work of, 463
Jain, R. K.: *Ensete berryi*—Revised Name for *Musa ensetaeformis* Berry, 342
Jakab, Dr. L., and others: Role of Mucoid Substances of the Aorta in the Deposition of Lipids, 152
James, W. Warwick: The Jaws and Teeth of Primates, *review* by Sir Wilfrid Le Gros Clark, 891
Jane, Prof. F. W.: Combating the Decay of Timber, *review*, 977
Japanese Potassium Symposium—Nine Papers read at the First Japanese Symposium, 1957, *review* by Dr. P. W. Arnold, 976
Japanese Red Cross Society: Eighth International Congress of Blood Transfusion, 201
Japanese Scientific and Technical Books and Dictionaries: A collection of, presented to the Science Museum Library, London, on behalf of the Prime Minister of Japan, Nobusuke Kishi, 201
Jardetzky, Wenceslas S.: Theories of Figures of Celestial Bodies, *review* by Prof. L. S. Goddard, 890
Jasper, Dr. H. H.: Self-Regulation in Living Systems (Tremor—Experimental Measurements on Tremor, using Microelectrodes), 298
Jaspilite (Roast Reduced): Formation of Fayalite in (J. B. Lean, K. J. Tucker, B. O. Holland and T. R. Thomson), 683
Jaws and Teeth of Primates (W. Warwick James), *review* by Sir Wilfrid Le Gros Clark, 891
Jay, K. E. B.: The Nuclear Handbook, *review*, 273
Jeffery, Dr. J. W.. Exploring Vector Space, *review*, 975
Jeffery, R. A., and Smith, E.: Work-Hardening and Ductility of Rhenium and their relation to the Behaviours of other Metals having a Hexagonal Structure, 52
Jellinek, Dr. F.: Character of the Ligands in Dibenzene Chromium, 871
Jenkins, Prof. F. A.: *Obituary* by Dr. H. G. Kuhn, 990
Jennings, J. N., and others: The Making of the Broads, *review* by Miles Burkitt, 636
Jennison, Dr. R. C.: Grants for Space Research—£15,277 (for micrometeorite investigations from an Earth satellite), and £15,020 (for low-frequency radio astronomy from an Earth satellite), 744
Jericho, M. H.: Awarded an Overseas Scholarship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Jeunehomme, M., and others: Mass Spectrometric Investigation of the Vaporization of Sulphides and the Dissociation Energy of S_2, 408
Jibril, A., and others: Non-Enzymic Reactions of Indoles with Coenzyme I, 374
Job in West African Religion: Oedipus and (Prof. Meyer Fortes), *review* by Michael Argyle, 96
Johansson, B. G. (Hanson, L. A., and): Presence of Immunologically Active Fragments after Proteolytic Degradation of Human γ-Globulin, 599
Johnson, B. E.: Potentiation of Hair-Growth by Ultra-Violet Light, 159
Johnson, R. F., and others: Fractionation of Nuclear Weapon Debris, 1100
Johnson, Matthey and Co., Ltd., London: Products of the Rare Earth Group, 832

Jones, Dr. B. M., and Cunningham, I.: Growth by Cell Division in Insect Tissue Culture, 1072
Jones, Dr. D. N.: Appointed lecturer in chemistry at the University of Sheffield, 466
Jones, F. R. Harden, and others: Echo Sounding Experiments in the Barents Sea, 855
Jones, Dr. G.: Appointed to the Sophie Fricke Royal Society Research Fellowship in the Rockefeller Institute, 1079
Jones, G. D.: Awarded an Overseas Scholarship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Jones, Sir Harold Spencer: Space Research, review, 268
Jones, R. A. Y.: Elected to a Junior Research Fellowship of Churchill College, Cambridge, 742
Jones, Prof. R. V.: Some Developments of the Optical Lever (Duddell Medal Address to the Physical Society), 905
Jordan, Prof. Joseph, and others: 'Enthalpy Titrations' and Thermochemistry in Molten Salts, 318
Journals and Newspapers (British): Bibliography of, 116
Judah, Dr. J. D.: Phosphoproteins and Mitochondrial and Cell Water, 506
Intracellular Localization of Enzymes, 853
Judah, Dr. J. D., and others: Protection against Liver Injury due to Murine Hepatitis Virus, 507
Jude, P. E.: La Grotte de Rochereil, 903
Judgment: The Anatomy of (Dr. M. L. Johnson Abercrombie), review by Prof. O. L. Zangwill, 817
Juice (Passion Fruit): An Acid-tolerant and Non-sporulating Yeast from (B. A. S. Rao and J. S. Pruthi), 342
Junction Transistor and its Applications (edited by E. Wolfendale), review by Dr. J. R. Tillman, 1058
Jungherr, E. L. (edited by C. A. Brandly and): Advances in Veterinary Science, Vol. 5, review by Prof. H. Burrow, 448
Jupiter: Ionospheric Modification of the Radio Emission from (Prof. Alex G. Smith, T. D. Carr, H. Bollhagen, N. Chatterton and F. Six), 568

KABERRY, Dr. P. (Chilver, E. M., and): Awarded jointly the Wellcome Medal for 1959 of the Royal Anthropological Institute, 114
Kac, Prof. Mark: Probability and related Topics in Physical Sciences, review by Prof. M. S. Bartlett, 1060
Kafig, Dr. E.: Freezing and Drying of Biological Materials, 749
Kalinko, M. K.: Submarine Oil Drilling, 903
Kallio, Prof. Paavo: Morphogenetics of *Micrasterias americana* in Clone Culture, 164
Kalmus, Dr. H.: Evolutionary Theory after Mendel, review, 726
Kamb, Prof. W. Barclay, and Datta, Sankar K.: Crystal Structures of the High-Pressure Forms of Ice—Ice III, 140
Kanda, S., and others: Distribution of Protein-bound Aminoazo Dyes in the Rat Liver Microsome, 943
Kapa, Dr. Eszter (Csaba, Dr. G., and): Uptake of Heparin by Cells, 711
Kapp, Prof. Reginald O.: Towards a Unified Cosmology, review by Dr. C. W. Kilmister, 634
Kassanis, B., and Nixon, H. L.: Activation of One Plant Virus by Another, 713
Katchalsky, Prof. A.: Colloid and Polymer Science (Application of the Thermodynamics of Irreversible Processes to the Study of Colloid—Chemical Phenomena), 378; (Fundamentals of Mechano-chemistry), 378
Kato, Jiro, and others: Plant-Growth Activity of α-Alkylphenylacetic Acids and 1,2-Benzo-1-cycloalkene-3-carboxylic Acids, 694
Katsumi, Masayuki, and others: Plant-Growth Activity of α-Alkylphenylacetic Acids and 1,2-Benzo-1-cycloalkene-3-carboxylic Acids, 694
Kawamata, Prof. J., and Imanishi, M.: Interaction of Actinomycin with Deoxyribonucleic Acid, 1112
Kawazu, Kazuyoshi, and others: Plant-Growth Activity of α-Alkylphenylacetic Acids and 1,2-Benzo-1-cycloalkene-3-carboxylic Acids, 694
Kawcyn, R. A., and others: Diamagnetic Moment of Gaseous Plasmas measured by Spin Resonance Techniques, 584
Kazassa, Corinna (Schreier, Prof. Kurt, and): Influence of Different Types of Malnutrition on the ^{14}C-Lysine Metabolism in Young Rats, 1117
Kearsley, Dr. M. J.: Appointed lecturer in mathematics at the University of Oxford, 117
Kearton, C. F.: Re-appointed a part-time member of the United Kingdom Atomic Energy Authority, 743
Keast, A., and others (edited by): Biogeography and Ecology in Australia, review by Prof. A. J. Marshall, 543
Keen, M. J.: Magnetization of Sediment Cores from the Eastern Atlantic Ocean, 220
Keep, Elizabeth (Knight, Dr. R. L., and): Abstract Bibliography of Fruit Breeding and Genetics to 1955—*Rubus* and *Ribes*, a Survey, review by Dr. G. Haskell, 184
Keilin, Dr. Joan: Nature of the Haem-binding Groups in Native and Denatured Haemoglobin and Myoglobin, 365
Kekwick, Dr. R. A., and Leymann, Dr. H.: Sedimentation Characteristics of the γ-Chain Haemoglobin (Haemoglobin 'Bart's'), 158
Kellenberger, G., and others: Mutations affecting the Density of Bacteriophage λ, 161
Kellett, E. A., and others: Dependence on Temperature of the Interlayer Spacing in Carbons of Different Graphitic Perfection, 1015
Kelliher, M. G., and Beadle, R.: Pulse-shortening in Electron Linear Accelerators, 1099
Kellogg, Dr. Donald A., and Glenner, Dr. George G.: Histochemical Localization of Human, Term Placental 17β-Œstradiol Dehydrogenase—Implications for the Transhydrogenase Reaction, 763
Kelsall, R. K.: Appointed to the newly created chair of sociological studies in the University of Sheffield, 463; work of, 463
Kemény, Dr. T., and others: Damage to Liver induced by DL-Methionine-Ethylester, 421
Kendall, Dr. John D.: Appointed director of European research laboratories to be established by the Minnesota Mining and Manufacturing Co., Ltd., 905
Kennedy, A. J. (Murphy, A. J., and): Combustion and Propulsion—High Mach Number Air-breathing Engines (Materials Problems raised by the Very High Temperatures of Hypersonic Air-breathing Engines), 21
Kent, P. E. (Falcon, N. L., and): Geological Results of Petroleum Exploration in Britain by the British Petroleum Company during the Years 1945-57, 1078
Kern, Dr. R. J.: Homogeneous Synthesis of Isotactic Polystyrene using n-Butyllithium Initiator, 410
Kerr, A. J.: Awarded a Nature Conservancy Diploma Course in Conservation and Ecology at University College, London, 742
Kersten, Dr. H., and others: Action of Nucleic Acids on the Inhibition of Growth by Actinomycin of *Neurospora crassa*, 60
Kersten, Dr. W., and others: Action of Nucleic Acids on the Inhibition of Growth by Actinomycin of *Neurospora crassa*, 60
Keto-Acids in Blood Serum and Urine of Cattle: Occurrence of, in comparison with Man, Horse, Sheep and Dig (Dr. C. J. G. van der Horst), 146
Ketones (Fluorinated): Cage Effect in the Liquid-Phase Photolysis of (R. Bowles, Dr. J. R. Majer and Prof. J. C. Robb), 314
Ketosteroids: Spotting, review by Prof. G. A. D. Haslewood, 183
Kettlewell, Dr. H. B. D. (Cook, L. M., and): Radioactive Labelling of Lepidopterous Larvae—a Method of Estimating Late Larval and Pupal Mortality in the Wild, 301
Keuper Series: Nomenclature of the (P. A. Garrett), 868; (Dr. C. J. Stubblefield), 869
Keynes, Dr. R. D.: Influence of Editors, 120
Kidney: Formation of a New Metabolite of Epinephrine and Norepinephrine in Liver and (Dr. M. Goldstein and Dr. S. B. Gertner), 147
Kidney (Mouse), undergoing Compensatory Hypertrophy: Radiosensitivity of (Lieut. V. J. Rosen, jun., and Dr. L. J. Cole), 612
Kidney Capsule: Development of Mouse Eggs beneath the (D. R. S. Kirby), 707
Kidney Slices from *Necturus*: Effect of Anti-Diuretic Hormone and Calcium on the Equivalent Pore Radius of (G. Whittembury, N. Sugino and Dr. A. K. Solomon), 699
Kidrich (Boris) Institute of Nuclear Sciences: Bulletin, Vol. 10, 831
Kikuchi, Dr. Masatake, and Yamaguchi, Akira: Polyphenol Oxidase Activity of *Nicotiana glutinosa* Leaves infected with Tobacco Mosaic Virus, 1048
Kikuchi, R., and others: Summative Action of Acetylcholine with Physiological Stimulus on the Generator Potential in the Lateral Eye of the Horseshoe Crab, 1118
Kilmister, Dr. C. W.: A Philosophy of Cosmology, review, 634
Kimber, R. W. L., and others: Mode of Formation of 3,4-Benzopyrene in Human Environment, 668
Kimmins, Dr. D. E.: A New Study of the British Odonata, review, 631
Kind, S. S.: Absorption-Elution Grouping of Dried Blood-stains on Fabrics, 789
Kinetics and Mechanism (Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives), (C. F. Blakely and Dr. A. Wassermann), 662
King, Prof. E. J.: Influence of Editors, 121
King's College, London: Appointment of Dr. P. G. Saffman as reader in mathematics, 117
  Retirement of Prof. W. Robson from the chair of biochemistry, 286
  Appointment of Dr. H. Harris to the chair of biochemistry, 286
  Appointment of A. J. Fuller as reader in physiology, 466
King-Hele, D. G.: Satellites and Scientific Research, review by Sir Harold Spencer Jones, 268
  Evaluation of the Second, Fourth and Sixth Harmonics in the Earth's Gravitational Potential, 490
  Proposals for Space Flight, review, 811
Kingston Technical College: Postgraduate Course on Recent Advances in Steroid Chemistry, 905
Kirby, D. R. S.: Development of Mouse Eggs beneath the Kidney Capsule, 707
Kirschenbaum, Prof. Donald M. (Parker, Prof. Frank S., and): Infra-Red Spectra of Amino-acids and related Substances in Water, 386
Kishi, Nobusuke: Presentation to the Science Museum Library, London, of a collection of Japanese Scientific and Technical Books and Dictionaries, 201
Kistiakowsky, Prof. G. B.: Elected to foreign membership of the Royal Society, 112; work of, 112
Kitchener, Dr. J. A. (Bamford, Dr. C. H., and): Colloid and Polymer Science (Calculation of Free-radical Reactivity and Stability of Colloidal Model Suspensions), 378
Kitten: Hind-Limb Reflexes in the—Velocity of Conduction and Spinal Transmission of Proprioceptive Hind-Limb Reflexes (Dr. Sten Skoglund), 132; Properties of the Two-Neuron Arc (Dr. Sten Skoglund), 134
Klein, O.: At the Tenth General Physics Conference of the Swedish National Committee for Physics (Systematics of Elementary Particles), 557
Klement, jun., W., and others: Non-crystalline Structure in Solidified Gold–Silicon Alloys, 869
Klinkenberg, A., and Sjenitzer, F.: 'Eddy' Diffusion in Chromatography, 1023
Klug, A., and others: Cytoplasmic Particles and their Role in Protein Synthesis (Pattern of Ribosomal Ribonucleic Acid in X-Ray Diffraction Photographs compared to that given by Extracted Ribonucleic Acid), 644
Klug, Harold P., and Brasted, Prof. Robert C.: The Elements and Compounds of Group IVA (Comprehensive Inorganic Chemistry, edited by Prof. M. Cannon Sneed and Prof. Robert C. Brasted, Vol. 7), review by Dr. K. W. Bagnall, 185
Klyne, Prof. W.: Appointed to the chair of chemistry in Westfield College, London, 361; work of, 361
Knecht, R. W.: Possibility of Detecting Ionospheric Drifts from the Occurrence of Spread *F* Echoes at Low Latitudes, 927
Knight, Dr. R. L., and Keep, Elizabeth: Abstract Bibliography of Fruit Breeding and Genetics to 1955—*Rubus* and *Ribes*, a Survey, review by Dr. G. Haskell, 184
Knipling, Dr. E. F., and others: DDT—the Insecticide DDT and its Significance (edited by Paul Muller), Vol. 2, Human and Veterinary Medicine (edited by Dr. S. W. Simmons), review by Prof. D. S. Bertram, 271
Knowledge: The Diffusion of (Dr. Michael Grant), 371
Knowledge of Materials, Association for the Advancement of the, and others: International Congress on the Technology of Plastics Processing, 559

Known Age : Marked Humpback Whale of (Dr. R. G. Chittleborough), 164
Knox, Alice W., and others : Use of Ferritin-conjugated Antibody to Localize Antigen by Electron Microscopy, 1094
Knox, Prof. G. A. : The Polychaete Family Longosomidae in New Zealand, 1131
Knox, Prof. R. : Antibiotic Therapy and Staphylococcal Diseases, *review*, 637
Kobayashi, Dr. Masatoshi : Function of the Corpus Allatum in 'Dauer-pupa' of the Silkworm, *Bombyx mori*, 346
Koch, L., and others : Electronic Equipment used in the Nuclear Energy Industry in France, 1076
Koda, Prof. Shigeyasu (Nakajima, Koichi, and) : Borrmann Effect observed in an Aluminium Single Crystal, 53
Kohiyama, Masamichi, and Ikeda, Yonosuke : Appearance of New Deficient Characters in Streptomycin-resistant Mutants of *Bacillus subtilis*, 168
Koketsu, Prof. K., and Noda, K. : Restoration of Membrane Excitability of Calcium-deficient Muscles by Anodal Polarization, 243
Kollar, F., and others : Precision Intercomparisons of Lead Isotope Ratios—Broken Hill and Mount Isa, 754
Kondratieva, E. N., and others : A New Species of Green Sulphur Bacteria, 167
Koningsberger, S. : Cytoplasmic Particles and their Role in Protein Synthesis (Part which S-Ribonucleic Acid might play in Protein Synthesis), 644
Konrad, Dr. Erich : Awarded the Colwyn Medal of the Institution of the Rubber Industry, 464 ; work of, 464
Kopecky, M., and others : Measurement of Magnetic Fields in Chromospheric Flares, 224
Kopelman, Arthur, and others : Effect of Lysergic Acid Diethylamide on Larval Growth, 153
Kopfermann, Prof. Hans : Elected a member of the Physics section of the Leopoldina Academy of Natural Sciences, 1079
Kornberg, Dr. Hans L. : Appointed to the newly established chair of biochemistry at the University of Leicester, 743, 1075 ; work of, 1075
Korner, Dr. A. : Cytoplasmic Particles and their Role in Protein Synthesis (Use of Ribosomes to study the Mechanism of Incorporation of Amino-Acids into Proteins), 644
Korsakov Journal of Neuropathology and Psychiatry : English translation of, 649
Koscielak, J., and Zakrzewski, K. : Substance from Erythrocytes of Blood Group A, 516
Kragh, A. M. : At the Nineteenth Meeting of the Research Panel of the British Gelatine and Glue Research Association (The Flocculation of Suspensions with Gelatine), 998
Kramish, Arnold : Atomic Energy in the Soviet Union, *review* by Dr. S. C. Curran, 630
Krech, David, and others : Strain Differences in Acetylcholine Concentration in the Brain of the Rat, 787
Krickeberg, K. : A Study of Non-Linear Problems, *review*, 727
Krijgsman, Prof. B. J., and Brown, A. C. : 'Water Rigour' as an Aid for Operating on Marine Gastropods, 69
Krishnamurthi, G., and others : Potassium Tolerance Tests in South Indian People, 328
Krishnan, Sir K. S. : Effect of Specular Reflexions on the Radiation Flux from a Heated Tube, 135
Kroger, Dr. F. A., and others (edited by) : Progress in Semiconductors, Vol. 4, *review* by Dr. J. R. Tillman, 185
Kroh, J., and others : Effects of Linear Energy Transfer on the Radiolysis of Water and Heavy Water, 475
Krohn, Prof. P. L. : Endocrinology of Reproduction, *review*, 5
Kroll, Dr. W. J. : The Fusion Electrolysis of Titanium (Castner Memorial Lecture of the Society of Chemical Industry), 994
Kruta, Dr. V. and Braveny, Dr. P. : Potentiation of Contractility in the Heart Muscle of the Rat and some other Mammals, 327
Krynov, E. L. : The Tunguska Meteorite, 1078
Kubie, Dr. G., and Spurny, Dr. K. : Radioactive Labelling of Membrane Filters for the Assay of Air-borne Material, 930
Kuffler, Prof. Stephen W. (Dudel, Dr. Josef, and): Excitation at the Crayfish Neuromuscular Junction with Decreased Membrane Conductance, 246
  A Second Mechanism of Inhibition at the Crayfish Neuromuscular Junction, 247
Kuhn, Dr. H. G. : *Obituary* of Prof F. A. Jenkins, 990
Kulkarni, B. D., and others : Microbiological Transformation of Terpenes—Hydroxylation of α-Pinene, 689
Kulkarni, S. B., and others : New Compounds for the Control of Water Evaporation, 870
Kuroda, Prof. P. K. : Nuclear Fission in the Early History of the Earth, 36
Kushner, Daniel S., and others : Immunological Relationships between the Rat Glomerulus and Nephritogenic Streptococci, 1095
Kutáček, Dr. M., and others : Biogenesis of Ascorbigen, 3-Indolylacetonitrile and Indole-3-carboxylic Acid from DL-Tryptophan-3-^{14}C in *Brassica oleracea* L., 61
Kuwano, Akihiko, and others : High-Energy Bound Phosphate and Diabetes Mellitus, 702

LABELLING (Radioactive), of Lepidopterous Larvae—a Method of Estimating Late Larval and Pupal Mortality in the Wild (L. M. Cook and Dr. H. B. D. Kettlewell), 301
Labelling (Radioactive), of Membrane Filters for the Assay of Air-borne Material (Dr. G. Kubie and Dr. K. Spurny), 930
Labilization of Deoxyribonucleic Acid in Thymus Nucleoprotein after Whole-body Irradiation (Dr. Ulrich Hagen), 1123
Laboratories (Graduate Research) : Grants for (United States National Science Foundation), 559
Laboratory Practice : The Anti-Globulin (Coombs) Test in (Dr. I. Dunsford and Jean Grant), *review* by Dr. R. Drummond, 357
Laboratory Synthesis : Aluminium Interlayers in Clay Minerals, Montmorillonite and Vermiculite— (B. L. Sawhney), 261
Laboratory-Teaching of Languages (Arthur D. Little, Inc., Industrial Bulletin No. 373), 568
Laboratory Testing in Soil Engineering (T. N. W. Akroyd), *review* by Dr. H. L. Penman, 891
Lack, Dr. David : The Conflict between Evolutionary Theory and Christian Belief, 98
Lack of Haematopoietic Potency of Liver of Mice fed on a Meat Diet (Judith Ilan and Prof. K. Guggenheim), 698
Lactate-buffered Glycerol Medium : Syntheses of Glucose, Cellobiose and other Saccharides by *Acetobacter acetigenum* in a (Dr. C. P. Jackson and K. Ramamurti), 942
Lactic Acid Bacteria : Two Types of Catalase-like Activity in (R. Whittenbury), 433, *erratum*, 466
Lactobacillus Bacteriophages : Host-Range of (Prof. J. N. Coetzee, H. C. de Klerk and T. G. Sacks), 348
δ-Lactone Compound : Isolation of a, from the Leaves of *Clitoria marina* Linn. (Dr. A. Sinha), 149
Lahiri, A., and others : Initial Stages of Oxidation of Coal, 502
Laing, Dr. R. D. : The Divided Self—a Study of Sanity and Madness, *review* by Dr. Clifford Allen, 1062
Lajtha, Dr. L. G., and others : Analysis of Metabolic Rates at the Cellular Level, 919
Lake Victoria : Breeding Sites of Non-Cichlid Fishes in (Dr. Philip S. Corbet), 616
Laki, K., and others : Some Aspects of the Fibrinogen–Fibrin Transition, 758
Lalor Foundation : Grants and Awards for 1961, 1078
Lamb, H. H. : Weather Records of the World, *review*, 727
Lamb, Warren : Selection of Executives, 31
Lambert, Dr. J. M., and others : The Making of the Broads, *review* by Miles Burkitt, 636
Laminated Structure of Bones from some Marine Mammals (Dr. R. M. Laws), 338
Lampreys (Parasitic and Non-Parasitic) : Development of the Gonads in (M. W. Hardisty), 341
Lancashire, R. B. (Lezberg, E. A., and) : Combustion and Propulsion—High Mach Number Air-breathing Engines (Nozzle Investigations using Hydrogen Air Mixtures), 20
Lancaster Royal Grammar School Natural History Society : *The New Biologian*, No. 9, 649
Land, F. W. : Recruits to Teaching—a Study of the Attainments, Qualifications and Attitudes of Students entering Training Colleges, 750
Land of the Marsupials, *review* by Prof. A. J. Marshall, 543
Land (Agricultural) : The Deposition of Strontium-89 and Strontium-90 on, and their Entry into Milk after the Reactor Accident at Windscale in October 1957 (United Kingdom Atomic Energy Authority and the Agricultural Research Council Joint Report on), 1077
Land Use and the Cyprus Problem, *review* by Prof. M. J. Wise, 628
Land Use (Rural) Pattern in Cyprus : The Evolution of the (Dr Demetrious Christodoulou), *review* by Prof. M. J. Wise, 628
Land Use Survey (World) : Regional Monograph No. 2, The Evolution of the Rural Land Use Pattern in Cyprus (Dr. Demetrious Christodoulou), *review* by Prof M. J. Wise, 628
Landau, Academician L. D. : Elected to foreign membership of the Royal Society, 113 ; work of, 113
  Elected a foreign associate of the United States National Academy of Sciences, 198
Landovitz, L. F., and Marshall, L. : Gravitational Red Shift of Hydrogen 21-cm. Radiation as a Method to measure Galactic Gravitational Potential, 223
Landsberg, H. E., and van Mieghem, Prof. J. (edited by) : Advances in Geophysics, Vols. 4 and 5, *review* by Dr. S. H. Hall, 1060
Lane-Petter, Dr. W. : Animal Experiments in Research, *review*, 977
Langbein, Dr. W. B. : Problems of the Arid Zones (Surface Hydrology, including Sedimentation), 295
Langer, G. (Pearson, R., and) : Generation of Aerosols by Vapour-Phase Polymerization of Methyl Acrylate, 235
Langer, Prof. Rudolph E. (edited by) : Boundary Problems in Differential Equations—Proceedings of a Symposium conducted by the Mathematics Research Center of the United States Army at the University of Wisconsin, 1959, *review* by Prof. E. T. Copson, 451
Langley Medal of the Smithsonian Institution awarded posthumously to Dr. Robert H. Goddard, 201
Languages : Laboratory-Teaching of (Arthur D. Little, Inc., Industrial Bulletin No. 373), 568
Lanthanides : Use of Azo Dyestuffs for the Polarographic Determination of the (T. M. Florence and L. E. Smythe), 771
Lapage, Dr. G. : Parasitic Helminths, *review*, 815
  Achievement—some Contributions of Animal Experiment to the Conquest of Disease, *review* by Dr. W. Lane-Petter, 977
Large Doses (Excessively), of Oral Griseofulvin : Tumour-promoting Effect of, on Tumours induced in Mice by Methylcholanthrene (Louis L. Barich, Takeshi Nakai, Jan Schwarz and Donna Jean Barich), 335
Laron, Dr Z., and Halberstadt, B. Epstein : Total and *l* (+) Tartaric Acid Inhibited Rat Serum Acid Phosphatase, 67
Larvae of some Euryhaline Diptera : Osmotic Regulation in the (D. W. Sutcliffe), 331
Larvae (Black-Fly) : Bacteria as a Source of Food for (F. J. H. Fredeen), 963
Larvae (Lepidopterous) : Radioactive Labelling of—a Method of Estimating Late Larval and Pupal Mortality in the Wild (L. M. Cook and Dr. H. B. D. Kettlewell), 301
Larval Growth : Effect of Lysergic Acid Diethylamide on (Dr. D. V. Siva Sankar, Arthur Kopelman, Peter Schulder and Eleanor Gold), 153
Larval (Late) and Pupal Mortality in the Wild : Radioactive Labelling of Lepidopterous Larvae—a Method of estimating (L. M. Cook and Dr. H. B. D. Kettlewell), 301
Laser, Dr. H., and Slater, Prof. E. C. : Effect of Heavy Water on Respiratory-chain Enzymes, 1115
Laszt, Prof. L. : Effect of the Cations of the Lyotropic Series on the Tension of Vascular Muscle, 329
Laszt, Prof L. (Hardung, V., and) : Viscoelastic Behaviour of Blood Vessels of the Muscular Type, 330
Late Larval and Pupal Mortality in the Wild : Radioactive Labelling of Lepidopterous Larvae—a Method of estimating (L. M. Cook and Dr. H. B. D. Kettlewell), 301
Latent Heat of Vaporization : A Relation between Ultra-sonic Velocity and (Prof. B. Ramachandra Rao and P. R. K. L. Padmini), 311
Lateral Eye of the Horseshoe Crab : Summative Action of Acetylcholine with Physiological Stimulus on the Generator Potential in the (R. Kikuchi, K. Naito and S. Minagawa), 1118
Lateral Ventricle of the Rat : Hunger Reduction produced by Injecting Glucose into the (L. J. Herberg), 245

Lathyrus odoratus · Flavonoid Pigments of (J B Harborne), 240
Latin America : Scientific Institutions and Scientists in (Unesco Centre for Scientific Co-operation in Latin America), Vol 4, Argentine, 29
Latin American Council of Cosmic Radiation Meeting in Rio de Janeiro, 648
Latitude . Dependence on, of the Amplitude of the Diurnal Variation of Cosmic Rays (Arne Eld Sandstrom, Eric Dyring and Stig Lindgren), 1099
Latitudes (Low) . Possibility of Detecting Ionospheric Drifts from the Occurrence of Spread F Echoes at (R. W. Knecht), 927
Latitudinal Variation of Frost-point Temperature and Wind : Airborne Measurements of (N C. Helliwell), 993
Lauder, Prof. I. · Given an Award under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme, 291
Lauder, I. M. : Tuberculosis in Animals (Tuberculosis in Dogs and Cats), 997
Lauffer, Max A , and others . Evidence for Internal Organization of Nucleic Acid in T_2 Bacteriophage, 781
Lauria, F., and others · Antileukaemic Activity of Glycyrrhetinic Acid, 607
Lawford, D. J. An Abnormal Serum Protein in Experimental Poisoning by Cadmium and other Metals, 946
Lawrence, Dr J C , and others . Phosphate Esters produced by Mammalian Skin from 2-Deoxy-D-Glucose, 1028
Laws, Dr R. M · Laminated Structure of Bones from some Marine Mammals, 338
Laws of Nature Symmetrical ? · Are the (Prof. O. R Frisch), 638
Layer Structures : Dislocations in (V. A. Phillips and P Cannon), 313
Laying Hen : Oxytocin in the Neurohypophysis of the (Katuhide Tanaka and Prof Seiichi Nakajo), 245
LeBlanc, jun., O. H (Devins, J. C , and) : Ionization and Attachment Coefficients in *n*-Alkyl Chloride Gases, 409
Le Fèvre, Prof. R J. W. : New Chemical Laboratories in the University of Sydney, 833
  The Chemistry of Natural Products, 1080
Lea, Dr. C. H. Physico-chemical, Biological and Applied Aspects of Autoxidation (Autoxidation in relation to Food), 747
Leach, E. H : Expression of Concentrations of Solutions, 350
Lead-210 and Polonium-210 in Grass (C. R Hill), 211
Lead Isotope Ratios · Precision Intercomparisons of—Broken Hill and Mount Isa (F Kollar, Prof R D Russell and T. J. Ulrych), 754
Lead Silicate Glass : Gamma Irradiation of (R S. Barker, D. A Richardson, E A. G McConkey and R. Rimmer), 135
Leads (Anomalous), from a Selected Geological Environment in West-Central New Mexico (William F Slawson and Carl F. Austin), 400
Leaf Sheath and Blade Relative Lengths of, with reference to the Developmental Stages of the Rice Plant (Dr. B. Saha), 259
Leake, B E. : Physics and Chemistry of the Earth, *review*, 544
Lean, J. B., and others Formation of Fayalite in Roast Reduced Jaspilite, 683
Learmonth, Dr E. M. · Physico-chemical, Biological and Applied Aspects of Autoxidation (Effects of Tocopherols in Autoxidizing Systems), 747
Leask, M. J. M Awarded a Senior Studentship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Leather : The Chemistry and Technology of (edited by Fred O'Flaherty, William T. Roddy and Robert M. Lollar), Vol. 2, Types of Tannages, *review* by Prof A G. Ward, 724
Leather Manufacturers' Research Association (British) Special Assistance for Effluent Liaison, 992
Leather Science : The Present Position of, *review* by Prof. A. G. Ward, 724
Leather Trades Chemists, Society of : Ninth Procter Memorial Lecture (Prof. W. T. Astbury), 905
Leaves of *Clitoria marina* Linn. : Isolation of a δ-Lactone Compound from the (Dr. A. Sinha), 149
Leaves (*Bryophyllum*) . Effects of Light and Darkness on the Rhythm of Output of Carbon Dioxide of Excised (Dr. Malcolm B. Wilkins), 523
Leaves (*Nicotiana glutinosa*), infected with Tobacco Mosaic Virus : Polyphenol Oxidase Activity of (Dr. Masatake Kikuchi and Akira Yamaguchi), 1048
Lederer, Prof. E : The Chemistry of Natural Products (Chemistry and Biochemistry of Biologically Active Bacterial Lipids), 1080
Lee, Chang-Ling, and others : Electrophoretic Separation of certain *in vitro* and *in vivo* Reactions of Rabbit Anti-Mouse Erythrocyte Serum, 157
Lee, Dr. D. H. K. · Problems of the Arid Zones (Human and Animal Physiology and Ecology, including Human and Animal Population Problems), 295
Lee, Frank A., and others : Determination of Fatty Acids of Lower Molecular Weight by Gas Chromatography, 689
Lee, Dr. S. G McK. : Appointed to the new chair of psychology in the University of Leicester, 743, 901 ; work of, 901
Lefebvre, R., and others : Quantum Chemistry—Methods and Applications, *review* by Prof. H. C. Longuet-Higgins, 541
Legallais, Frances Y , and others · Production of Tumours in *Rattus* (*Mastomys*) *natalensis* by Polyoma Virus, 423
Legrand, J.-P , and Helary, A. · Local Increase of Intensity of Cosmic Radiation, 397
Legume Seed Coats · Inhibition of Nodule Bacteria by an Antibiotic from (J. A. Thompson), 619
Legumes : Nutrition of the—Proceedings of the University of Nottingham Fifth Easter School in Agricultural Science, 1958 (edited by Prof. E. G Hallsworth), *review* by Prof. Walter Stiles, 815
Lehmann, Dr. H. (Kekwick, Dr. R A , and) : Sedimentation Characteristics of the γ-Chain Haemoglobin (Haemoglobin 'Bart's'), 158
Lehmann, Dr. H., and others : Sickling Phenomenon in Deer, 333
Lein, Dr. J., and others : Bacterial Penicillin Amidase, 237
Leishmania donovani Infections · Treatment of, with Surface-active Agents (Dr. J. D. Fulton), 1129
Lelliot, R. A. (Hollings, M., and) : Freeze-drying of Plant Viruses, 1078
Leloir, Prof L. F. : Elected a foreign associate of the United States National Academy of Sciences, 198
Leloir, Prof. L. F , and others : Mechanism of Starch Biosynthesis, 918
Lemée, Prof. G., and Emberger, Prof. L. : Problems of the Arid Zones (Plant Ecology), 295
Lengerová, Alena : Polyvalent Immunological Tolerance in Homologous Radiation Chimaeras, 160
Length and Time : Mass, *review* by G. R. Noakes, 183
  An Introduction to the Physics of Mass, (Prof. Norman Feather), *review* by G. R. Noakes, 183
Lengths (Relative), of Leaf Sheath and Blade with reference to the Developmental Stages of the Rice Plant (Dr B. Saha), 259
Lenhoff, Dr Howard M , and Bovaird, John : Enzymatic Activation of a Hormone-like Response in *Hydra* by Proteases, 671
Lens Epithelium Comparison between the Effects of Cysteine and of Anoxia on the Rate of Mitosis in (Dr. Antoinette Pirie and Dr. Ruth van Heyningen), 947
Leo III, a New All-Transistor Digital Computer (Leo Computers, Ltd.), 373
Leo Computers, Ltd. . *Leo III*, a New All-Transistor Digital Computer, 373
Leopold, Dr. L. . Problems of the Arid Zones (Alternative Uses of Limited Water Supplies—United States-Water and the Arid Zone), 296
Leopoldina Academy of Natural Sciences : Election of Prof Adolf Butenandt as an honorary member, 117
  Election of new members, 1079
Lepidopteran : Occurrence and Function of the Provisional Embryonic Cuticle of a (Dr. R. K. Sharan), 1040
Lepidopterous Larvae : Radioactive Labelling of—a Method of Estimating Late Larval and Pupal Mortality in the Wild (L M Cook and Dr H. B. D. Kettlewell), 301
Lesions (Medial Temporal) Effects of, on Taste Preference in the Monkey (Dr. L. Weiskrantz), 879
Lesslie, I W : Tuberculosis in Animals (The Tuberculin Test and the Laboratory Diagnosis of Tuberculosis), 996
Leszynsky, Dr. Hannah E., and others : Reversibility of an Inherited Metabolic Block (Inborn Error of Metabolism), 515
Lett, J. T. (Alexander, Peter, and) : Role of Oxygen in the Cross-linking and Degradation of Deoxyribonucleic Acid by Ionizing Radiations, 933
Lettré, H : Intracellular Localization of Enzymes (Film on Pinocytosis in Tissue Cultures), 836
Leucocyte-attracting Effect (Eosinophil), of Histamine in Skin (Dr R. K. Archer), 155
Leucocytes of Blood of Normal and Leukaemic Subjects . Zinc Content of Erythrocytes and (E. Dennes, R. Tupper and Prof. A. Wormall), 302
Leukaemia (Murine) : Bone Marrow Depression in (James T Duhig), 71
Leukaemia Cells (Acute) . Proliferative Capacity of (Dr. Felice Gavosto, Giovanni Maraini and Alessandro Pileri), 611
Leukaemia Cells (L1210 Mouse) : Effect of 6-Mercaptopurine on the Net *in vitro* Gas Production of Sensitive and Resistant (Dr. H. J. Woodliff), 156
Leukaemic Subjects (Normal and) : Zinc Content of Erythrocytes and Leucocytes of Blood of (E. Dennes, R. Tupper and Prof A. Wormall), 302
Leukaemogenic Agent · Recovery of, from Non-Leukaemic Tissues of Thymectomized Mice (J F A. P Miller), 703
Level (Cellular) : Analysis of Metabolic Rates at the (Dr. L. G. Lajtha. R. Oliver, R. J. Berry and Elizabeth Hell), 919
Levels of Blood Uric Acid in Five Species of Birds : Variability of (Jack W. Hudson and Charles R. Taylor), 788
Levels of Catecholamine in Brain : A Suggested Effect on, produced by Small Doses of Reserpine (F Barbara Orlans and Dr. Bernard B. Brodie), 1034 , (Herbert Sheppard and Joseph H Zimmerman), 1035
Levels of Pyridine Nucleotides in Liver Poisoning (Dr. C. H. Gallagher and Dr. K. R. Rees), 148
Lévêque, Pierre Appointed director of the International Information Centre for Food Irradiation, 741
Lever (Optical) : Some Developments of the (Prof. R. V Jones), 905
Leverhulme Trust Fund : Grant of £3,800 to Queen Elizabeth College, London, to enable a sociological research programme to be started in the Department of Nutrition, 201
Levine, Dr Bernard B . Degradation of Benzylpenicillin at *p*H 7·5 to D-Benzylpenicilloic Acid, 939
  Formation of D-Penicillamine-Cysteine Mixed Disulphide by Reaction of D-Benzylpenicilloic Acid with Cystine, 940
Levitt, Dr. J. . Freezing and Drying of Biological Materials, 749
Levvy, Dr. G. A. · The β-D-Fucosidase Activity of Mammalian Tissues and its relation to other Glycosidases, 1027
Lewis, Dr D. J., and others : Attachment of Immature Simuliidae to other Arthropods, 618
Lewis, Peter R. · The Literature of the Social Sciences, *review*, 729
Lewis, W V. : Given an Award under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme, 291
Lezberg, E. A., and Lancashire, R. B Combustion and Propulsion—High Mach Number Air-breathing Engines (Nozzle Investigations using Hydrogen Air Mixtures), 20
Liacopoulos, P., and others : Influence of the Ionic Strength of the Medium on the Anaphylactic Sensitization of Isolated Tissues *in vitro*, 697
Liacopoulos-Briot, M , and others Influence of the Ionic Strength of the Medium on the Anaphylactic Sensitization of Isolated Tissues *in vitro*, 697
Liaison (Effluent) · Special Assistance for (British Leather Manufacturers' Research Association), 992
Libraries in the United Kingdom with access to 'Telex' : Directory of (Library Association), 558
Library (National), Calcutta (compiled by) : Bibliography of Indian Scientific and Technical Publications (Council of Scientific and Industrial Research, New Delhi), 199
Library (National Central) : Book-buying Policy of the (S P L Filon), 992
Library (National Lending), for Science and Technology, 992
Library Association · Annual Report for 1959, 27
  Special Subject List No. 32, The English Newspaper since 1900 (F. Atkinson), 116
Library Association (Reference, Special and Information Section) : Directory of Libraries in the United Kingdom with access to 'Telex', 558
Liebig (Justus) University of Giessen . Roentgen Prize awafded to J. B Adams, 201
Life (America's Wild-) : Chemical Control of Agricultural Pests and Conservation of (United States National Academy of Sciences—National Research Council Committee on), 114
Life (Animal) : South African—Results of the Lund University Expedition in 1950-1951, Vol. 6 (edited by Bertil Hanstrom, Per Brinck and Gustav Rudebeck), *review* by H. Oldroyd, 1063
Ligands in Dibenzene Chromium · Character of the (Dr. F. Jellinek), 871
Light (Ultra-Violet) : Potentiation of Hair-Growth by (B. E. Johnson), 159
  Recovery in the Presence of Chloramphenicol of *Escherichia coli* B (H) Irradiated with (Kenshi Suzuki and Yukiko Iwama), 347

Light (Ultra-violet and Visible) : Absorption of, by Ultra-thin Sections of Vitrinite from a High-volatile Bituminous Coal (Sabri Ergun, J. T. McCartney and R. E. Walline), 1014
Light and Darkness : Effects of, on the Rhythm of Output of Carbon Dioxide of Excised *Bryophyllum* Leaves (Dr. Malcolm B. Wilkins), 523
Light Curves of Meteors (Dr. R. Ananthakrishnan), 675
Lightning (Ball) : Electromagnetic Standing Waves and (Dr. Lewi Tonks), 1013
Litvak, Dr. M. (Mankiewicz, Dr. E., and) : Effect of *Candida albicans* on the Evolution of Experimental Tuberculosis, 250
Lilley, J. S. : Appointed to a research fellowship in physics in the University of Birmingham, 117
Lilly, Dr. Lorna J. : Genetics, Radiobiology and Radiology Proceedings, *review*, 97
Limb (Hind-) Reflexes : Velocity of Conduction and Spinal Transmission of Proprioceptive (Hind-Limb Reflexes in the Kitten), (Dr. Sten Skoglund), 132
Limb (Hind-) Reflexes in the Kitten—Velocity of Conduction and Spinal Transmission of Proprioceptive Hind-Limb Reflexes (Dr. Sten Skoglund), 132 ; Properties of the Two-Neuron Arc (Dr. Sten Skoglund), 134
Limestone in South Wales : Relic-Soil on (D. F. Ball), 497
Limfjord : Conditioning *Ostrea edulis* L. from the, for Reproduction out of Season (I. A. Aboul-Ela), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, No. 25), *review* by Dr. A. J. Southward, 360
Limit (A New), to the Galactic Magnetic Field set by Measurements of the Zeeman Splitting of the Hydrogen Line (Dr. R. D. Davies, C. H. Slater, W. L. H. Shuter and P. A. T. Wild), 1088
Limited Amount of Streptomycin : Absence of Carbon Monoxide-sensitive Respiration in a Streptomycin-dependent Mutant of *Escherichia coli* grown in (Hanna Engelberg and Dr. M. Artman), 801
Linamarin and Lotaustralin in White Clover : Biosynthesis of (G. W. Butler and Beris G. Butler), 780
Lindahl, Prof. P. E., and Öberg, K. E. : Mechanism of the Physiological Action of Rotenone, 784
Lindenbaum, Dr. A., and Schubert, Dr. J. : Sustained Action of Injected Chelating Agents, 575
Lindgren, Stig, and others : Dependence on Latitude of the Amplitude of the Diurnal Variation of Cosmic Rays, 1099
Linear Accelerators (Electron) : Pulse-shortening in (M. G. Kelliher and R. Beadle), 1099
Linear Circuit Theory : General and, *review* by Prof. A. H. M. Arnold, 811
Linear Energy Transfer : Effects of, on the Radiolysis of Water and Heavy Water (Dr. E. Collinson, Prof. F. S. Dainton and J. Kroh), 475
Linhard, J., and others : Haptoglobin Types in 398 Blood Donors from Dakar (Senegal), 517
Linnett, Prof. J. W. : Valence-Bond Structures—a New Proposal, 859
Linnett, Prof. J. W., and others : Recombination of Oxygen Atoms in the Gas Phase, 686
Lipaemic Clearing Action of Artificial Anticoagulants (Dr. E. P. George, Dr. G. V. Hall and Dr. G. S. Furkas), 782
Lipid Bodies (so-called Golgi Bodies) from Mitochondria : Cytochemical Evidence of the Origin of (H. C. Chopra), 713
Lipid Research at the Rowett Institute, 1951-59 (Dr. G. A. Garton), 115
Lipids : Role of Mucoid Substances of the Aorta in the Deposition of (Dr. S. Gero, Dr. J. Gergely, Dr. T. Dévényi, Dr. L. Jakab, Dr. J. Székely and Dr. S. Virág), 152
Lipids of Pasture Grasses : Fatty Acid Composition of the (Dr. G. A. Garton), 511
Lipids (Testis), in the Common Frog, *Rana temporaria* : Cyclical Changes in the Distribution of the (Dr. B. Lofts and C. Boswell), 708
Liquid Systems : Equations for Determining Diffusion Coefficients in, by the Diaphragm-Cell Technique (F. A. L. Dullien and Prof. L. W. Shemilt), 767
Liquid (Gas) Chromatography of Conjugated Fatty Acids (Dr. N. W. R. Daniels and J. Wendy Richmond), 55
Liquid (Gas-) Chromatography Analysis of C_2–C_4 Hydrocarbons : Two Highly Selective Solvents for (Dr. A. van der Wiel), 142
Liquid-Phase Photolysis of Fluorinated Ketones : Cage Effect in the (R. Bowles, Dr. J. R. Majer and Prof. J. C. Robb), 314
Liquids (Dielectric) : Photo-Injection of Charge into (M. J. Morant), 48
Lissamine Green : A Rapid Method for Studying Tumour Blood Supply using (L. N. Owen), 795
Lister Institute : Report for 1960, 649
Literature on Dielectrics : Digest of, Vol. 22, 1958 (edited by R. A. Sodermann and L. F. Frisco), (United States National Academy of Sciences—National Research Council, Publication No. 713), *review* by S. Weintroub, 728
Literature of the Social Sciences (Peter R. Lewis), *review*, 729
Lithgow, R. I. : The National Engineering Laboratory, 1960—Open Days, 899
Lithium and Sodium Molecules : Excited Electronic States of (Dr. R. F. Barrow, N. Travis and C. V. Wright), 141
Lithium Bromide (Urea–) Solutions : Viscosity of Concentrated (Dr. Irving I. Geschwind), 324
Lithium Montmorillonite : Effect of Surface Density of Charge on the Physical Swelling of (Dr. J. P. Quirk and B. K. G. Theng), 567
Litter-mate Cats : Proportion of Noradrenaline to Adrenaline in the Adrenal Glands of (Dr. K. R. Butterworth and Dr. Monica Mann), 785
Little, Inc., Arthur D. : Industrial Bulletin No. 373, Laboratory-Teaching of Languages, 568
  Basic Research in the Navy (United States Department of Defense, Department of the Navy, Naval Research Advisory Committee), 178
Little (Arthur D.) Research Institute : Annual Report for 1959, 124
Liver : Damage to, induced by DL-Methionine-Ethylester (L. Fehér, F. V. Selmeczi, K. Szalay and Dr. T. Kemény), 421
Liver of Mice fed on a Meat Diet : Lack of Haematopoietic Potency of (Judith Ilan and Prof. K. Guggenheim), 698
Liver (Foetal) : Pattern of Haemopoiesis in the (D. Brynmor Thomas, P. M. Russell and Prof. J. M. Yoffey), 876
Liver Glycogen and the Blood Glucose in the Rat adapted to a Fat Diet : An Inverse Relation between the (Dr. P. A. Mayes), 325
Liver Injury due to Murine Hepatitis Virus : Protection against (Dr. J. D. Judah, G. Bjotvedt and T. Vainio), 507
Liver Microsome (Rat) : Distribution of Protein-bound Aminoazo Dyes in the (Dr. T. Yamada, M. Matsumoto, S. Kanda and Prof. H. Terayama), 943
Liver Mitochondria (Rat) : A High-Energy Phosphate Requirement for Succinate Oxidation in Uncoupled (Dr. Giovanni Felice Azzone and Dr. Lars Ernster), 65
Liver Poisoning : Levels of Pyridine Nucleotides in (Dr. C. H. Gallagher and Dr. K. R. Rees), 148
Liver and Kidney : Formation of a New Metabolite of Epinephrine and Norepinephrine in (Dr. M. Goldstein and Dr. S. B. Gertner), 147
Liverwort *Sphaerocarpos* : Maternal Inheritance and Interspecific Hybrids of the (Dr. William T. Doyle), 429
Living Bull Spermatozoa : Effect of Acridine Orange on (C. van Duijn, jun.), 1006
Living Material : The Effects of Pollution on (edited by W. B. Yapp), *review* by Dr. G. C. Ware, 1061
Living Systems : Self-Regulation in (Ottawa Symposia on), 3, Tremor, 297
Lloyd, D. C. : Significance of the Type of Host Plant Crop in Successful Biological Control of Insect Pests, 430
Lloyd, G. D., and others : Radioactive and Natural Strontium in Human Bone (Atomic Energy Research Establishment, *R*23246), 994
Local Aurorae : Atmospherics on 20 kc./s. at the Time of (Father E. Gherzi), 225
Local Cytotoxic Change in Man from Griseofulvin : Absence of (Prof. Leon Goldman, Amanda Beyer and Jan Schwarz), 335
Local Health Service (United Nations, World Health Organization, Report Series No. 194), 465
Local Increase of Intensity of Cosmic Radiation (J.-P. Legrand and A. Helary), 397
Localization by Autoradiography at -195° C. of Radioactive Areas in Rats exposed to a High Flux of Thermal Neutrons—Importance of Phosphorus-32 in Consecutive Internal Irradiation (Jean Chanteur and Pierre Pellerin), 472
Localization of a Halogenated Porphyrin in Mouse Tumours (K. I. Altman and Prof. K. Salomon), 1124
Localization (Histochemical), of Human, Term Placental 17β-Œstradiol Dehydrogenases—Implications for the Transhydrogenase Reaction (Dr. Donald A. Kellogg and Dr. George G. Glenner), 763
Localization (Intracellular), of Enzymes (Centre Inter-Universitaire de Recherches Enzymologiques Colloquium on), 836
Localize Antigen by Electron Microscopy : Use of Ferritin-conjugated Antibody to (Richard A. Rifkind, Konrad C. Hsu, Councilman Morgan, Beatrice C. Seegal, Alice W. Knox and Harry M. Rose), 1094
Localized Ultra-violet Irradiation : Influence of, on the Incorporation of Adenine-8-^{14}C and DL-Methionine-^{35}S in *Acetabularia mediterranea* (Prof. J. Brachet and Dr. M. J. Olszewska), 954
Lock, J. A., and others : Translocation of Wild Animals as a Means of Game Control, 518
Lodge, Dr. G. A. : Experiments on the Nutrition of Sows, 115
Lofts, Dr. B., and Boswell, C. : Cyclical Changes in the Distribution of the Testis Lipids in the Common Frog, *Rana temporaria*, 708
Lofts, Dr. B., and others : Effects of Whole-body Irradiation on the Breeding Plumage of the Weaver Finch, *Quelea quelea*, 615
Logan, J. K., and others : The Helium-4 Scale of Temperature, 1077
Logemann, Dr. W., and others : Antileukaemic Activity of Glycyrrhetinic Acid, 607
Logic (Symbolic), and its Applications : Introduction to (Rudolf Carnap), translated by William H. Meyer and John Wilkinson, *review* by F. I. G. Rawlins, 729
Logic, Methodology and Philosophy of Science (International Union for History and Philosophy of Science International Congress for), 201
Lollar, Robert M., and others (edited by) : The Chemistry and Technology of Leather, Vol. 2, Types of Tannages, *review* by Prof. A. G. Ward, 724
London : Protection against Tidal Flooding in (N. B. Webber), 293
London Hospital Medical School : Appointment of Dr. I. Doniach to the chair of morbid anatomy, 466
London Research Foundation : Grant of £56,000 to Queen Elizabeth College, London, to further the research work of the Department of Nutrition with special reference to its work on fertility control, 201
London School of Hygiene and Tropical Medicine : Appointment of Prof. E. T. C. Spooner as dean, 466
Long Island Sound : Oceanography of (Gordon A. Riley, Eugene Harris, Henry M. Schurr, P. T. Wangersky, Sarah W. Richards and R. Wade Covill) ; Guide for Preparing Figures (Y. H. Olsen and James E. Morrow, Jr.), 123
Longfield, Cynthia, and others : Dragonflies, *review* by Dr. D. E. Kimmins, 631
Longitude Effect in Temperate Zone Sporadic *E* and the Earth's Magnetic Field (L. H. Heisler and Dr. J. D. Whitehead), 676
Longosomidae : The Polychaete Family, in New Zealand (Prof. G. A. Knox), 1131
Longuet-Higgins, Prof. H. C. : Quantum Chemistry, *review*, 541
Lorenzini : Electrical Sensitivity of the Ampullae of (Dr. R. W. Murray), 957
Lotaustralin in White Clover : Biosynthesis of Linamarin and (G. W. Butler and Beris G. Butler), 780
Lovell, Prof. A. C. B. : Grant of £2,500 for Space Research (for the tracking of satellites and space probes), 744
Lovelock, Dr. J. E. : An Ionization Detector for Permanent Gases, 49
Low, Kerstin, and Edvarson, K. : Content of Caesium-137 and (Zirconium + Niobium)-95 in Swedish Soils, 736
Low, William : Paramagnetic Resonance in Solids (Solid State Physics—Advances in Research and Applications, Supplement 2), *review* by Dr. R. O. Davies, 886
Low-Frequency (Very) Hiss observed at Byrd Station, Antarctica : Association between Aurorae and (Dr. L. H. Martin, Dr. R. A. Helliwell and K. R. Marks), 751
Low-Grade Mental Deficiency in a Large Swedish Rural Population : A Clinical and Genetico-Statistical Study of Schizophrenia and (Bertil Hallgren and Torsten Sjogren), 298
Low Latitudes : Possibility of Detecting Ionospheric Drifts from the Occurrence of Spread *F* Echoes at (R. W. Knecht), 927
Low-priced Books for Overseas, 741
Low Temperature : The Second Virial Coefficient of Methane at (G. Thomaes and R. Van Steenwinkel), 229
Low-Temperature Fuel Cell (Shell Research Centre), 994

Low Temperatures : Thermal Expansion at (Guy K. White), 927
Low Temperatures (Extremely) : Survival of Woody Plants at (Johnson Parker), 1133 ; (Dr. Akira Sakai), 1134
Lowell Technological Institute Research Foundation (Geophysics Research Directorate of the United States Air Force Cambridge Research Center, with the co-operation of) : Exploding Wires—Based on Conference on the Exploding Wire Phenomenon, 1959 (edited by William G. Chace and Howard K. Moore), *review* by Dr. B. A. Thrush, 726
Lowenstein, Dr. John M. : Synergism of Bivalent Metal Ions in Transphosphorylation, 570
Lower Atmosphere : Turbulent Transfer in the (Dr. C. H. B. Priestley), *review* by Prof. P. A. Sheppard, 974
Lower Molecular Weight : Determination of Fatty Acids of, by Gas Chromatography (Marie L. Vorbeck, Leonard R. Mattick, Frank A. Lee and Carl S. Pederson), 689
Lowther, R. L., and Boll, W. G. : Ethionine and Plant Growth Systems, 831
Lugli, A. M., and others : An Antibiotic Complex derived from a *Streptomyces* and Active against Gram-positive Bacteria, 1029
Luke, Sir Harry : Continuity in a Small Pacific Island, *review*, 816
Lumbricus terrestris (Annelid) : Biosynthesis of Squalene by the (Joyce M. Wootton and Lemuel D. Wright), 1027
Lund University Expedition in 1950-1951 : Results of the, Vol. 6, South African Animal Life (edited by Bertil Hanstrom, Per Brinck and Gustav Rudebeck), *review* by H. Oldroyd, 1063
Lung : Epidemiology of Cancer of the (United Nations, World Health Organization, Technical Report Series No. 192), 115
Lunt, Ramona B., and others : Transformation of Resistance to 8-Azaguanine in *Diplococcus pneumoniae*, 800
Lusena, Dr. C. V. : Freezing and Drying of Biological Materials, 749
Luyet, Prof. B. : Freezing and Drying of Biological Materials, 748
Lymph and Blood of Sheep infected experimentally with the Virus of Tick-borne Encephalitis : Virus and Antibodies in the (Doubravka Málková), 716
Lynam, F. C. : The Development of Pulp and Particle Board Industries and their Effect on Forest Management (The Development of the Chipboard Industry), 33
Lynen, F. : Intracellular Localization of Enzymes, 853
Lyon, Dr. A. J., and others : Equatorial Spread-*F* and *F*-Layer Heights, 1086
Lyophilization (Association des Cours Internationaux de Lyophilization second International Course on), 29
Lyotropic Series : Effect of the Cations of the, on the Tension of Vascular Muscle (Prof. L. Laszt), 329
Lysergic Acid Derivatives : Production of, by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture (F. Arcamone, C. Bonino, Prof. E. B. Chain, A. Ferretti, P. Pennella, A. Tonolo and Lidia Vero), 238
Lysergic Acid Diethylamide : Effect of, on Larval Growth (Dr. D. V. Siva Sankar, Arthur Kopelman, Peter Schilder and Eleanor Gold), 153
Lyttleton, Dr. J. W. : Stabilization by Manganous Ions of Ribosomes from Embryonic Plant Tissue, 1026

MAČAN, Dr. T. T. : North American Fresh-Water Biology, *review*, 6
McAuliffe, Dr. D. J. : Appointed lecturer in ophthalmology at the University of Edinburgh, 465
McBurney, Dr. C. B. M. : The Stone Age in Northern Africa, *review* by M. C. Burkitt, 1062
Maccabaean Prize and Medal for an essay on a subject connected with the History of Medicine or Pharmacy (Worshipful Society of Apothecaries of London), 650
Maccabaeans, Society of : Award of the Meldola Medal for 1961, 743
MacCabe, J. R. : *Obituary*, 23
McCarrison, Sir Robert : *Obituary* by Dr. H. M. Sinclair, 195
McCartney, J. T., and others : Absorption of Ultra-violet and Visible Light by Ultra-thin Sections of Vitrinite from a High-volatile Bituminous Coal, 1014
McConkey, E. A. G., and others : Gamma Irradiation of Lead Silicate Glass, 135.
McCrea, Prof. W. H. : Astrophysics of Non-Static Systems, *review*, 538
  Interpretation of Cosmology, 583
MacDermot, Violet : The Muscular Disease Myasthenia gravis, 28
Macdonald, A. M. G. : Colorimetric Analysis, *review*, 3
MacDonald, Dr. D. K. C. : Self-Regulation in Living Systems—Tremor, 297
McDonald, Dr. Ian W. : The Ian Clunies Ross Animal Research Laboratory, Prospect, New South Wales, 980
Macdonald, Dr. J. A. : Appointed professor of botany at the University of St. Andrews, 1075 ; work of, 1075
Macdonald, W. J. P., and others : Ocean Currents in McMurdo Sound, 867
MacDowall, J. : Distribution of Atmospheric Ozone—a Preliminary Analysis of some International Geophysical Year Observations, 382
McGee, Prof. J. D. : Grant of £1,000 from the Paul Instrument Fund (in supplement of a previous grant), for the construction of a television system for X-ray image intensification, 291
McGivering, I., and others : Management in Britain—a General Characterization, 537
McGrath, M. M. : Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Botany), 742
MacGregor, J. J. : Scope for Expanding Pulp and Board Industries in Britain, 32
Mach Number (High), Air-breathing Engines (AGARD fourth Colloquium on Combustion and Propulsion), 18
MacKeand, J., and others : Translocation of Wild Animals as a Means of Game Control, 518
McKenna, Susan M. O., and others : The Solar Flare of June 1, 1960, 926
Mackenzie, Dr. D. W. R. : Appointed to a lectureship in microbiology at the Queen's University, Belfast, 117
Mackinnon Research Studentship awarded by the Royal Society to Dr. D. T. Edmonds, 291
McLafferty, G. H. : Combustion and Propulsion—High Mach Number Air-breathing Engines (Basic Studies on Air Intakes), 20
McLaren, Dr. Anne, and Michie, Dr. Donald : Control of Pre-Natal Growth in Mammals, 363
McLennan, Prof. H. : Given an Award under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme, 291
McMurdo Sound : Ocean Currents in (A. E. Gilmour, W. J. P. Macdonald and F. G. Van der Hoeven), 867
MacNaughton, Dr. F. L. : Self-Regulation in Living Systems (Tremor—'Clonus', Alternating Contractions and Relaxations of Muscle), 297
MacNeill, B. H., and Ismen, Hikmet : Virus-Streak Disease of Tomatoes, 903
McNicol, Dr. R. W. E. (Thomas, Prof. J. A., and) : A Highly Directive Rotating Array for 16 Mc./s., 398
MacNutt, Mary M. (von Maltzahn, Prof. Kraft E., and) : Intracellular Configuration and Dedifferentiation in *Splachnum ampullaceum* (L.) Hedw., 344
McQuillen, Dr. K. : Cytoplasmic Particles and their Role in Protein Synthesis (Time Relationships during Protein Synthesis in *Escherichia coli*), 644
Macrae, W. D. : Tuberculosis in Animals (Eradication of Tuberculosis from Cattle), 998
Macromolecules (Biological) : Ultracentrifugation of (Colloid and Biophysics Committee of the Faraday Society Discussion on), 905
Macroscopic Swelling of Vermiculite Crystals in Water (G. F. Walker), 312
Madness : The Divided Self—a Study of Sanity and (Dr. R. D. Laing), *review* by Dr. Clifford Allen, 1062
Madréporaires Fossiles : Contribution à la Systématique des (James Alloiteau), *review* by Dr. H. Dighton Thomas, 95
Magalhaes, L. E., and others : Race Differences in the Ability to excrete Beetroot Pigment (Betanin), 806
Magill, J. H. : A New Technique for Following Rapid Rates of Crystallization, 770
Magnetic Field (Earth's) : Longitude Effect in Temperate Zone Sporadic *E* and the (L. H. Heisler and Dr. J. D. Whitehead), 676
Magnetic Field (Electric and) : Michael Faraday and the Evolution of the Concept of the (Prof. L. Pearce Williams), 730
Magnetic Field (Galactic) : A New Limit to the, set by Measurements of the Zeeman Splitting of the Hydrogen Line (Dr. R. D. Davies, C. H. Slater, W. L. H. Shuter and P. A. T. Wild), 1088
Magnetic Field Fluctuations (Periodic), in the Sceptre Discharge (Dr. N. L. Allen), 279
Magnetic Fields in Chromospheric Flares : Measurement of (M. Blaha, M. Kopecky and Z. Svestka), 224
Magnetic Properties of Tektites and Glasses formed by Fusion of Terrestrial Rocks : Comparison of the Chemical Composition and (Dr. Irving Friedman, Dr. Arthur Thorpe and Dr. Frank E. Senftle), 1089
Magnetic Resonance : Nuclear, *review* by Dr. L. M. Jackman, 358
  High-resolution Nuclear (J. A. Pople, W. G. Schneider and H. J. Bernstein), *review* by Dr. L. M. Jackman, 358
Magnetic Resonance Spectroscopy (Proton) : Structure Determination with the Help of (Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives), (C. F. Blakely, Dr. R. F. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662
Magnetization of Sediment Cores from the Eastern Atlantic Ocean (M. J. Keen), 220
Magnetization (Stress-Dependent), in some Quartz-Dolerites (Dr. D. W. Powell), 225
Magneto-Ionic Theory and its Applications to the Ionosphere (J. A. Ratcliffe), *review* by Sir Harrie Massey, 810
Magnitude' : 'Dex' or 'Order of ? (Prof. J. B. S. Haldane), 879
Magnusson, Bengt (Brosset, Prof. Cyrill, and) : The Silicon—Boron System, 54
Mahon, Dr. J. : Parasites as Enemies and Allies, 203
Maier-Leibnitz, H. : At the Tenth General Physics Conference of the Swedish National Committee for Physics (Research Programme of the Munich Reactor), 557
Maiman, Dr. T. H. : Stimulated Optical Radiation in Ruby, 493
Maintenance of Rumen Oligotrich Protozoa : Effect of Penicillin on the (G. S. Coleman), 518
Maintenance of Shape of the Human Red Cells : Adenosine Triphosphate and (Makoto Nakao, Toshiko Nakao and Saburo Yamazoe), 945
Martland, B. J. G. : Birds in Colour, *review*, 273
  The Second BBC Naturalist, *review*, 728
Majer, Dr. J. R. : Appointed lecturer in chemistry at the University of Birmingham, 117
Majer, Dr. J. R., and others : Cage Effect in the Liquid-Phase Photolysis of Fluorinated Ketones, 314
Major Element Relationships in Tektites (R. D. Cherry, Dr. S. R. Taylor and Maureen Sachs), 680
Makarov, E. S. : Crystal Chemistry of Simple Compounds of Uranium, Thorium, Plutonium, Neptunium (translated from the Russian by E. B. Uvarov), *review* by Dr. L. E. J. Roberts, 728
Making of the Broads (Dr. J. M. Lambert, J. N. Jennings, C. T. Smith, Charles Green and J. N. Hutchinson), *review* by Miles Burkitt, 636
Malaya : Newly Discovered Rock-Shelter Art in (J. M. Matthews), 373
Male and Female Mice (Resistance of), to Ectromelia : Effect of a Primary Tuberculous Infection on the (Dr. A. W. Gledhill and Dr. R. J. W. Rees), 703
Malhotra, S. K. : Awarded a Senior Studentship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Malik, Dr. C. P. : Effect of Variations in Temperature on Meiosis in *Gagea reticulata* Schultes, 805
Málková, Doubravka : Virus and Antibodies in the Lymph and Blood of Sheep infected experimentally with the Virus of Tick-borne Encephalitis, 716
Malnutrition : Influence of Different Types of, on the ^{14}C-Lysine Metabolism in Young Rats (Prof. Kurt Schreier and Corinna Kassens), 1117
Mammalian Skin : Phosphate Esters produced by, from 2-Deoxy-D-glucose (Dr. S. A. Brooks, Dr. J. C. Lawrence and Dr. C. R. Ricketts), 1028
Mammalian Tissues : The β-D-Fucosidase Activity of, and its relation to other Glycosidases (Dr. G. A. Levvy), 1027
Mammals : Control of Pre-Natal Growth in (Dr. Anne McLaren and Dr. Donald Michie), 363
  Potentiation of Contractility in the Heart Muscle of the Rat and some other (Dr. V. Kruta and Dr. P. Braveny), 327
  Serum Iron and Total Iron-binding Capacity in certain (Prof. Jose Planas and Saunio de Castro), 1126

Mammals (Marine): Laminated Structure of Bones from some (Dr. R. M. Laws), 338
Man: Absence of Local Cytotoxic Change in, Griseofulvin (Prof. Leon Goldman, Amanda Beyer and Jan Schwarz), 335
  Cytology and Cell Culture Genetics of (Symposium published by the *American Journal of Human Genetics*), 116
  The Future of (Prof. P. B. Medawar), *review* by Dr. J. D. Nisbet, 446
  Mechanisms of Meiotic Non-disjunction in (John S. S. Stewart), 804; (Dr. Curt Stern), 805
  Nature and (John Hillaby), *review* by T. H. Hawkins, 979
Man, Research Institute for the Study of (Division of Anthropology of the New York Academy of Sciences and the): Conference on Culture, Society and Health, 658
Man's Technological Progress from Steam Engine to Satellite: Science as History—the Story of (Heinz Gartmann), translated from the German by Alan G. Readett, *review* by J. L. Stollery, 8
Man's (A Plain) Guide to Atomic Energy (P. J. Duncton), 1076
Man (Prehistoric), in Europe (Frank C. Hibben), *review* by Miles Burkitt, 729
Man, Horse, Sheep and Dog: Occurrence of Keto-Acids in Blood Serum and Urine of Cattle in comparison with (Dr. C. J. G. van der Horst), 146
Man-made Fibres, *review* by Prof. C. S. Whewell, 2
Man-Made Textile Encyclopedia (edited by J. J. Press), *review* by Prof. C. S. Whewell, 2
Man-Power: Flight by (Dr. E. Guerra and Dr. B. Gunther), 419
Manpower Problems (Trained): The Public Service in New States—a Study in some (Kenneth Younger), 971
Management: Cybernetics and (Stafford Beer), *review* by J. A. Easterbrook, 269
Management in Britain—a General Characterization (I. McGivering, D. G. J. Matthews and W. H. Scott), 537
Management in the Industrial World—an International Analysis (Frederick Harbison and Charles S. Myers), 537
Management, British Institute of (South London Committee): Conference on Research Necessary for the Preparation and Use of Case Studies. 660
Management (Forest): The Development of Pulp and Particle Board Industries and their Effect on (Society of Foresters of Great Britain Discussion on), 32
Management and Technology, 537
Managerial Resources—an International Survey, 535
Manchester College of Science and Technology. Summer School in Modern Methods of Crystal Structure Determination, 201
  Course of lectures on Problems of Radioactivity at Water and Sewage Works, 743
Mandelstam, Dr. Stanley: Appointed to a new chair of mathematical physics in the University of Birmingham, 117, 197; work of, 197
Mandryk, M., and others: Differentiation in *Peronospora tabacina* Adam., 710
Manganous Ions: Stabilization by, of Ribosomes from Embryonic Plant Tissue (Dr. J. W. Lyttleton), 1026
Mangelsdorf, Jun., Prof. Paul C., and Washington, Elmer L.: Packing of Mixtures of Hard Spheres, 930
Mankiewicz, Dr. E., and Liivak, Dr. M.: Effect of *Candida albicans* on the Evolution of Experimental Tuberculosis, 250
Mann, Jun., L. T., and others: Homotransplant Antigens—Preparation of Active Cellular Fractions, 774
Mann, Dr. Monica (Butterworth, Dr. K. R., and): Proportion of Noradrenaline to Adrenaline in the Adrenal Glands of Litter-mate Cats, 785
Manot, Prof. M.-M. (Mathieu, Prof. J.-P., and): Tables of Constants and Numerical Data, Vol. 11, Selected Constants—Optical Rotatory Power, 4, Alkaloids, *review* by Dr. J. Walker, 7
Mansell, Dr. A. L. (Barrett, Dr. Jack, and): Ultra-Violet Absorption Spectra of the Molecules H_2O, HDO and D_2O, 138
Mansfeld, Prof. Rudolf: Elected a member of the Botany section of the Leopoldina Academy of Natural Sciences, 1079
Manton, Dr. S. M. (Saunders, J. T., and): A Manual of Practical Vertebrate Morphology, third edition, *review* by Dr. N. B. Marshall, 9
Manual of Mathematical Physics (Paul L. Richards), *review* by Prof. R. Eisenchitz, 445
Marini, Giovanni, and others: Proliferative Capacity of Acute Leukaemia Cells, 611
Marangoni Effects: The (L. E. Scriven and C. V. Sternling), 186
Marconi's Research and Development Laboratories: Appointment of G. D. Speake as deputy chief of research, 290
Marine Animals: The Biology of (Dr. J. A. Colin Nicol), *review* by Prof. C. M. Yonge, 630
  Physiology of, *review* by Prof. C. M. Yonge, 630
Marine Biological Reports from Denmark, *review* by Dr. A. J. Southward, 360
Marine Gastropoda: 'Water Rigour' as an Aid when Operating on (Prof. B. J. Krijgsman and A. C. Brown), 69
Marine Mammals: Laminated Structure of Bones from some (Dr. R. M. Laws), 338
Marine Physics: Studies in, *review* by Dr. G. E. R. Deacon, 183
Marine Plankton: Abundance of (R. M. Cassie), 289
Markakis, Prof. P.: Zone Electrophoresis of Anthocyanins, 1092
Marked Humpback Whale of Known Age (Dr. R. G. Chittleborough), 164
Markov, Dr. K. L., and others: Adaptive Chain in the Conversion of Anti-metabolites into Metabolites, 1041
Markov, K. K., and others: Work of the Antarctic Expeditions of the Academy of Sciences of the U.S.S.R., 287
Markowitz, A. S., and others: Immunological Relationships between the Rat Glomerulus and Nephritogenic Streptococci, 1095
Marks, K. R., and others: Association between Aurorae and Very Low-Frequency Hiss observed at Byrd Station, Antarctica, 751
Marks, Dr. V., and Smith, Dr. M. J. H.: Anti-Inflammatory Activity of Salicylate, 610
Marr, J. D. (Ward, Dr. A. H., and): Radioactive Fall-out in Ghana, 299
Marrow Cells (Bone): Acetone Fixation for the Cytochemical Demonstration of Dehydrogenases in Blood and (Dennis Quaglino and Dr. F. G. J. Hayhoe), 85
Marrow Cells (Transplanted Bone), in Radiation Chimaeras: Identification of (P. Czerski, O. Rosiek and J. Sabliński), 955
Marrow (Bone) Depression in Murine Leukaemia (James T. Duhig), 71
Marsden, Sir Ernest: Radioactivity of Soils, Plants and Bones, 192
Marshall, Prof. A. J.: The Land of the Marsupials, *review*, 543
Marshall, Prof. A. J., and others: Effects of Whole-body Irradiation on the Breeding Plumage of the Weaver Finch, *Quelea quelea*, 615
Marshall, L. (Landovitz, L. F., and): Gravitational Red Shift of Hydrogen 21-cm. Radiation as a Method to measure Galactic Gravitational Potential, 223
Marshall, Dr. L. H., and Hanna, C. H.: Dextran and Insulin in Rats, 1118
Marshall, Dr. N. B.: A Manual of Practical Vertebrate Morphology, *review*, 9
  The Galathea Expedition, *review*, 443
Marshall, T. G., and others: Diamagnetic Moment of Gaseous Plasmas measured by Spin Resonance Techniques, 584
Marshall Chair of the Physiology of Reproduction, Cambridge, 113
Marsupials: The Land of the, *review* by Prof. A. J. Marshall, 543
Martensite: Retained Austenite and the Tempering of (S. Matas and Prof. R. F. Hehemann), 685
Martin, A. J., and others: An Improvement in the Ductility of Beryllium at High Temperatures, 494
Martin, E. M.: Cytoplasmic Particles and their Role in Protein Synthesis (Role of Ribonucleic Acid in Protein Synthesis), 644
Martin, Dr. F. M.: Appointed lecturer in public health and social medicine at the University of Edinburgh, 465
Martin, Dr. L. H.: Observations of 'Whistlers' and 'Chorus' at the South Pole, 1018
Martin, Dr. L. H., and others: Association between Aurorae and Very Low-Frequency Hiss observed at Byrd Station, Antarctica, 751
Martin, W. B., and others: New Inhibitor of Monoamine Oxidase, 941
Masks of God: The—Primitive Mythology (Dr. Joseph Campbell), *review* by Dr. K. O. L. Burridge, 7
Masri, M. S., and others. Excretion of Catechol after Ingestion of Quinic and Shikimic Acids, 691
Mass, Length and Time, *review* by G. R. Noakes, 183
  An Introduction to the Physics of (Prof. Norman Feather), *review* by G. R. Noakes, 183
Mass Spectra (Carbon Dioxide): High-Energy Oxygen Ions in (R. M. S. Hall), 683
Mass Spectrometric Investigation of the Vaporization of Sulphides and the Dissociation Energy of S_2 (R. Colin, Prof. P. Goldfinger and M. Jeunehomme), 408
Mass Spectrometry (Solid-Source), using Negative Ions: Isotopic Analysis of Silicon by (Dr. D. C. Newton, J. Sanders and A. C. Tyrrell), 683
Massachusetts Institute of Technology: Seminar Lectures on the Physiological Role of Fast Transfer Reactions, 904
Massey, Sir Harrie: Ionospheric Propagation of Electromagnetic Waves, *review*, 810
  Collisions (Forty-third Guthrie Lecture of the Physical Society), 853
Mast Cells and 5-Hydroxytryptamine in Precancerous Mouse Skin (Dr. R. E. Coupland and Dr. J. F. Riley), 1128
Matas, S., and Hehemann, Prof. R. F.: Retained Austenite and the Tempering of Martensite, 685
Mateles, Dr. Richard I.: Ferricyanide Reduction Method for Reducing Sugars, 241
Material with Proactivator Activity: Isolation of, from Human Serum (H. B. W. Greig and Elise M. Cornelius), 1125
Material (Air-borne): Radioactive Labelling of Membrane Filters for the Assay of (Dr. G. Kuble and Dr. K. Spurny), 930
Material (Living): The Effects of Pollution on (edited by W. B. Yapp), *review* by Dr. G. C. Ware, 1061
Material (Reference): Guide to (edited by Dr. A. J. Walford, with the assistance of L. M. Payne), *review* by R. Brightman, 273
Materials. Non-destructive Testing of (British Council Course on), 1079
Materials, Association for the Advancement of the Knowledge of, and others: International Congress on the Technology of Plastics Processing, 559
Materials (Biological): Freezing and Drying of (Dr. Harold T. Meryman, and 12 other Authors), 748
Materials (Botanical): Alpha Activity of certain (Prof. W. V. Mayneord, R. C. Turner and J. M. Radley), 208
Materials Research and Development for National Security: More Effective Organization and Administration of (United States National Academy of Sciences—National Research Council, Publication No. 718), 470
Maternal Inheritance and Interspecific Hybrids of the Liverwort *Sphaerocarpos* (Dr. William T. Doyle), 429
Mathematical Association: To award a Diploma in Mathematics, 114
Mathematical Physics at Birmingham, 197
Mathematical Physics: Manual of (Paul I. Richards), *review* by Prof. R. Eisenschitz, 445
Mathematics at Oxford, 830
Mathematics: The Diploma in (Mathematical Association), 114
Mathematics (Applied), at Bangor, 197
Mather, Prof. Kenneth: Genetics of Continuous Variation, *review*, 813
Mather, R. L., and others: Fractionation of Nuclear Weapon Debris, 1100
Mathias, Dr. A. P., and others: Activity of Bovine Pancreatic Ribonuclease A in Mixed Solvent Systems, 601
Mathieson, Dr. A. McL.: The Chemistry of Natural Products (The Direct Determination of the Molecular Structure of Natural Products), 1080
Mathieu, Prof. J.-P., and Manot, Prof. M.-M.: Tables of Constants and Numerical Data, Vol. 11, Selected Constants—Optical Rotatory Power, 4, Alkaloids, *review* by Dr. J. Walker, 7
Matkovics, Dr. Béla (Fehér, Dr. T., and): Chemical Constitution of the Red Blood Cell Membrane, 701
Matrix (Organic), of Tooth Enamel (J. E. Eastoe), 411
Matrix Antifouling Compositions: Mode of Action of Soluble (A. Partington), 1105
Matsumoto, M., and others: Distribution of Protein-bound Aminoazo Dyes in the Rat Liver Microsome, 943
Matter: Penetration of Charged Particles in—Proceedings of an Informal Conference, Gatlinburg, Tennessee, 1958 (edited by A. Vehling), (United States National Academy of Sciences—National Research Council, Nuclear Science Series, Report No. 29), 1086
Matthews, D. G. J., and others: Management in Britain—a General Characterization, 537
Matthews, J. M.: Newly Discovered Rock-Shelter Art in Malaya, 373

Mattick, Leonard R., and others: Determination of Fatty Acids of Lower Molecular Weight by Gas Chromatography, 689
Maturation (Ovarian). Breeding of the Rabbit Flea, *Spilopsyllus cuniculi* (Dale)—Requirement of a 'Factor' from a Pregnant Rabbit for (A. R. Mead-Briggs and A. J. B. Rudge), 1136
Matzke, Jorgen: Effect of Testicular Hyaluronidase on the Permeability of Human Arterial Tissue, 873
Maxwell, Capt. L. R.: Cost of Scientific Periodical Publications, 1052
Maxwell, Dr. R. W.: Appointed a senior lecturer in engineering at the University of Leicester, 743
May, B. R., and Smith, D. E.: Final Months and Descent of Satellite *Sputnik* 3, 456
  The Sudden Discontinuity in the Orbital Period of *Sputnik* 4 Satellite, 866
Mayes, Dr. P. A.: An Inverse Relation between the Liver Glycogen and the Blood Glucose in the Rat adapted to a Fat Diet, 325
Mayneord, Prof. W. V., and others. Alpha Activity of certain Botanical Materials, 208
Mazumdar, B. K., and others: Initial Stages of Oxidation of Coal, 502
Mazur, Dr. P.: Freezing and Drying of Biological Materials, 749
Mead-Briggs, A. R., and Rudge, A. J. B.: Breeding of the Rabbit Flea, *Spilopsyllus cuniculi* (Dale)—Requirement of a 'Factor' from a Pregnant Rabbit for Ovarian Maturation, 1136
'Meaning': The Relativity of (Dr. W. Ross Ashby), 532
Means of Game Control. Translocation of Wild Animals as a (Dr. A. M. Harthoorn, J. A. Lock and J. MacKeand), 518
Means (Possible), of Predicting the Nitrogen-supplying Power of Soils: Ammonia released on Treating Soils with *N* Sodium Hydroxide as a (A. H. Cornfield), 260
Means (Two): Significance of the Difference between, when the Population Variances may be Unequal (John B. de V. Weir), 438
Measurement of Grassland Productivity—Proceedings of the University of Nottingham Sixth Easter School in Agricultural Science, 1959 (edited by Prof. J. D. Ivins), *review* by Dr. G. W. Cooke, 544
Measurement of Magnetic Fields in Chromospheric Flares (M. Blaha, M. Kopecky and Z. Svestka), 224
Measurement of Slip (*Ko*) and Viscous (*Bo*) Flow Coefficients of Permeable Solids (J. G. Biram), 865
Measurement (Electrostatic), of the Geoelectric Effect in Coleoptiles (Carl Hellmuth Hertz), 320
Measurement (Flow), in Closed Conduits (National Engineering Laboratory Symposium on), 905
Measurement (Routine), of Particle Shape Factors in the Sieve Range: A Method for the (Dr. Colin C. Harris), 401; (D. Howitt), 403
Measurement (Simultaneous), of Adsorption and Electrodekinetic Parameters at Metal Surfaces (A. M. Peers), 503; (Dr. E. A. Blomgren and Dr. J. O'M. Bockris), 504
Measurements of the Zeeman Splitting of the Hydrogen Line: A New Limit to the Galactic Magnetic Field set by (Dr. R. D. Davies, C. H. Slater, W. L. H. Shuter and P. A. T. Wild), 1088
Measurements (Airborne), of Latitudinal Variation of Frost-point Temperature and Wind (N. C. Helliwell), 993
Measurements (Gamma-Ray). Fall-out Caesium in Surface Sea Water off the California Coast (1959–60) by (Dr. Theodore R. Folsom, Dr. G. J. Mohanrao and Perrin Winchell), 480
Measurements (Reflectance). Use of, in assessing the Colour Changes of Ageing Bloodstains (Dr. D. Patterson), 688
Measurements (Instruments and) Conference and Exhibition. Fifth International (Royal Swedish Academy of Engineering Sciences and the Swedish Association of Technical Physicists), 374
Measuring the Size of Isolated Cells (Dr. Samuel S. Epstein and Jacqueline B. Weiss), 461
Measuring Instruments. Chemical Plant Instrumentation—some Notes on the Use of (Association of British Chemical Manufacturers), 1079
Meat. Science and, *review* by Prof. J. Hawthorn, 888
Meat Diet: Lack of Haematopoietic Potency of Liver of Mice fed on a (Judith Ilan and Prof. K. Guggenheim), 698
Meat Institute Foundation (American), (Members of the Research Staff of the). The Science of Meat and Meat Products, *review* by Prof. J. Hawthorn, 888
Meat-Products. The Science of Meat and (Members of the Research Staff of the American Meat Institute Foundation), *review* by Prof. J. Hawthorn, 888
Meat and Meat Products: The Science of (Members of the Research Staff of the American Meat Institute Foundation), *review* by Prof. J. Hawthorn, 888
Mechanical Engineering at Cardiff, 555
Mechanical Forces: Initiation of Chemical Reactions by (Dr. Robert Schnurmann and Ivor S. Stringer), 587
Mechanics: Statistical (with special reference to Irreversibility), (Institute of Physics and the Physical Society Conference on), 1079
Mechanics (Applied): Tenth International Congress of, 201
Mechanics (Experimental): International Congress on, 559
Mechanism: Kinetics and (Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives), (C. F. Blakely and Dr. A. Wassermann), 662
Mechanism of Formaldehyde-induced Mutagenesis—the Uniqueness of Adenylic Acid in the Mediation of the Mutagenic Activity of Formaldehyde (Dr. Thomas Alderson), 485
Mechanism of the Physiological Action of Rotenone (Prof. P. E. Lindahl and K. E. Öberg), 784
Mechanism of Starch Biosynthesis (Dr. Maria A. Rongine de Fekete, Dr. Luis F. Leloir and Dr. Carlos E. Cardini), 918
Mechanism (A Second), of Inhibition at the Crayfish Neuromuscular Junction (Dr. Josef Dudel and Prof. Stephen W. Kuffler), 247
Mechanisms: Detoxication (Prof. R. Tecwyn Williams), second edition, *review* by Prof. E. Boyland, 94
Mechanisms of Meiotic Non-disjunction in Man (John S. S. Stewart), 804; (Dr. Curt Stern), 805
Mechanisms (Adrenergic): Parallelism of Changes produced by Cooling and by Drugs known to affect (Prof. Eleanor Zaimis), 213
Medal of the Iron and Steel Institute, 286
  First Award made to the Royal Society, 286
Medawar, Prof. P. B.: Appointed director of the National Institute for Medical Research, 374, 991; work of, 991
  The Future of Man, *review* by Dr. J. D. Nisbet, 446
Media (Gaseous): Evaporation and Droplet Growth in (N. A. Fuchs), translated from the Russian by J. M. Pratt, edited by Dr. R. S. Bradley, *review* by Prof. F. H. Garner, 451
Media (Physiological), for Tissues of *Helix* (C. K. Goddard), 68
Medial Temporal Lesions: Effects of, on Taste Preference in the Monkey (Dr. L. Weiskrantz), 879
Mediation of the Mutagenic Activity of Formaldehyde: Mechanism of Formaldehyde-induced Mutagenesis—the Uniqueness of Adenylic Acid in the (Dr. Thomas Alderson), 485
Medical Helminthology (Dr. J. M. Watson), *review* by Dr. G. Lapage, 815
Medical Research in the Paris Hospitals, 26
Medical Research, National Institute for: Appointment of Prof. P. B. Medawar as director, 374, 991
Medical Research Council. Neuropsychiatric Research Unit transferred from the Whitchurch Hospital, Cardiff, to the Council's Laboratories at Carshalton, 466
Medical Sciences (General). Highlights of Research Progress in, 1959 (United States Department of Health, Education and Welfare, Publication No. 739), 200
Medical and Veterinary Zoology: Index-Catalogue of (United States Department of Agriculture), Supplements 9 and 10, 559
Medicine: Human and Veterinary (Dr. W. J. Hayes, Jr., Dr. S. W. Simmons and Dr. E. F. Knipling), (edited by Dr. S. W. Simmons), (DDT—the Insecticide DDT and its Significance, edited by Paul Muller, Vol. 2), *review* by Prof. D. S. Bertram, 271
  Travelling Fellowships in, 994
  The Wish to Fall Ill—a Study of Psychoanalysis and (Dr. Karin Stephen), *review* by Dr. Clifford Allen, 978
Medicine as a Social Science, *review* by Prof. E. Maurice Backett, 633
Medicine, Royal Society of, and others. First British Congress on the History of Medicine and Pharmacy, 374
Medicine or Pharmacy. Maccabaean Prize and Medal for an essay on a subject connected with the History of (Worshipful Society of Apothecaries of London), 650
Medicine and Pharmacy: History of (Faculty of the History of Medicine and Pharmacy of the Worshipful Society of Apothecaries of London, in co-operation with the Royal College of Physicians, the Royal College of Surgeons of England and the Royal Society of Medicine First British Congress on), 374
Medina, Dan (Sachs, Dr. Leo, and): Polyoma Virus Mutant with a Reduction in Tumour Formation, 715
Medium: Influence of the Ionic Strength of the, on the Anaphylactic Sensitization of Isolated Tissues *in vitro* (R. Binaghi, M. Liacopoulos-Bruit, Dr. B. N. Halpern and P. Liacopoulos), 697
Medulla (Denervated Adrenal), of the Rat: Effect of Reserpine on the Nucleotide and Catecholamine Content of the (Prof. Nils-Åke Hillarp), 1032
Mee, C. H. B.: Appointed assistant lecturer in physics at the University of Southampton, 290
Mehta, D. J., and others. Diuretic Activity of 2-Amino-4-meta-chloro-anilino-1,3,5,triazine (*R*-37), 1034
Meier, Jurg, and others. 'Enthalpy Titrations' and Thermochemistry in Molten Salts, 318
Meiosis in *Gagea reticulata* Schultes: Effect of Variations in Temperature on (Dr. C. P. Malik), 805
Meiotic Non-disjunction in Man: Mechanisms of (John S. S. Stewart), 804; (Dr. Curt Stern), 805
Melanin Granules and Mitochondria (Dr. Ruth V. Baker, M. S. C. Birbeck, Dr. H. Blaschko, Prof. T. B. Fitzpatrick and Dr. M. Seiji), 392
Melanocyte-stimulating Component in the Dorsal Skin Secretion of *Xenopus laevis*: Serotonin, a (Dr. F. C. G. van de Veerdonk), 948
Meldola Medal for 1961 of the Society of Maccabaeans, 743
Meleka, Dr. A. H., and Barr, W.: A Possible Origin of Exo-Electron Emission in Plastically Deformed Metals, 232
Mellanby, Dr. Kenneth: Nigeria's Feeding-Stuffs, *review*, 637
Mellon Institute, Pittsburgh: Conference on Diffraction, 650
  Mellon Institute Research 1959-1960—the Annual Report to the Board of Trustees of the Institute for the Fiscal Year 1959-1960 (Matthew R. Ridgway), 908
Melville, Dr. R.: Australian Native Plants for Home Gardens, *review*, 637
Membrane (Red Blood Cell): Chemical Constitution of the (Dr. T. Fehér and Dr. Béla Matkovics), 701
Membrane Conductance (Decreased): Excitation at the Crayfish Neuromuscular Junction with (Dr. Josef Dudel and Prof. Stephen W. Kuffler), 246
Membrane Excitability of Calcium-deficient Muscles: Restoration of, by Anodal Polarization (Prof. K. Koketsu and K. Noda), 243
Membrane Filters: Radioactive Labelling of, for the Assay of Air-borne Material (Dr. G. Kubie and Dr. K. Spurny), 930
Membrane Fractions (Mitochondrial): Sodium and Potassium in (Dr. Frank Ulrich), 949
Membrane Potential of the Anterior Byssus Retractor Muscle of *Mytilus edulis* (Dr. D. H. Paul), 1121
Membranes (Pseudocoelomic), of *Ascaris lumbricoides*: Use of Collagenase in the Characterization of (Barbara Dawson), 798
'Memories' for Nuclear Physics (G. W. Hutchinson), 854
Men (British), of Science, a New Series to be published by Nelson, 374
Mendel. Evolutionary Theory after, *review* by Dr. H. Kalmus, 726
Mental Deficiency (Low-Grade), in a Large Swedish Rural Population: A Clinical and Genetico-Statistical Study of Schizophrenia and (Bertil Hallgren and Torsten Sjogren), 298
Meprobamate: Depressing Activity of, on the Reticulo-Endothelial System (Prof. A. Del Vecchio and L. Bolis), 513
Mercaptalbumin: An Ortho Effect influencing Fungitoxicity, Electronic Absorption Spectra, and Chemical Reactivity with (Dr. H. P. Burchfield and Eleanor E. Storrs), 593
6-Mercaptopurine. Effect of, on the Net *In vitro* Gas Production of Sensitive and Resistant *L*1210 Mouse Leukaemia Cells (Dr. H. J. Woodliff), 156
6-Mercaptopurine in Immunological Responsiveness (Dr. John L. Robinson and Dr. Charles L. Christian), 796

Mercer, E. H. (Birbeck, M. S. C., and) : Cytoplasmic Particles and their Role in Protein Synthesis (Electron Microscopy in formulating Hypotheses of some Aspects of Protein Synthesis), 644
Meredith, Dr. D. S. : Banana Fruit-spot ('Speckle') caused by *Deightoniella torulosa* (Syd.) Ell., 961
Merino and Polwarth Wools : Abnormal Crimping in (R. E. Chapman, B. F. Short and P. G. Hyland), 960
Meristic Character in Coleoptera : Ovarioles as a (Dr. J. G. Robertson), 526
Merritt, James A., and others : Ultra-violet Absorption Spectra of the Diazines, 500
Meryman, Dr. Harold T. (and 12 other Authors) : Freezing and Drying of Biological Materials, 748
Meso-inositol (^{14}C-), in the Rat : Metabolism of (Dr. D. A. Nixon), 77
π-Mesonic X-Rays : The Method of Observing (Dr. D. West), 853
Messel Medal Address to the Society of Chemical Industry (Viscount Chandos), 831
Metabolic Block (Inborn Error of Metabolism) : Reversibility of an Inherited (Dr. Herman Zondek, Dr. Hannah E. Leszynsky and Dr. Joseph A. Stein), 515
Metabolic Processes : Role of Initial Value of, in Oxygen Consumption Changes in Rats during Irradiation (Dr. A. Vacek), 76
Metabolic Rates at the Cellular Level : Analysis of (Dr. L. G. Lajtha, R. Oliver, R. J. Berry and Elizabeth Hell), 919
Metabolism : Polypeptides of the Human Pituitary with Direct Action on (Dr. J. Bornstein and Deirdre Hyde), 125
    Reversibility of an Inherited Metabolic Block (Inborn Error of (Dr. Herman Zondek, Dr. Hannah E. Leszynsky and Dr. Joseph A. Stein), 515
Metabolism of ^{14}C-Meso-inositol in the Rat (Dr. D. A. Nixon), 77
Metabolism of Oxygen-15 (C. T. Dollery and J. B. West), 1121
Metabolism (Brain) : Isolation and Probable Functions of Betaine Esters in (Prof. E. A. Hosein and Peter Proulx), 321
Metabolism (^{14}C-Lysine), in Young Rats : Influence of Different Types of Malnutrition on the (Prof. Kurt Schreier and Corinna Karassus), 1117
Metabolite (New), of Epinephrine and Norepinephrine in Liver and Kidney : Formation of a (Dr. M. Goldstein and Dr. S. B. Gertner), 147
Metabolites : Adaptive Chain in the Conversion of Antimetabolites into (Dr. K. I. Markov, Dr. G. K. Seev and Dr. E. V. Golovinsky), 1041
Metacorticoid Hypertensive Rats : Electro-shock Seizure Threshold of (Dr. F. M. Sturtevant), 874
Metal : Potentiometric Study of Priming Paints for (Dr. N. R. Bharucha), 756
Metal Ethylenediamine Tetraacetic Acid Chelates : Differential Thermal Analysis of some Transition (Prof. Wesley W. Wendlandt and G. Robert Horton), 769
Metal Films (Evaporated) : Hydrocracking of Neopentane and Neohexane over (Dr. J. R. Anderson and B. G. Baker), 937
Metal Ions : Fungitoxicity of (Dr. E. Somers), 427
Metal Ions (Alkali), in Analcite : Energies of Activation for Self-diffusion of (Prof. R. M. Barrer and L. V. C. Rees), 768
Metal Ions (Bivalent), in Transphosphorylation : Synergism of (Dr. John M. Lowenstein), 570
Metal Surfaces : Simultaneous Measurement of Adsorption and Electrode-kinetic Parameters at (A. M. Peers), 503 ; (Dr. E. A. Blomgren and Dr. J. O'M. Bockris), 504
Metallic Corrosion, *review* by Dr. J. M. West, 182
Métallurgie, Société Française de : Meeting on the Heat Treatment of Metals and Alloys, 559
Metallurgists, Institution of : Presidential Address, Effectiveness in Industry (W. E. Bargett), 378
Metals : An Abnormal Serum Protein in Experimental Poisoning by Cadmium and other (D. J. Lawford), 946
    Colorimetric Determination of Traces of (Prof. E. B. Sandell), third edition, *review* by A. M. G. Macdonald, 3
    The Corrosion and Oxidation of (Dr. Ulick R. Evans), *review* by Dr. J. M. West, 182
    The Extraction of, and the Chemistry of Metals (Prof. F. D. Richardson), 466
    The Newer, *review* by Prof. A. G. Quarrell, 725
Metals having a Hexagonal Structure : Work-Hardening and Ductility of Rhenium and their relation to the Behaviours of other (R. A. Jeffery and E. Smith), 52
Metals under Simple Shear : A Simple Method of Investigating the Creep of (Prof. E. N. da C. Andrade), 494
Metals, Institute of : Annual Autumn Meeting, 559
Metals, Institute of (Metal Physics Committee) : The Physical Nature of Plastic Flow (Dr. J. J. Gilman), 374
Metals (Plastically Deformed) : A Possible Origin of Exo-Electron Emission in (Dr. A. H. Meleka and W. Barr), 232
Metals and Alloys : Heat Treatment of (Société Française de Métallurgie Meeting on), 559
Metals and Compounds (Titanium) : Analytical Chemistry of (Maurice Codell), *review* by Prof. A. G. Quarrell, 725
Metarrhizium anisopliae (Metch.) Sor. and *Beauveria bassiana* (Bals.) Vuill. : Pathogenicity of, to Two Species of Elateridae (Dr. R. D. Tinline and R. Y. Zacharuk), 794
Meteorite : The Tunguska (V. N. Rodionov and M. A. Tsikulin), 1077 ; (B. I. Vronsky), 1078 ; (E. L. Krynov), 1078
Meteorites : Fossil (B. I. Vronsky), 648
Meteorites (Iron) : The Sulphide Phase in some (Dr. H. J. Axon), 406
Meteorological Office (Air Ministry) : Geophysical Memoirs No. 102, Average Water Vapour Content of the Air (J. K. Bannon and L. P. Steele), 748
    Scientific Paper No. 1, Airborne Measurements of Latitudinal Variation of Frost-point Temperature and Wind (N. C. Helliwell), 993
Meteorological Organization (International) Prize awarded by the World Meteorological Organization to Prof. J. van Mieghem, 740
Meteorological Organization (World) : International Meteorological Organization Prize awarded to Prof. J. van Mieghem, 740
Meteorological Society (Royal) : L. F. Richardson Prize, 28
    Summer Meeting (Weather Problems in Agriculture), 995
Meteors : Light Curves of (Dr. R. Ananthakrishnan), 675
Methane at Low Temperature : The Second Virial Coefficient of (G. Thomaes and R. Van Steenwinkel), 229
Methionine and Sodium Butyrate (Glucose,) : Reduction of the Intestinal Absorption of, by the Cation Trimethylhexadecylammonium (Dr. J. A. Nissim), 308
D,L-Methionine-^{35}S in *Acetabularia mediterranea* : Influence of Localized Ultra-violet Irradiation on the Incorporation of Adenine-8-^{14}C and (Prof. J. Brachet and Dr. M. L. Olszewska), 954
DL-Methionine-Ethylester : Damage to Liver Induced by (I. Fehér, F. V. Selmeczi, K. Szalay and Dr. T. Kemény), 421
Method for the Detection of Inhibition of Auxin Transport (B. E. S. Gunning), 428
Method of Estimating Late Larval and Pupal Mortality in the Wild : Radioactive Labelling of Lepidopterous Larvae—a (L. M. Cook and Dr. H. B. D. Kettlewell, 301
Method for the Isolation of Plant Protoplasts and Vacuoles (Dr. E. C. Cocking), 962
Method to Measure Galactic Gravitational Potential : Gravitational Red Shift of Hydrogen 21-cm. Radiation as a (L. F. Landovitz and L. Marshall), 223
Method of Observing π-Mesonic X-Rays (Dr. D. West), 853
Method for the Routine Measurement of Particle Shape Factors in the Sieve Range (Dr. Colin C. Harris), 401 ; (D. Hewitt), 403
Method (Elson and Morgan) : Glucosamine Values of Muramic Acid and other Amino-Sugars by the (R. E. Strange), 38
Method (Ferricyanide Reduction), for Reducing Sugars (Dr. Richard I. Mateles), 241
Method (A New), for the Differential Precipitation of Nucleic Acids from Aqueous Solutions (William G. Aldridge), 323
Method (A New), for the Synthesis of Cyclic Ethers (L. F. Schmoyer and L. C. Case), 592
Method (A Rapid), for Studying Tumour Blood Supply using Lissamine Green (L. N. Owen), 795
Method (A Simple), of Investigating the Creep of Metals under Simple Shear (Prof. E. N. da C. Andrade), 494
Method (A Simple Azo-Dye), for Histochemical Demonstration of Acid Phosphatase (Dr. Tibor Barka), 248
Methodology and Philosophy of Science : Logic, (International Union for History and Philosophy of Science International Congress for), 201
Methods : A Handbook of Colorimetric Chemical Analytical (Tintometer, Ltd.), fifth edition, *review* by A. M. G. Macdonald, 3
Methods (Modern), of Crystal Structure Determination (Manchester College of Science and Technology Summer School in), 201
Methods (Sampling) : Earthworm Population Studies—a Comparison of (F. Raw), 257
Methods (Uniform), of Sugar Analysis, International Commission for—Report of the Proceedings of the Twelfth Session, Washington, D.C., 1958, *review* by Prof. E. L. Hirst, 9
2(o-Methoxyphenoxymethyl)-5-Oxazolidone : Synergetic Action of, on Morphine, Dihydrocodeine and Aminopyrine Analgesia (Dr. E. Fischer, J. L. J. Szabó and M. Stamburgo), *erratum*, 559
Methyl Acrylate : Generation of Aerosols by Vapour-Phase Polymerization of (R. Pearson and G. Langer), 235
Methylcholanthrene : Tumour-promoting Effect of Excessively Large Doses of Oral Griseofulvin on Tumours Induced in Mice by (Louis L. Barich, Takashi Nakai, Jan Schwarz and Donna Jean Barich), 335
Metric System : Decimal Coinage and the—Should Britain Change ? (A joint Report of Committees appointed by the British Association for the Advancement of Science and the Association of British Chambers of Commerce), 30
Metropolitan Water Board : Thirty-eighth Report on the Results of the Bacteriological, Chemical and Biological Examination of the London Waters for the Years 1957-1958 (E. Windle Taylor), 468
Meurling, Patrick : Presence of a Pituitary Portal System in Elasmobranchs, 336
Mexico (New) : Anomalous Leads from a Selected Geological Environment in West-Central (William F. Slawson and Carl F. Austin), 400
Mica : Thermal Conduction in, along the Planes of Cleavage (H. J. Goldsmid and A. E. Bowley), 864
Mice : Effect of Hydration on Hexobarbitone-induced Sleep in (Dr. N. K. Bhide), 1030
    Tumour-promoting Effect of Excessively Large Doses of Oral Griseofulvin in Tumours induced in, by Methylcholanthrene (Louis L. Barich, Takashi Nakai, Jan Schwarz and Donna Jean Barich), 335
Mice fed on a Meat Diet : Lack of Haematopoietic Potency of Liver of (Judith Ilan and Prof. K. Guggenheim), 698
Mice treated with Phosphorus-32 : Fertility of (E. A. D. Holmberg, Dr. A. Pavlovsky, C. D. de Pasqualini and S. L. Rabasa), 876
Mice (New-born) : Fate of Homologous Adult Spleen Cells injected into (A. J. S. Davies and Sheila M. A. Doak), 610
Mice (Resistance of Male and Female), to Ectromelia : Effect of a Primary Tuberculous Infection on the (Dr. A. W. Gledhill and Dr. R. J. W. Rees), 703
Mice (Thymectomized) : Recovery of Leukaemogenic Agent from Non-Leukaemic Tissues of (J. F. A. P. Miller), 703
Michie, Dr. Donald (McLaren, Dr. Anne, and) : Control of Pre-Natal Growth in Mammals, 363
Micrasterias americana in Clone Culture : Morphogenetics of (Prof. Paavo Kallio), 164
Microanalytical Separation of Steroids by Gas Chromatography (C. C. Sweeley and Dr. E. C. Horning), 144
Microbial Synthesis of Protein in relation to the Biogenesis of Nucleic Acids with *Azotobacter vinelandii* as the Test Organism (Maharani Chakravorty), 239
Microbial Systematics : Discussion on, 190
Microbiological Transformation of Terpenes—Hydroxylation of α-Pinene (P. K. Bhattacharyya, B. R. Prema, B. D. Kulkarni and S. K. Pradhan), 689
Microbiology (General), Society of : Formation of a Microbial Systematics Group, 190
Micrococcal Phosphodiesterase : Mode of Action of (Dr. K. K. Reddi), 74
Microflora (Rhizosphere), of *Camellia sinensis* : Foliar Application of Nutrients and (Dr. C. S. Venkata Ram), 621
Microgram Quantities of Silver : Non-destructive Analysis of, by Radioactivation (Dr. Minoru Okada), 57
125-500 Microns : Pure Rotational Absorption of Ozone in the Region (Dr. H. A. Gebbie, N. W. B. Stone and C. D. Walshaw), 765

Microscope (Electron) Images of Dislocations (Dr. Hatsujiro Hashimoto and Dr. Kazuo Fujita), 51
Microscopy Electron (Nederlandse Vereniging voor Electronenmicroscopie European Regional Conference on), 29
Microscopy (Electron) : Use of Ferritin-conjugated Antibody to Localize Antigen to (Richard A. Rifkind, Konrad C. Hsu, Councilman Morgan, Beatrice C. Seegal, Alice W. Knox and Harry M Rose), 1094
Microscopy (Electron), of Ultra-thin Sections : A Vacuolar System in Cells of *Agrobacterium tumefaciens* as shown by (Miguel Rubio-Huertos and Paul R Desjardins), 1043
Microsome (Rat Liver) . Distribution of Protein-bound Aminoazo Dyes in the (Dr. T. Yamada, M. Matsumoto, S. Kanda and Prof H Terayama), 943
Milcou, Prof S M , and Pavel, S Antigonadotropic Function of the Pineal Gland and the Oxytocin of the Neurosecretory Hypothalamic System, 950
Mild Steel : Correlation of the Alternating Stresses required to Initiate and Propagate a Fatigue Crack in (N E Frost), 233
Miles, Dr. H T . Appointed lecturer in physics at University College, Swansea, 117
Miley, Dr R. A (Rimington, Prof C , and) The Fourth International Goitre Conference, 651
Milieu Cell, Organism and (edited by Prof Dorothea Rudnick), (Seventeenth Symposium of the Society for the Study of Development and Growth), *review* by Dr. E N. Willmer, 450
Milk . Radiostrontium and Radiocaesium in, during 1959 (W Anderson, L K Burton and J O Crookall), 108
Milk after the Reactor Accident at Windscale in October 1957 : The Deposition of Strontium-89 and Strontium-90 on Agricultural Land and their Entry into (United Kingdom Atomic Energy Authority and the Agricultural Research Council joint Report on), 1077
Mill, A. G. · Appointed agricultural and food attaché to the British Embassy in Buenos Aires, 1075 ; work of, 1075
Miller, Dr. G L Tantalum and Niobium, *review* by Prof. A. G. Ward, 725
Miller, Dr. Henry : Brain and Behaviour, *review*, 6
Miller, H. C. : International Association for the Protection of Industrial Property, 202
Miller, John A. : Potassium-Argon Ages of some Rocks from the South Atlantic, 1019
Miller, J F A. P : Recovery of Leukaemogenic Agent from Non-Leukaemic Tissues of Thymectomized Mice, 703
Millman, Dr. A. P (Grey, I , and) Spectral Reflectivity of Ore Minerals, 282
Milne, M. K. · Planning for the Changing World Population, *review*, 816
Milobedzki, Prof Tadeusz : *Obituary* by Dr. Wiktor Wawrzyczek, 991
Milstone, Dr J H : Chromatography of Blood Thrombokinase on 'DEAE'-Cellulose, 1127
Milsum, Dr. J. H. · Self-Regulation in Living Systems, 297
Mimetic Twinning in Urea-Ammonium Bromide (C. G. C. Catesby), 765
Mimosa pudica Behaviour of a Threadlike Apparatus in the Petiole of (Dr Hideo Toriyama), 709
Minagawa, S , and others : Summative Action of Acetylcholine with Physiological Stimulus on the Generator Potential in the Lateral Eye of the Horseshoe Crab, 1118
Mind : The Hidden, *review* by Dr. Clifford Allen, 978
Minerals (Clay), Montmorillonite and Vermiculite : Aluminium Interlayers in—Laboratory Synthesis (B. L. Sawhney), 261
Minerals (Epidote) : Stability of (Prof W. S. Fyfe), 497
Minerals (Ore) : Spectral Reflectivity of (I. Grey and Dr. A. P. Millman), 282
Mines (Safety in) Research Establishment Bibliography, 1960 (compiled by E. B. Smith), second edition, *review* by Prof. S. G. Ward, 1063
Mines and Quarries, H.M Inspectors of . Annual Reports for 1959—Scottish Division ; Northumberland and Cumberland Division ; Durham Division , North Eastern Division ; North Western Division ; East Midland Division ; West Midland and Southern Division ; South Western Division, 1076
Mines and Quarries Accidents in, 1076
Mining and Metallurgy, Institution of . Election of A. R O. Williams as president for 1961-62, 994
Minnesota Mining and Manufacturing Co , Ltd. · Appointment of Dr. John D. Kendall as director of European research laboratories, 905
Minor Elements in Soils, *review* by A. H. Debnam, 629
Mirage of Health (Dr. René Dubos), *review* by Prof. E. Maurice Beckett, 633
Missing Link · Adventures with the (Prof. Raymond A. Dart, with Dennis Craig), *review* by Sonia Cole, 888
Mitchell, C. (Bakerman, Dr. S., and) : Infra-red Examination of the Association of Cornea Proteins with Water, 1033
Mitchell, G. F . Pleistocene History of the Irish Sea (Presidential Address to Section C (Geology) of the British Association for the Advancement of Science), 842
Mitchell, Prof. J. C. : Awarded the Rivers Memorial Medal of the Royal Anthropological Institute, 114
Mitochondria : Ageing of (Dr. C. H Gallagher), 162
  Cytochemical Evidence of the Origin of Lipid Bodies (so-called Golgi Bodies) from (H. C. Chopra), 713
  Melanin Granules and (Dr. Ruth V Baker, M. S. C. Birbeck, Dr. H. Blaschko, Prof T. B. Fitzpatrick and Dr. M. Seiji), 392
Mitochondria (Rat Liver) A High-Energy Phosphate Requirement for Succinate Oxidation in Uncoupled (Dr. Giovanni Felice Azzone and Dr Lars Ernster), 65
Mitochondrial Membrane Fractions : Sodium and Potassium in (Dr. Frank Ulrich), 949
Mitochondrial and Cell Water : Phosphoproteins and (Dr. J. D. Judah), 506
Mitosis in Lens Epithelium · Comparison between the Effects of Cysteine and of Anoxia on the Rate of (Dr. Antoinette Pirie and Dr. Ruth van Heyningen), 947
Mitsui, Tetsuo, and others Plant-Growth Activity of α-Alkylphenylacetic Acids and 1,2-Benzo-1-cycloalkene-3-carboxylic Acids, 694
Miwa, Tomoo, and others : Xylan of Siphonaceous Green Algae, 82
Mixed Disulphide (D-Penicillamine-Cysteine) : Formation of, by Reaction of D-Benzylpenicilloic Acid with Cystine (Dr. Bernard B Levine), 940
Mixed Solvent Systems · Activity of Bovine Pancreatic Ribonuclease A in (Dorothy Findlay, Dr. A. P. Mathias and Dr. B. R. Rabin), 601
Mixtures of Hard Spheres : Packing of (Prof. Paul C. Mangelsdorf, Jun , and Elmer L. Washington), 930
MNSs Gene Frequencies in English Blood Donors (Dr. T. E. Cleghorn), 701
Moata · Australia's Second Atomic Reactor, 741
Mockler, R. C , and others . A Comparison of Atomic Beam Frequency Standards, 681
Mode of Action of Micrococcal Phosphodiesterase (Dr K. K. Reddi), 74
Mode of Action of Soluble Matrix Anti-fouling Compositions (A. Partington), 1105
Mode of Formation of 3,4-Benzopyrene in Human Environment (Prof. G. M. Badger, R. W. L. Kimber and T. M. Spotswood), 663
Model, Y. M., and Nudelman, A. V. : The Glacial Cover of the Antarctic, as determined by Seismic Survey, 287
Modèles du Noyau : Les (Michel Trocheris), *review* by Dr. J M. Soper, 979
Models (Molecular and Crystal Structure) : Bibliography on (Deane K. Smith), (United States National Bureau of Standards, Monograph No. 14), 903
Modern Education : Evolution of, *review* by Dr. James L. Henderson, 357
Modern Methods of Crystal Structure Determination (Manchester College of Science and Technology Summer School in), 201
Modern Schools (Secondary) . Science Teaching in (Science Masters' Association Survey on), 206
Modern Science : Causation and, *review* by Dr. J. O. Wisdom, 92
Modernization of the Stockholm Cyclotron, 381
Modes (Rare), in the Spontaneous Fission of Californium-252 (Prof. E. W. Titterton and T. A Brinkley), 228
Modification of the Neurocranium in *Zygaena malleus* and the Nature of the Optic Stalk in Selachii (Dr. A. R. Hamdy), 257
Modification (Hexagonal), of Black Chromium Electro-deposit (Hideya Okada and Takeo Ishida), 496
Modification (Ionospheric), of the Radio Emission from Jupiter (Prof. Alex G. Smith, T. D. Carr, H. Bollhagen, N. Chatterton and F. Six), 568
Mohanrao, Dr. G. J., and others : Fall-out Caesium in Surface Sea Water off the California Coast (1959-60) by Gamma-Ray Measurements, 480
Molecular Basis (Chemical and), of Nerve Activity (David Nachmansohn), *review* by Dr. D. H. Brinton, 447
Molecular Complex of Benzene and Hexafluorobenzene (Dr. C R. Patrick and G. S Prosser), 1021
Molecular Geometry, *review* by Dr. J. W. Cook, 812
Molecular Structure : The Determination of (P. J. Wheatley), *review* by Dr. J. W. Cook, 812
Molecular Weight (High) : Gas-Solid Chromatographic Separation of Hydrocarbons of (C. G. Scott and D A. Rowell), 143
Molecular Weight (Lower) : Determination of Fatty Acids of, by Gas Chromatography (Marie L. Vorbeck, Leonard R. Mattick, Frank A. Lee and Carl S Pederson), 689
Molecular and Crystal Structure Models : Bibliography on (Deane K. Smith), (United States National Bureau of Standards, Monograph No. 14), 903
Molecules (Lithium and Sodium) · Excited Electronic States of (Dr. R F. Barrow, N Travis and C. V. Wright), 141
Molecules (Non-ionized) · Viscosity Increments of (Alfred Polson), 482
Molten Salts : 'Enthalpy Titrations' and Thermochemistry in (Prof. Joseph Jordan, Jurg Meier, Edward J. Billingham, jun , and James Pendergrast), 318
Molybdenum and Strontium : Atomic Absorption Spectrophotometric Determination of (D. J David), 1109
Moncaster, M. E., and others : Gallium Arsenide for γ-Ray Spectroscopy, 405
Monetary Thought and Monetary Policy in England (Prof. R. S Sayers), 844
Monkey : Effects of Medial Temporal Lesions on Taste Preference in the (Dr L Weiskrantz), 879
Monoamine Oxidase : New Inhibitor of (Dr. J. D. Taylor, A. A. Wykes, Y C. Gladish and W. B. Martin), 941
Monoamine Oxidase Inhibitor : Anti-Fertility Action of a (W. G. Spector), 514
Montagu, Prof Ashley : Artificial Thickening of Bone and the Piltdown Skull, 174
Montague, Dr. M. D , and Morton, Prof R. K. : Chemical and Physical Properties of the Small Deoxyribonucleic Acid Component of Crystalline Cytochrome B_2, 916
Montefinale, Dr. Alberto (Papée, Dr Henry M., and) · Change of the Chlorine—Sodium Ratio in the Atmosphere with Altitude and Distance from the Source of Sodium Chloride, and the Distribution of Atmospheric Nitrate over the United States, 1103
Monteith, Dr. J. L. : Weather Problems in Agriculture (The Carbon Dioxide Flux over a Field of Sugar Beet), 995
Months (Final), and Descent of Satellite *Sputnik* 3 (B. R. May and D. E. Smith), 456
Montmorillonite (Lithium) . Effect of Surface Density of Charge on the Physical Swelling of (Dr. J. P. Quirk and B. K G. Theng), 967
Montmorillonite and Vermiculite (Clay Minerals,) · Aluminium Interlayers in—Laboratory Synthesis (B. L. Sawhney), 261
Moon Radar Determination of the Scattering Properties of the (Dr. Fred B. Daniels), 399
Moon as a Radar Reflector : Roughness of the (Dr. B. H. Briggs), 466, 490
Moore, Prof H. : *Obituary* by Prof R W. Douglas, 1074
Moore, Howard K. (edited by William G Chace and) : Exploding Wires—Based on Conference on the Exploding Wire Phenomenon, 1959, conducted by Geophysics Research Directorate of the Air Force Cambridge Research Center, with the co-operation of Lowell Technological Institute Research Foundation), *review* by Dr. B A. Thrush, 726
Moore, Dr. N. W., and others : Dragonflies, *review* by Dr. D. E. Kimmins, 631
Moore, W. C. : The Plant Pathology Laboratory, Harpenden, 21
Moores, John : At the sixty-sixth Annual Conference of the Museums Association (Relations of Museums and Industry), 657
Moran, Dr. T. (Hinton, Dr. J. J. C., and) : Plant Hormone Activity—Stilboestrol applied to the Wheat Seedling, 258
Morant, M. J. Photo-Injection of Charge into Dielectric Liquids, 48
Mordarska, H., and others : Anti-neoplastic Activity of Tetrahydro-1,3-oxazine Derivatives, 426
Mordarski, M., and others : Anti-neoplastic Activity of Tetrahydro-1,3-oxazine Derivatives, 426
Morgan, Councilman, and others : Use of Ferritin-conjugated Antibody to Localize Antigen by Electron Microscopy, 1094

Morgan, M. B.: Appointed deputy controller of aircraft (research and development) in the Ministry of Aviation, 646; work of, 646

Moritz, A. G.: Awarded an Overseas Scholarship for 1960 by the Royal Commission for the Exhibition of 1851, 116

Morphine, Dihydrocodeine and Aminopyrine Analgesia: Synergetic Action of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on (Dr. E. Fischer, J. L. J. Szabó and M. Stamburgo), *erratum*, 559

Morphogenetics of *Micrasterias americana* in Clone Culture (Prof. Paavo Kallio), 164

Morphology (Vertebrate): A Manual of Practical (J. T. Saunders and Dr. S. M. Manton), third edition, *review* by Dr. N. B. Marshall, 9

Morpurgo, Dr. Paul: Appointed Leverhulme Research Fellow in the sociology of nutrition at Queen Elizabeth College, London, 201

Morris, R. N.: Appointed lecturer in econometrics and social statistics at the University of Birmingham, 465

Morrison, Dr. J. W., abd Rajhathy, Dr. T.: Frequency of Quadrivalents in Autotetraploid Plants, 528

Morrow, F., and others: An Improvement in the Ductility of Beryllium at High Temperatures, 494

Morrow, Jr., James E. (Olsen, Y. H., and): Oceanography of Long Island Sound—Guide for Preparing Figures, 123

Mortality (Late Larval and Pupal), in the Wild: Radioactive Labelling of Lepidopterous Larvae—a Method of estimating (L. M. Cook and Dr. H. B. D. Kettlewell), 301

Morton, A. G., and others: Radioactive and Natural Strontium in Human Bone (Atomic Energy Research Establishment, *R*23246), 994

Morton, Maurice (edited by): Introduction to Rubber Technology, *review* by Dr. W. F. Watson, 359

Morton, Prof. R. K. (Montague, Dr. M. D., and): Chemical and Physical Properties of the Small Deoxyribonucleic Acid Component of Crystalline Cytochrome b_2, 916

Mosaic Virus (Cucumber) Infection Process: Direct Infra-Red Spectral Analysis of the (Prof. G. W. Cochran, G. W. Welkie and J. L. Chidester), 1049

Mosaic Virus (Tobacco): Polyphenol Oxidase Activity of *Nicotiana glutinosa* Leaves infected with (Dr. Masatake Kikuchi and Akira Yamaguchi), 1048

Mosaic Virus (Tobacco) Protein: A Difference between the Sub-Units of ? (Dr. H. G. Aach), 75

Moscardó, Salvador Oliver: Awarded a Spanish fellowship by the Ramsay Memorial Fellowship Trustees, 832

Moscow Physiological Society (U.S.S.R.-Great Britain Society and the): Joint Meeting to celebrate the centenary of the births of W. M. Bayliss and J. S. Haldane, 912

Moser, C., and others: Quantum Chemistry—Methods and Applications, *review* by Prof. H. C. Longuet-Higgins, 541

Mosquito: The Yellow Fever, *review* by Prof. V. B. Wigglesworth, 813

Mosquitoes (Nulliparous): Recognition of, without Dissection (Dr. Philip S. Corbet), 525

Moss, A. A. (Claringbull, Dr. G. F., and): The Enkomi Silver Cup, 1051

Motion (Rotational), of a Rigid Body: Effect of a Resisting Couple on the (T. Nonweiler), 311

Motions: Stellar (Dr. R. v. d. R. Woolley), 841

Motz, Dr. H.: Grant of £500 from the Paul Instrument Fund (in supplement of a previous grant), for the construction of a linear accelerator working at 1·6 cm. (*J*-band), 291

Moullec, Dr. J., and others: Haptoglobin Types in 398 Blood Donors from Dakar (Senegal), 517

Mountains (Gobi): Tectonics of the (V. P. Solonenko and N. A. Florensov), 373

Mourant, Dr. A. E.,: Awarded the Huxley Memorial Medal for 1961 of the Royal Anthropological Institute, 114

Mourkides, G. A., and others: Non-Enzymic Reactions of Indoles with Coenzyme I, 374

Mouse: Dichorial One-Egg Twins in the (Dr. A. J. Bateman), 339

Mouse (Albino): A Transplantable Spontaneous Osteogenic Sarcoma observed in the Muscle Tissue of an (R. G. Herne, M. Gregoire and G. Rona), 1129

Mouse Ascites: Isolation of a Non-pathogenic Tumour-destroying Virus from (Dr. J. G. Bennette), 72

Mouse Ascites Cells: Uptake of Thymidine and Synthesis of Deoxyribonucleic Acid in (Dr. A. R. Crathorn and Dr. K. V. Shooter), 614

Mouse Eggs: Development of, beneath the Kidney Capsule (D. R. S. Kirby), 707

Mouse Kidney undergoing Compensatory Hypertrophy: Radiosensitivity of (Lieut. V. J. Rosen, Jun., and Dr. L. J. Cole), 612

Mouse (L1210) Leukaemia Cells: Effect of 6-Mercaptopurine on the Net in vitro Gas Production of Sensitive and Resistant (Dr. H. J. Woodliff), 156

Mouse Skin (Precancerous): Mast Cells and 5-Hydroxytryptamine in (Dr. R. E. Coupland and Dr. J. F. Riley), 1128

Mouse Tumours: Localization of a Halogenated Porphyrin in (K. I. Altman and Prof. K. Salomon), 1124

Mouth and Blastopore (Dr. Joan B. Williams), 1132

Moving Envelopes of Stars (Prof. V. V. Sobolev), translated by Sergei Gaposchkin, *review* by Prof. W. H. McCrea, 538

Mozley, Dr. Alan: Ecological Processes, *review* by W. H. Dowdeswell, 451

Mucoid Substances of the Aorta: Role of, in the Deposition of Lipids (Dr. S. Gero, Dr. J. Gergely, Dr. T. Dévényi, Dr. L. Jakab, Dr. J. Székely and Dr. S. Virág), 152

Mucosa (Gastro-intestinal): Action of some Surface-active Compounds on the (Dr. J. A. Nissim), 305

Mullaly, Terence: At the sixty-sixth Annual Conference of the Museums Association (Purchase of Art Objects for Museums), 657

Mullard Cryomagnetics Laboratory at Oxford, 25

Müller, Dr. Miklós, and others: Increase of Esterase Activity during Intracellular Digestion in a Histophagous Ciliate, 65

Muller, Paul (edited by): DDT—the Insecticide DDT and its Significance, Vol. 2, Human and Veterinary Medicine (Dr. W. J. Hayes, Jr., Dr. S. W. Simmons and Dr. E. F. Knipling), (edited by Dr. S. W. Simmons), *review* by Prof. D. S. Bertram, 271

Mullins, L., and Turner, D. T.: Analysis of Solubility Data to estimate Small Amounts of Chain Fracture during the Cross-linking of Rubber, 145

Multiple Nature of Cellulase of *Myrothecium verrucaria*: Evidence for (P. Y. F. Prins-van der Meulen and G. J. Schuringa), 695

Munro, Dr. G. H.: Ionospheric Information from Satellite Signals, 1017

Muramic Acid and other Amino-Sugars: Glucosamine Values of, by the Elson and Morgan Method (R. E. Strange), 38

Murine Hepatitis Virus: Protection against Liver Injury due to (Dr. J. D. Judah, G. Bjotvedt and T. Vainio), 507

Murdock, W. W.: Awarded a Nature Conservancy Research Studentship for post-graduate training in Ecology (Zoology), 742

Murine Leukaemia: Bone Marrow Depression in (James T. Duhig), 71

Murphy, A. J., and Kennedy, A. J.: Combustion and Propulsion—High Mach Number Air-breathing Engines (Materials Problems raised by the Very High Temperatures of Hypersonic Air-breathing Engines), 21

Murphy, Dr. Gardner: Human Potentialities, *review* by Dr. D. J. West, 270

Murphy, I. C., and others: Preliminary Psychomotor Stress Studies with Subnormal Psychopathic Subjects, 172

Murphy, M. A.: Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Zoology), 742

Murray, Dr. R. W.: Electrical Sensitivity of the Ampullae of Lorenzini, 957

Murray, Dr. W. L.: Theory of High Explosives, *review*, 539

Murthy, D. V.: Insects attacking *Striga*, 959

Musa ensetaformis Berry: *Ensete berryi*— Revised Name for (R. K. Jain), 342

Muscle (Anterior Byssus Retractor), of *Mytilus edulis*: The Membrane Potential of the (Dr. D. H. Paul), 1121

Muscle (Heart), of the Rat and some other Mammals: Potentiation of Contractility in the (Dr. V. Kruta and Dr. P. Braveny), 327

Muscle (Nerve—Smooth) Transmission: Autonomic (G. Burnstock and Mollie E. Holman), 951

Muscle (Striated): A Hypothesis of Contraction in (Dr. M. Spencer and Dr. C. R. Worthington), 388

Muscle (Vascular): Effect of the Cations of the Lyotropic Series on the Tension of (Prof. L. Laszt), 329

Muscle Tissue of an Albino Mouse: A Transplantable Spontaneous Osteogenic Sarcoma observed in the (R. G. Herne, M. Gregoire and G. Rona), 1129

Muscle Twitch and Tetanus: *p*H Changes during (A. Distèche), 1119

Muscles (Calcium-deficient): Restoration of Membrane Excitability of, by Anodal Polarization (Prof. K. Koketsu and K. Noda), 243

Muscular Disease Myasthenia gravis (E. R. Bickerstaff and A. L. Woolf), 28; (Violet MacDermot), 28

Muscular Dystrophy Association of America: Grant of 7,000 dollars to the Department of Biomolecular Structure in the University of Leeds, 465

Muscular Type. Visco-elastic Behaviour of Blood Vessels of the (V. Harding and Prof. L. Laszt), 330

Muscular Weakness in Rats: Production of, by a Creatine Analogue (Coy D. Fitch and Prof. James S. Dinning), 421

Museum of Applied Science of Victoria, Melbourne: Annual Report for 1958-59, 372

Museum of English Rural Life: Report for 1959, 26

Museum (National), of Wales: Exhibit to illustrate the interchange of animal species between Wales and some of the Commonwealth Countries, 831

Museum (South African): *Annals* of the, Vol. 45, Part 3, 199

Museum (South Australia): Annual Report for 1958-59, 287

Museums Association: Sixty-sixth Annual Conference, 657

Mushroom Growing (Ministry of Agriculture, Fisheries and Food, Bulletin No. 34), seventh edition, 902

Mutagenesis: Mechanism of Formaldehyde-induced—the Uniqueness of Adenylic Acid in the Mediation of the Mutagenic Activity of Formaldehyde (Dr. Thomas Alderson), 485

Mutagenic Activity of Formaldehyde: Mechanism of Formaldehyde-induced Mutagenesis—the Uniqueness of Adenylic Acid in the Mediation of the (Dr. Thomas Alderson), 485

Mutant (A Bacterial), with Impaired Potassium Transport (Dr. Stanley G. Schultz and Dr. A. K. Solomon), 802

Mutant (Polyoma Virus), with a Reduction in Tumour Formation (Dr. Leo Sachs and Dan Medina), 715

Mutant (Streptomycin-dependent), of *Escherichia coli* grown in Limited Amount of Streptomycin: Absence of Carbon Monoxide-sensitive Respiration in a (Hanna Engelberg and Dr. M. Artman), 801

Mutants (Streptomycin-resistant), of *Bacillus subtilis*: Appearance of New Deficient Characters in (Masaaki Kohiyama and Yonosuke Ikeda), 168

Mutation (Brown): Occurrence of a, in the Syrian Hamster (Roy Robinson), 170

Mutations affecting the Density of Bacteriophage λ (G. Kellenberger, M. L. Zichichi and J. Weigle), 161

Myasthenia gravis: The Muscular Disease (E. R. Bickerstaff and A. L. Woolf), 28; (Violet MacDermot), 28

Mycological Conference: Sixth Commonwealth (Commonwealth Mycological Institute), 834

Mycological Institute (Commonwealth): Sixth Commonwealth Mycological Conference, 834

Myers, Charles S. (Harbison, Frederick, and): Management in the Industrial World—an International Analysis, 537

Myers, Dr. D. K.: Synthesis of Diphosphopyridine Nucleotide in Irradiated Rats, 1124

Myrbäck, Prof. Karl: Elected a member of the Chemistry section of the Leopoldina Academy of Natural Sciences, 1079

Myoglobin: Nature of the Haem-binding Groups in Native and Denatured Haemoglobin and (Dr. Joan Keilin), 365

Myrothecium verrucaria: Evidence for Multiple Nature of Cellulase of (P. Y. F. Prins-van der Meulen and G. J. Schuringa), 695

Mythical Science: A, *review* by Dr. K. O. L. Burridge, 7

Mythology (Primitive): The Masks of God— (Dr. Joseph Campbell), *review* by Dr. K. O. L. Burridge, 7

Mytilus edulis: The Membrane Potential of the Anterior Byssus Retractor Muscle of (Dr. D. H. Paul), 1121

NACHMANSOHN, David : Chemical and Molecular Basis of Nerve Activity, *review* by Dr. D H. Brinton, 447
Naito, K., and others : Summative Action of Acetylcholine with Physiological Stimulus on the Generator Potential in the Lateral Eye of the Horseshoe Crab, 1118
Nakai, Takashi, and others : Tumour-promoting Effect of Excessively Large Doses of Oral Griseofulvin on Tumours induced in Mice by Methylcholanthrene, 335
Nakajima, Koichi, and Koda, Prof Shigeyasu : Borrmann Effect observed in an Aluminium Single Crystal, 53
Nakajo, Prof. Seiichi (Tanaka, Katuhide, and) : Oxytocin in the Neurohypophysis of the Laying Hen, 245
Nakao, Makoto, and others : Adenosine Triphosphate and Maintenance of Shape of the Human Red Cells, 945
Nakao, Toshiko, and others : Adenosine Triphosphate and Maintenance of Shape of the Human Red Cells, 945
Name (Revised), for *Musa ensetaeformis* Berry : *Ensete berryi*— (R. K. Jain), 342
National Academy of Sciences (United States) : Election of Foreign Associates, 198
National Academy of Sciences, United States (National Research Council) : Formation of a Committee on Chemical Control of Agricultural Pests and Conservation of America's Wild-Life, 114
  The Biological Effects of Atomic Radiation, 380
  Publication No 718, More Effective Organization and Administration of Materials Research and Development for National Security, 470
  Publication No 713, Digest of Literature on Dielectrics, Vol. 22, 1958 (edited by R. A Sodermann and L. F Frisco), *review* by S. Weintroub, 728
  Appointment of Prof Robert C Elderfield as chairman of the Division of Chemistry and Chemical Technology, 647
  Appointment of Dr. Edward P. Espenshade, jun., as chairman of the Division of Earth Sciences, 647
  Appointment of Dr Emil W. Haury as chairman of the Division of Anthropology and Psychology, 647
  Appointment of Prof J. Barkley Rosser as chairman of the Mathematics Division, 647
  Annual Report for 1958-59, 749
  Nuclear Science Series, Report No. 29 (Publication No. 752) : Penetration of Charged Particles in Matter—Proceedings of an Informal Conference, Gatlinburg, Tennessee, 1958 (edited by A. Vehling), 1086
National Academy of Sciences (United States)—National Research Council (International Union of Nutritional Sciences of the), and others : Fifth International Congress on Nutrition, 201
National Agricultural Advisory Service : Appointment of V. Cory as county advisory officer for Yorkshire (West Riding), 1079
National Bureau of Standards (United States). Monograph No. 14, Bibliography on Molecular and Crystal Structure Models (Deane K. Smith), 903
  Monograph No. 10, The Helium-4 Scale of Temperature (F. C. Brickwedde, H. van Dijk, M. Durieux, J. R Clement and J. K. Logan), 1077
National Central Library : Book-buying Policy of the (S. P. L. Filon), 992
National Centre of Atmospheric Research (United States) : Appointment of Dr Walter Orr Roberts as director, 200
National Chemical Laboratory, Teddington . Report for 1959, 902
  Open Days, 994
National Committee for Physics (Swedish) : Tenth General Physics Conference, 557
National Conference for the Preservation of the Countryside (Council for the Preservation of Rural England), 559
National Council for Technological Awards : Report for 1959-1960, 286
National Engineering Laboratory : Open Days (R I. Lithgow), 899
  Symposium on Flow Measurement in Closed Conduits, 905
National Film Archive : Catalogue, Part 2, Silent Non-Fiction Films (1895-1934), 199
National Institute for Medical Research : Appointment of Prof. P. B. Medawar as director, 374, 991
National Institute for Research in Dairying : Report for 1959, 909
National Institutes of Health (United States) : Appointment of Dr. J. H. Gerber as director of the Center for Aging Research, 374
  Tenth Annual Instrument Symposium and Research Equipment Exhibit, 559
National Laboratory (Oak Ridge) . Joint Conferences on Analytical Chemistry in Nuclear Reactor Technology and Nuclear Reactor Chemistry, 994
National Lending Library for Science and Technology, 992
National Library, Calcutta (compiled by) . Bibliography of Indian Scientific and Technical Publications (Council of Scientific and Industrial Research, New Delhi), 199
National Museum of Wales : Exhibit to illustrate the interchange of animal species between Wales and some of the Commonwealth Countries, 831
National Observatory, Kitt Peak, Tucson, Arizona : Financial support from the United States National Science Foundation for the construction of, 910
National Park : The Serengeti (Sir Landsborough Thomson), 174
National Physical Laboratory : Open Days (H. G. Short), 454
National Radio Astronomy Observatory, Green Bank, West Virginia : Financial support from the United States National Science Foundation for the construction of, 910
National Research Council of Canada and the Chemical Institute of Canada : Tenth High Polymer Forum, 117
National Research Council, United States (National Academy of Sciences) : Formation of a Committee on Chemical Control of Agricultural Pests and Conservation of America's Wild-Life, 114
  The Biological Effects of Atomic Radiation, 380
  Publication No. 718, More Effective Organization and Administration of Materials Research and Development for National Security, 470
  Appointment of Prof. Robert C. Elderfield as chairman of the Division of Chemistry and Chemical Technology, 647
  Appointment of Dr. Edward P. Espenshade, jun., as chairman of the Division of Earth Sciences, 647
  Appointment of Dr Emil W. Haury as chairman of the Division of Anthropology and Psychology, 647
  Appointment of Prof. J Barkley Rosser as chairman of the Mathematics Division, 647
  Publication No. 713, Digest of Literature on Dielectrics, Vol 22, 1958 (edited by R. A. Sodermann and L F Frisco), *review* by S. Weintroub, 728
  Annual Report for 1958-59, 749
  Nuclear Science Series, Report No. 29 (Publication No 752), Penetration of Charged Particles in Matter—Proceedings of an Informal Conference, Gatlinburg, Tennessee, 1958 (edited by A. Vehling), 1086
National Research Council (United States), International Union of Nutritional Sciences of the National Academy of Sciences, and others : Fifth International Congress on Nutrition, 201
National Science Foundation (United States) : Grant of 500,000 dollars to the University Corporation on Atmospheric Research to assist in establishing the United States National Centre of Atmospheric Research, 200
  Grants for Graduate Research Laboratories, 559
  Financial support for the construction of the National Radio Astronomy Observatory at Green Bank, West Virginia, and the Kitt Peak National Observatory, Tucson, Arizona, 910
National Security : More Effective Organization and Administration of Materials Research and Development for (United States National Academy of Sciences—National Research Council, Publication No. 718), 470
National Society for Clean Air : Year Book for 1960, 200
Native Plants (Australian), for Home Gardens (A E Brooks), *review* by Dr. R. Melville, 637
Native and Denatured Haemoglobin and Myoglobin : Nature of the Haem-binding Groups in (Dr. Joan Keilin), 365
NATO . AGARD fourth Colloquium on Combustion and Propulsion (High Mach Number Air-breathing Engines), 18
  Meetings of AGARD for the second half of 1960, 116
  Sixteenth Meeting of the Aero Space Medical Panel of AGARD, 994
  Avionics Panel of AGARD Symposium on Radio Navigation, 1079
NATO in the 1960's—the Implications of Interdependence (Alastair Buchan), 179
Natriferin, the Frog Water-Balance Principle and Arginine Vasotocin : Evidence for the Identity of (Prof Wilbur H Sawyer), 1030
Natural Forest . The Dangerous Concept of the (T R. Peace), 848
Natural History, Society for the Bibliography of : Sherborn Fund Facsimile No. I, Géographie des Plantes (Alexander von Humboldt et A Bonpland), 904
Natural Occurrence of Delayed-type Iso-hypersensitiveness (Dr. Jack R. Battisto), 69
Natural Products : The Chemistry of (Symposium on, sponsored by the International Union of Pure and Applied Chemistry, organized by the Australian Academy of Science), 1080
Natural Resources (Geonomy and), American Institute of : John Fleming Medal awarded to Dr. Maurice Ewing, 905
Natural Strontium (Radioactive and), in Human Bone (J. W. Arden, F. J. Bryant, E H. Henderson, G. D. Lloyd and A G. Morton), 994
Naturalist : Fossils for the, *review* by Prof. S. Simpson, 271
  The Second BBC (edited by Desmond Hawkins), *review* by B. J. G. Marchand, 728
Nature : Are the Laws of, Symmetrical ? (Prof. O R. Frisch), 638
  Fluorine Compounds in—the Distribution of Carbon-Fluorine Compounds in some Species of *Dichapetalum* (Sir Rudolph Peters and R. J. Hall), 573
Nature, Council for : Nature and Conservation in East Anglia, 649
Nature of Adenovirus Nucleic Acid . Site and (Dr. M A. Epstein and Dr. S. J Holt), 1050
Nature of the Haem-binding Groups in Native and Denatured Haemoglobin and Myoglobin (Dr. Joan Keilin), 365
Nature of the Optic Stalk in Selachii : Modification of the Neurocranium in *Zygaena malleus* and the (Dr. A. R. Hamdy), 257
Nature of the Primary Species in the Radiolysis of Aqueous Solutions : Effects of *p*H and the (J. T. Allen and Dr. G. Scholes), 218
Nature (Multiple), of Cellulase of *Myrothecium verrucaria* : Evidence for (P. Y. F. Prins-van der Meulen and G. J Schurings), 695
Nature (The Physical), of Plastic Flow (Dr J. J. Gilman), 374
Nature and Conservation in East Anglia (Council for Nature), 649
Nature and Man (John Hillaby), *review* by T. H. Hawkins, 979
Nature Conservancy : New Nature Reserve at Cwm Glas, Crafnant, 464
  Addition to the Newborough Warren Ynys Llanddwyn Nature Reserve, 464
  Addition to the Coed Rheidol Nature Reserve, 464
  Awards for 1960 of Research Studentships for postgraduate training in Ecology, 742
  The Bangor Research Station of the, 744
  Appointment of Dr. R. Elfyn Hughes as director of the Bangor Research Station, 744
Nature Conservation in Wales, 464
Nature Reserve : Coed Rheidol (Nature Conservancy), 464
  Newborough Warren Ynys Llanddwyn (Nature Conservancy), 464
Nature Reserve (New), at Cwm Glas, Crafnant (Nature Conservancy), 464
Navigation : Radio (Avionics Panel of AGARD Symposium on), 1079
Navy : Basic Research in the (United States Department of Defense, Department of the Navy, Naval Research Advisory Committee), (Report prepared by Arthur D. Little, Inc.), 178
Naval College (Royal), Greenwich . Nuclear Training Facilities at the (Prof J. Edwards), 545
Naylor, E. : A North American Xanthoid Crab New to Britain, 256
Neary, Dr. G J : Ageing and Radiation, 10
Necessary ? : Is Hyperconjugation (C N R. Rao), 913
Necrosis (Autogenous), in an *Antirrhinum* Species Hybrid (B. J. Harrison), 527
Necturus : Effect of Anti-Diuretic Hormone and Calcium on the Equivalent Pore Radius of Kidney Slices from (G Whittembury, N. Sugino and Dr. A. K. Solomon), 699
Nederlands Radiogenootschap, and others : International Symposium on Data Transmission, 290
Nederlandse Vereniging voor Electronenmicroscopie : European Regional Conference on Electron Microscopy, 29

Need for Educational Research, 883
Negative Ions : Isotopic Analysis of Silicon by Solid Source Mass Spectrometry using (Dr. D. C. Newton, J. Sanders and A. C. Tyrrell), 683
Negherbon, William O. : Handbook of Toxicology, Vol. 3, Insecticides, *review* by Prof. V. B. Wigglesworth, 544
Neglected Problem : Suicide—a, 207
Nemec, Prof. Pavel (Becina, Vladimir, and) : 'pH-Chromatography' of some Amphoteric Antibiotics, 1111
Neohexane : Hydrocracking of Neopentane and, over Evaporated Metal Films (Dr. J. R. Anderson and B. G. Baker), 937
Neonatal Humans (Premature) : Delayed-type Hypersensitivity in (Jonathan W. Uhr. Joseph Dancis and Charlotte Grantz Neumann), 1130
Neopentane and Neohexane : Hydrocracking of, over Evaporated Metal Films (Dr. J. R. Anderson and B. G. Baker), 937
Nephritogenic Streptococci : Immunological Relationships between the Rat Glomerulus and (A. S Markowitz, S. Howard Armstrong, jun., and Daniel S. Kushner), 1095
Neptunium (Uranium, Thorium, Plutonium,) : Crystal Chemistry of Simple Compounds of (E. S. Makarov), translated from the Russian by E. B. Uvarov, *review* by Dr. L. E. J. Roberts, 728
Nerve Activity : Chemical and Molecular Basis of (David Nachmansohn), *review* by Dr D. H. Brinton, 447
Nerve Fibres (Degenerating), in Birds : Effect of Cortisone on (Dr. P. Glees), 327
Nerve—Smooth Muscle Transmission : Autonomic (G. Burnstock and Mollie E. Holman), 951
Nervous System (The Central), and Behavior—Transactions of the Second Conference, Princeton, 1959 (edited by Mary A. B. Brazier), *review* by Dr. Henry Miller, 6
Netherlands Chemical Federation (Royal), and others : International Congress on the Technology of Plastics Processing, 559
Neumann, Charlotte Grantz, and others : Delayed-type Hypersensitivity in Premature Neonatal Humans, 1130
Neural Crest Cell (Amphibian) . Pterin Synthesis in the (Tadao Hama and Masataka Obika), 326
Neurocranium in *Zygaena malleus* : Modification of the, and the Nature of the Optic Stalk in Selachii (Dr A. R. Hamdy), 257
Neurohypophysis of the Laying Hen : Oxytocin in the (Katuhide Tanaka and Prof. Seiichi Nakajo), 245
Neuromuscular Junction (Crayfish) : Excitation at the, with Decreased Membrane Conductance (Dr. Josef Dudel and Prof. Stephen W. Kuffler), 246
A Second Mechanism of Inhibition at the (Dr. Josef Dudel and Prof. Stephen W. Kuffler), 247
Neuropathology and Psychiatry, Korsakov Journal of : English translation of, 649
Neuropharmacology—Transactions of the Fourth Conference, Princeton, 1957 (edited by Harold A. Abramson), *review* by Dr. D. H. Brinton, 447
Neuropsychiatric Research Unit of the Medical Research Council transferred from the Whitchurch Hospital, Cardiff, to the Council's Laboratories at Carshalton, 466
Neuropsychiatry : Recent American Research in, *review* by Dr. D. H. Brinton, 447
Neurosecretory Hypothalamic System : Antigonadotropic Function of the Pineal Gland and the Oxytocin of the (Prof. S.-M. Milcou and S. Pavel), 950
Neurospora crassa . Action of Nucleic Acids on the Inhibition of Growth by Actinomycin of (Dr. W. Kersten, Dr. H. Kersten and Prof. H. M. Rauen), 60
Neutral Carbohydrates : Presence of, in Human Aortic Tissue (Dr. Sv. Bertelsen), 411
Neutron Activation : Non-destructive Analysis of Selenium by, followed by Gamma-Ray Spectrometry (Dr. Minoru Okada), 594
Neutrons (Thermal) : Localization by Autoradiography at -195° C. of Radioactive Areas in Rats exposed to a High Flux of—Importance of Phosphorus-32 in Consecutive Internal Irradiation (Jean Chanteur and Pierre Pellerin), 472
New All-Transistor Digital Computer : *Leo III*, a (Leo Computers, Ltd.), 373
New American Observatories (V C Reddish), 910
New Benzothiadiazine Diuretic : A Potent (Dr. Richard M. Taylor and Martin M. Winbury), 603
New Bicyclopentyl Derivatives : Conversion of Cyclopentadiene into—Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy (C. F. Blakely, Dr. R. J. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662 ; Kinetics and Mechanism (C. F Blakely and Dr A. Wassermann), 662
New Biologian, No. 9 (Lancaster Royal Grammar School Natural History Society), 649
New British Analogue Computer, the *Radic* (The Redifon Company), 288
New Chemical Laboratories in the University of Sydney (Prof. R. J. W. LeFevre), 833
New Compounds for the Control of Water Evaporation (A. V. Deo, N. R. Sanjana, S. B. Kulkarni, M. K. Gharpurey and A. B Biswas), 870
New Deficient Characters in Streptomycin-resistant Mutants of *Bacillus subtilis* : Appearance of (Masamichi Kobiyama and Yonosuke Ikeda), 168
New Filmstrips (Educational Publications, Ltd , Wakefield), 832
New Frontiers in Optics and Spectroscopy (Pittsburgh Conference and the Optical Society of America Symposium on), 289
New Gas Chromatography Research Center (Barber-Colman Company, Houston), 289
New Horizons in Chemistry (Sir Alexander Todd), 819
'New' Human Blood Group Antigen, Sw^a (Dr T. E. Cleghorn), *erratum*, 743
New Hydrides of Iron and Osmium : Some (Dr. J. Chatt, F. A. Hart and R. G. Hayter), 55
New Inhibitor of Monoamine Oxidase (Dr. J. D. Taylor, A. A. Wykes, Y. C. Gladish and W. B. Martin), 941
New Laboratory of the Department of Metallurgy, University of Oxford, 105
New Limit to the Galactic Magnetic Field set by Measurements of the Zeeman Splitting of the Hydrogen Line (Dr R. D. Davies, C. H. Slater, W. L. H. Shuter and P. A. T. Wild), 1088
New Metabolite of Epinephrine and Norepinephrine in Liver and Kidney : Formation of a (Dr. M. Goldstein and Dr. S. B. Gertner), 147
New Method for the Differential Precipitation of Nucleic Acids from Aqueous Solutions (William G. Aldridge), 323
New Method for the Synthesis of Cyclic Ethers (L. F. Schmoyer and L. C. Case), 592
New Mexico (West-Central) : Anomalous Leads from a Selected Geological Environment in (William F Slawson and Carl F Austin), 400
New Nature Reserve at Cwm Glas, Crafnant (Nature Conservancy), 464
New Phase in a Silicon bearing 17 per cent Chromium, 8 per cent Nickel and 1 per cent Niobium Steel (M. J. O'Hara, D Wilkinson and R. T. Allsop), 407
New Plasma Confinement Geometry (James L. Tuck), 863
New Principle in Weaving, 27
New Proposal : Valence-Bond Structures—a (Dr. J. W. Linnett), 859
New Research Reactor . *Hector*, a (United Kingdom Atomic Energy Authority), 992
New Species of Green Sulphur Bacteria (V. V. Shaposhnikov, E. N Kondrat'eva and V. D. Federov), 167
New States : The Public Service in—a Study in some Trained Manpower Problems (Kenneth Younger), 971
New Study of the British Odonata, *review* by Dr D. E. Kimmins, 631
New Technique for Following Rapid Rates of Crystallization (J. H Magill), 770
New Treatise on Plant Physiology, *review* by Prof Walter Stiles, 889
New York Academy of Sciences . Annals, Vol. 85, Article 2, Freezing and Drying of Biological Materials (Dr. Harold T. Meryman, and 12 other Authors), 748
New York Academy of Sciences (Division of Anthropology), and the Research Institutute for the Study of Man : Conference on Culture, Society and Health, 658
New Zealand : The Polychaeta Family Longosomidae in (Prof G. A. Knox), 1131
University Education in (Prof. V J Chapman), 107
New Zealand Department of Scientific and Industrial Research : Appointment of Dr. F. F. Evison as superintendent of the Seismological Observatory, Wellington, 830
New Zealand Universities . Report of the Committee on, 107
New-born Mice : Fate of Homologous Adult Spleen Cells injected into (A. J. S. Davies and Sheila M. A. Doak), 610
New-Born Opossum (*Didelphis virginianam*) : Wound Healing in the (Prof. Matthew Block), 340
Newborough Warren Ynys Llanddwyn Nature Reserve : Addition to the (Nature Conservancy), 464
Newer Metals : The, *review* by Prof. A. G. Quarrell, 725
Newly Discovered Rock-Shelter Art in Malaya (J M. Matthews), 373
Newspaper (The English), since 1900 (F. Atkinson), 116
Newspapers (British Journals and) : Bibliography of, 116
Newstead, Prof. Gordon : General Circuit Theory, *review* by Prof. A. H. M. Arnold, 811
Newton, Dr. D. C , and others : Isotopic Analysis of Silicon by Solid-Source Mass Spectometry using Negative Ions, 683
Newton, Isaac : The Correspondence of (edited by Prof. H W. Turnbull), Vol. I, 1661-1675, *review* by Prof. L. Rosenfeld, 537
Niblett, Prof. W R. : Graduate Schools in British Universities, 560
Nickel and Cobalt: Determination of, by Atomic Absorption (J. E. Allan), 1110
Nickel (8 per cent), and 1 per cent Niobium Steel : A New Phase in a Silicon bearing 17 per cent Chromium, (M. J. O'Hara, D. Wilkinson and R. T. Allsop), 407
Nickel Orthosilicate : Olivine–Spinel Transition on (Dr A. E Ringwood), 1019
Nicol, Dr. D. S H W., and Smith, Dr. L. F. : Amino-Acid Sequence of Human Insulin, 483
Nicol, Dr. J. A Colin : The Biology of Marine Animals, *review* by Prof C. M. Yonge, 630
Nicol, Prof T. : Topographical Anatomy of the Dog, *review*, 451
Nicol, Prof. T., and others : Effect of some Aromatic Hydroxy Compounds on the Phagocytic Activity of the Reticulo-Endothelial System, 422
Effect of Three Compounds related to Diethylstilboestrol on the Phagocytic Activity of the Reticulo-Endothelial System, 1032
Nicolaides, E. D , and others : Synthesis and Biological Properties of L-Arginyl-L-Prolyl-L-Prolyl-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenlyalanyl-L-Arginine, an Octapeptide related to Bradykinin, 773
Nicotiana glutinosa Leaves infected with Tobacco Mosaic Virus : Polyphenol Oxidase Activity of (Dr. Masatake Kikuchi and Akira Yamaguchi), 1048
Nigeria : Use of Dieldrin in the Control of *Glossina palpalis* (R-D) in (J B Davies), 84
Nigeria's Feeding-Stuffs (V. A. Oyenuga), second edition, *review* by Dr. Richard Mellanby, 637
Nigeria (Northern) : Rock Shelter Paintings near Bauchi (Hamo Sassoon), 200
Night Sky in August, 289 ; in September, 650 ; in October, 1079
Niobium : Tantalum and (Dr. G. L. Miller), *review* by Prof. A. G. Quarrell, 725
Niobium Steel (1 per cent) : A New Phase in a Silicon bearing 17 per cent Chromium, 8 per cent Nickel and (M. J. O'Hara, D. Wilkinson and R. T. Allsop), 407
Nisbet, Dr J. D. : The Two Heredities, *review*, 446
Nisizawa, Kazutosi, and others : Xylan of Siphonaceous Green Algae, 82
Nisman, B., and Fukuhara, H. : Cytoplasmic Particles and their Role in Protein Synthesis (Mechanism of Protein Synthesis in Micro-organisms), 645
Nissim, Dr. J. A. : Action of some Surface-active Compounds on the Gastro-intestinal Mucosa, 305
Reduction of the Intestinal Absorption of Glucose, Methionine and Sodium Butyrate by the Cation Trimethylhexadecylammonium, 308
Nitrate (Atmospheric), over the United States : Change of the Chlorine—Sodium Ratio in the Atmosphere with Altitude and Distance from the Source of Sodium Chloride and the Distribution of (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Nitrate Ion : Effect of, on the Distribution of Sucrose in the Rat's Ventricle (S. T. Taketa, C. G. Alexander and Prof G. A. Feigen), 419
Nitration (Radiation-induced), of Aliphatic Hydrocarbons (Dr. Tyson Rigg), 933

Nitrogen and its Compounds : Utilization of, by Plants—Symposia of the Society for Experimental Biology, No 13 (edited by H K. Porter), *review* by Prof. Walter Stiles 815
Nitrogen Fixation : Copper and Cobalt in (Prof E. G. Hallsworth, S. B. Wilson and E. A. N Greenwood), 79
Nitrogen-supplying Power of Soils : Ammonia released on Treating Soils with *N* Sodium Hydroxide as a Possible Means of Predicting the (A H Cornfield), 260
Nitsan, J : Effect of Glutathione and Alloxan on the Photoperiodic Response of *Xanthium*, 81
Nixon, Dr D. A. Metabolism of ¹⁴C-Mesoinositol in the Rat, 77
Nixon, H. L. (Kassanis, B., and) : Activation of One Plant Virus by Another, 713
Nizamuddin, M., and Womersley, Dr H. B S. · Structure and Systematic Position of the Australian Brown Alga, *Notheia anomala*, 673
Noakes, G R. : Mass, Length and Time, *review*, 183
  The World Around Us, *review*, 975
Noda, K (Koketsu, Prof. K., and) Restoration of Membrane Excitability of Calcium-deficient Muscles by Anodal Polarization, 243
Nodule Bacteria Inhibition of, by an Antibiotic from Legume Seed Coats (J A. Thompson), 619
Noise in Factories (A. G. Aldersey-Williams), 1085
Noise (Geomagnetic), at 230 kc./s (L H. Dowden), 677
Nomenclature of the Keuper Series (P. A. Garrett), 868 ; (Dr. C. J Stubblefield), 869
Non-Cichlid Fishes in Lake Victoria : Breeding Sites of (Dr. Philip S. Corbet), 616
Non-Crystalline Structure in Solidified Gold–Silicon Alloys (W. Klement, jun., R. H. Willens and Prof. Pol Duwez), 869
Non-Destructive Analysis of Microgram Quantities of Silver by Radio-activation (Dr Minoru Okada), 57
Non-Destructive Analysis of Selenium by Neutron Activation followed by Gamma-Ray Spectrometry (Dr. Minoru Okada), 594
Non-Destructive Testing of Materials (British Council Course on), 1079
Non-Disjunction (Meiotic), in Man . Mechanisms of (John S. S Stewart), 804 ; (Dr. Curt Stern), 805
Non-Enzymic Reactions of Indoles with Coenzyme I (Prof S. G A. Alivisatos, G A. Mourkides and A. Jibril), 374
Non-Fibrous Deoxyribonucleoprotein (Water-soluble), from Calf Thymus Nuclei (Dr. Richard S Walsh), 943
Non-Ionized Molecules . Viscosity Increments of (Alfred Polson), 482
Non-Leukaemic Tissues of Thymectomized Mice Recovery of Leukaemogenic Agent from (J F. A P Miller), 703
Non-Linear Problems A Study of, *review* by K. Krickeberg, 727
Non-Linear Problems in Random Theory (Prof Norbert Wiener), *review* by K. Krickeberg, 727
Non-Parasitic Lampreys (Parasitic and) : Development of the Gonads in (M. W Hardisty), 341
Non-Pathogenic Tumour-destroying Virus ` Isolation of a, from Mouse Ascites (Dr J. G. Bennette), 72
Non-Residential Summer School on Numerical Analysis (Delegacy for Extra-Mural Studies, University of Oxford), 374
Non-Specific Haemagglutinin from Cellulose and Cellulose Ion Exchanger (Prof. B. Schmidt. Dr. K Grossgebauer and D. Hartmann), 790
Non-sporulating Yeast (An Acid-tolerant and), from Passion Fruit Juice (B. A. S. Rao and J. S. Pruthi), 342
Non-Static Systems : Astrophysics of, *review* by Prof. W. H. McCrea, 538
'Non-Tasters' ('Tasters' and), of 6-*n*-Propylthiouracil . Differential Reactivity of Saliva from (Frances Griffin and Prof Roland Fischer), 417
Nonanal as a Growth Factor for Wood-rotting Fungi (Prof. Nils Fries), 166
Nonanal Residues in Potatoes : Determination of (W. F. van Vliet and W. H Schriemer), 235
Nonweiler, T : Effect of a Resisting Couple on the Rotational Motion of a Rigid Body, 311
Noradrenaline labelled with Tritium : Effect of Cocaine on the Disposition of (Dr L. G. Whitby, G. Hertting and Dr. J Axelrod), 604
Noradrenaline to Adrenaline : Proportion of, in the Adrenal Glands of Litter-mate Cats (Dr. K. R. Butterworth and Dr. Monica Mann), 785
Norbury, Dr. J. F Appointed to a senior lectureship in fluid mechanics in the University of Liverpool, 117
Nordin, Albert A. (Bloch, Prof. Hubert, and) : Production of Tuberculin Sensitivity, 434
Norepinephrine in Liver and Kidney : Formation of a New Metabolite of Epinephrine and (Dr M Goldstein and Dr. S. B Gerstner), 147
Normal Human Sera : Immuno-Electrophoretic Differentiation of Haptoglobins from another Group-Specific Inheritable System in (Dr. Jan Hirschfeld), 126
Normal Urine : The Plasma Proteins in (Dr I. Berggård), 776
Normal and Leukaemic Subjects · Zinc Content of Erythrocytes and Leucocytes of Blood of (E. Dennes, R. Tupper and Prof A Wormall), 302
Normal (Superconducting-) Transition in Tin Films : Speed of the (D. J. Oliver, M. J. Rayner and E. H. Rhoderick), 492
Norman, Ulla (Revész, László, and) : Chromosome Ploidy and Radiosensitivity of Tumours, 861
Norrish, R. S. . Infra-Red Frequency Shifts, 142
North (David) Plant Research Centre, Brisbane (K. T Glasziou), 745
North African Prehistory, *review* by M. C. Burkitt, 1062
North America : Sap-Transmissible Viruses associated with Diseases of Grape Vines in Europe and (C. H. Cadman, H. F. Dias and B. D. Harrison), 577
North America, Arctic Institute of : Grant-in-Aid Programme, 831
North American Fresh-Water Biology, *review* by Dr. T. T. Macan, 6
North American Xanthoid Crab New to Britain (E. Naylor), 256
North Sea (Central) : A Quantitative Investigation of the Echinoderm Fauna of the (Dr. Erik Ursin), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 24), *review* by Dr A. J. Southward, 360
Northampton College of Advanced Technology, London : Advanced Course on Direction and Supervision of Scientific and Engineering Personnel, 905
Northern Africa : The Stone Age in (Dr. C. B. M. McBurney), *review* by M C. Burkitt, 1062
Northern Highlands : Scotland—the (Dr. J. Phemister), (Handbook of Regional Geology), third edition, 831
Northrop, D. C., and others Gallium Arsenide for γ-Ray Spectroscopy, 405
Norwegian Sea : Investigations on the Quantitative and Qualitative Distribution of Zooplankton in the Southern Part of the (V K. Hansen), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 23), *review* by Dr. A J. Southward, 360
Nose and Skin : Bacterial Population of the (H. Williams Smith and W. E. Crabb), 288
Not Enough · Chemistry is (Dr. James Taylor), 841
Notheia anomala (Australian Brown Alga) : Structure and Systematic Position of the (M. Nizamuddin and Dr H B. S. Womersley), 673
Novikoff, A. B. : Intracellular Localization of Enzymes, 836
Noyau . Les Modèles du (Michel Trocheris), *review* by Dr J. M. Soper, 979
Nucci, L M (Zipkin, M. A., and) : Combustion and Propulsion (High Mach Number Air-breathing Engines), 19
Nucléaires (Réacteurs) : Évacuation et Récupération de la Chaleur des (Richard Alami et Paul Ageron), *review* by R J. Syme, 636
Nuclear Energy Industry in France Electronic Equipment used in the (P. Desneiges, M. Doireau, L Koch and J. Weill), 1076
Nuclear Engineering Abstracts, Vol 1, No. 1, 993
Nuclear Fission in the Early History of the Earth (Prof P. K. Kuroda), 36
Nuclear Handbook (consulting editor, Prof. O. R. Frisch), *review* by K. E. B. Jay, 273
Nuclear Magnetic Resonance, *review* by Dr. L M. Jackman, 358
Nuclear Magnetic Resonance : High-resolution (J. A. Pople, W. G. Schneider and H. J. Bernstein), *review* by Dr. L. M. Jackman, 358
Nuclear Physics (Institute of Physics and the Physical Society Conference on), 832
  'Memories' for (G W Hutchinson), 854
Nuclear Physics Instruments : Application of Computer Techniques to (G G. Scarrott), 854
Nuclear Power (Ministry of Power Programme), 1055
Nuclear Power Plant Design : Evolution of (Sir Christopher Hinton), 1064
Nuclear Weapon Debris : Fractionation of (Prof. C. Sharp Cook, R. L. Mather, R F. Johnson and F M. Tomnovec), 1100
Nuclear Reactor Chemistry (Oak Ridge National Laboratory Conference on), 994
Nuclear Reactor Technology : Analytical Chemistry in (Oak Ridge National Laboratory Conference on), 994
Nuclear Research in the U.S.S.R., *review* by Dr S. C. Curran, 630
Nuclear Safety, Advisory Committee on . Appointment of an, 113
Nuclear Science . Annual Review of (edited by Emilio Segrè and Leonard L Schiff, in association with Gerhart Friedlander and Walter E. Meyerhof), Vol. 9, *review* by Dr. E. B. Paul, 182
  Progress in, *review* by Dr. E. B Paul, 182
Nuclear Sciences, Boris Kidrich Institute of : Bulletin, Vol. 10, 831
Nuclear Structure : International Conference on, 290
Nuclear Training Facilities at the Royal Naval College, Greenwich (Prof. J. Edwards), 545
Nucleated and Enucleated Fragments of *Amoeba proteus* : Effect of Pyruvate upon (Dr. Edmund Guttes and Sophie Guttes), 432
Nuclei (Atomic) : Theory of (Publication by the Physical Society of Japan of a volume of papers on), 743
Nuclei (Calf Thymus) : Water-soluble, Non-fibrous Deoxyribonucleoprotein from (Dr. Richard S. Walsh), 943
Nuclei (Somatic Cell) . Absorbance of Feulgen-stained (Dr. Symon Iversen), 86
Nucleic Acid in *T₂* Bacteriophage : Evidence for Internal Organization of (Irwin J. Bendet, David A. Goldstein and Max A. Lauffer), 781
Nucleic Acid (Adenovirus) : Site and Nature of (Dr. M. A. Epstein and Dr. S. J. Holt), 1050
Nucleic Acids : Action of, on the Inhibition of Growth by Actinomycin of *Neurospora crassa* (Dr. W. Kersten, Dr. H. Kersten and Prof. H. M. Rauen), 60
  The Biosynthesis of (Biochemical Society Colloquium on), 994
  Microbial Synthesis of Protein in relation to the Biogenesis of, with *Azotobacter vinelandii* as the Test Organism (Maharani Chakravorty), 239
Nucleic Acids from Aqueous Solutions : A New Method for the Differential Precipitation of (William G. Aldridge), 323
Nucleic Acids and Nucleoproteins : Chemical Effects of Ionizing Radiations on (P. Emmerson, Dr. G. Scholes, D. H. Thomson, J. F. Ward and Prof. J Weiss), 319
Nucleoprotein in the Cell Nucleus Selective Cytochemical Demonstration of Arginine Groups in (Dr. E. A Barnard and Dr L. G. E. Bell), 508
Nucleoprotein (Thymus) : Labilization of Deoxyribonucleic Acid in, after Whole-body Irradiation (Dr. Ulrich Hagen), 1123
Nucleoproteins : Chemical Effects of Ionizing Radiations on Nucleic Acids and (P. Emmerson, Dr. G. Scholes, D H. Thomson, J. F. Ward and Prof. J. Weiss), 319
Nucleotide (Diphosphopyridine) : Synthesis of, in Irradiated Rats (Dr. D. K. Myers), 1124
Nucleotide and Catecholamine Content of the Denervated Adrenal Medulla of the Rat : Effect of Reserpine on the (Prof. Nils-Åke Hillarp), 1032
Nucleotides (Pyridine), in Liver Poisoning : Levels of (Dr. C. H. Gallagher and Dr. K. R. Rees), 148
Nucleus (Cell) : Selective Cytochemical Demonstration of Arginine Groups in Nucleoprotein in the (Dr E. A Barnard and Dr L. G. E Bell), 508
Nucleus and Cytoplasm : The Relationship between—Proceedings of the Symposium held at the Université Libre de Bruxelles, 1958 (edited by Dr. R. J. C. Harris), *review* by Dr. E. N. Willmer, 450
Nudelman, A. V. (Model, Y. M., and) : The Glacial Cover of the Antarctic, as determined by Seismic Survey, 287
Nuffield Foundation : Grant of £50,000 to the Borough Road College, Isleworth, for a new science block to be known as the Nuffield Science Building, 371
Nuffield Foundation (a Study sponsored by the) : Principles for British Agricultural Policy (edited by H. T. Williams), *review* by Sir John Russell, 721
Nuffield Foundation (Royal Society and) Commonwealth Bursaries Scheme : Awards, 291
Nulliparous Mosquitoes : Recognition of, without Dissection (Dr. Philip S Corbet), 525
Nullius in verba, *review* by Dr. William P. D. Wightman, 356

Numerical Analysis (Delegacy for Extra-Mural Studies, University of Oxford, Non-residential Summer School on), 374
Numerical Data: Tables of Constants and, Vol. 11, Selected Constants—Optical Rotatory Power, 4, Alkaloids (Prof. J.-P. Mathieu and Prof. M.-M. Janot), *review* by Dr. J. Walker, 7
Nutrients: Foliar Application of, and Rhizosphere Microflora of *Camellia sinensis* (Dr. C. S. Venkata Ram), 621
Nutrition (International Union of Nutritional Sciences, the American Institute of Nutrition and the United States National Committee, and the International Union of Nutritional Sciences of the United States National Academy of Sciences—National Research Council fifth International Congress on), 201
Nutrition of the Legumes—Proceedings of the University of Nottingham Fifth Easter School in Agricultural Science, 1958 (edited by Prof. E. G. Hallsworth), *review* by Prof. Walter Stiles, 815
Nutrition, American Institute of: Election of Dr. W. R. Aykroyd as an honorary member, 29
  Election of honorary members, 374
Nutrition of Sows: Experiments on the (Dr. G. A. Lodge), 115
Nutrition Society (Scottish Group): Symposium on Food Habits in Britain, 905
Nutrition (Plant): Aspects of, *review* by Prof. Walter Stiles, 815
Nutritional Sciences, International Union of, of the United States National-Academy of Sciences—National Research Council, and others: Fifth International Congress on Nutrition, 201
Nutritive Values of Carbohydrates for the Silkworm, *Bombyx mori* (Dr. Toshio Ito), 527
Nutzenergie aus Atomkernen (Dr. Karl Rudolf Schmidt), *review* by K. R. E. Smith, 979
Nyholm, Prof. R. S., and others: Orienting Effects in Octahedral Aquation, 477
Nylander, Prof. Gunnar: Urinary Excretion of Œstrogens in Cases of Chronic Prostato-vesiculitis, 154

OAK RIDGE National Laboratory: Joint Conferences on Analytical Chemistry in Nuclear Reactor Technology and Nuclear Reactor Chemistry, 994
Oakley, Dr. Kenneth P.: Artificial Thickening of Bone and the Piltdown Skull, 174
Öberg, K. E. (Lindahl, Prof. P. E., and): Mechanism of the Physiological Action of Rotenone, 784
Oberry, J. L. (Connors, J. F., and): Combustion and Propulsion—High Mach Number Air-breathing Engines (Basic Studies on Air Intakes), 20
Obika, Masataka (Hama, Tadao, and): Pterin Synthesis in the Amphibian Neural Crest Cell, 326
Obligately Parasitic and Saprophytic Fungi: Incorporation of Acetate into Protein by (Dr. Richard C. Staples and Dr. H. P. Burchfield), 1040
O'Brien, Prof. R. N., and Rosenfield, C.: Possible Discovery of Ion-Pairs by Interferometry, 935
Obruchev, S. V.: The Problem of the 'Abominable Snowmen', 558
Observation (Direct), of Surface Contamination formed in Demountable Vacuum Systems (D. E. Bradley), 227
Observations of 'Whistlers' and 'Chorus' at the South Pole (Dr. L. H. Martin), 1018
Observations (Electrophysiological), on a Sound-producing Fish (A. Packard), 63
Observations (International Geophysical Year): Distribution of Atmospheric Ozone—a Preliminary Analysis of some (J. MacDowall), 382
Observatoires Astronomiques et les Astronomes (Fernand Rigaux), *review* by Dr. R. v. d. R. Woolley, 1063
Observatories: New American (V. C. Reddish), 910
Observatories (Cape and Royal Greenwich): Integration of the, 464
Observatory (National), Kitt Peak, Tucson, Arizona: Financial support from the United States National Science Foundation for the construction of, 910
Observatory (National Radio Astronomy), Green Bank, West Virginia: Financial support from the United States National Science Foundation for the construction of, 910
Observatory (Seismological), Wellington, New Zealand: Retirement of R. C. Hayes as superintendent, 24
  Appointment of Dr. F. F. Evison as superintendent, 830
Observing π-Mesonic X-Rays: The Method of (Dr. D. West), 853
Occurrence of a Brown Mutation in the Syrian Hamster (Roy Robinson), 170
Occurrence of Free D-Serine in the Earthworm (Dr. H. Rosenberg and Prof. A. H. Ennor), 617
Occurrence of Keto-Acids in Blood Serum and Urine of Cattle in comparison with Man, Horse, Sheep and Dog (Dr. C. J. G. van der Horst), 146
Occurrence of *Pyrosoma* on the Continental Slope (T. R. Cowper), 878
Occurrence of Spread F Echoes at Low Latitudes: Possibility of Detecting Ionospheric Drifts from the (R. W. Knecht), 927
Occurrence (Alleged), of the Perchlorate Ion in Sea-Water (R. Greenhalgh and Dr. J. P. Riley), 1107
Occurrence (Natural), of Delayed-type Iso-hypersensitiveness (Dr. Jack R. Battisto), 69
Occurrence (Possible), of Interference Systems in Virus-infected Plants (A. D. Thomson), 761
Occurrence and Function of the Provisional Embryonic Cuticle of a Lepidopteran (Dr. R. K. Sharan), 1040
Ocean: Introduction to the Theory of Sound Transmission with Application to the (Prof. C. B. Officer), *review* by Dr. A. B. Wood, 539
Ocean (Eastern Atlantic): Magnetization of Sediment Cores from the (M. J. Keen), 220
Ocean Currents in McMurdo Sound (A. E. Gilmour, W. J. P. Macdonald and F. G. Van der Hoeven), 867
Ocean (Indian) Expedition (Dr. G. E. R. Deacon), 561
Oceanographic Institution (Woods Hole): First Henry Bryant Bigelow Medal awarded to Dr. H. B. Bigelow, 647
Oceanographic Research: Intergovernmental Conference on, 647
Oceanographic and Fisheries Research by the Submarine *Severyanka* (V. P. Zaitsev), 559
Oceanography of Long Island Sound (Gordon A. Riley, Eugene Harris, Henry M. Schurr, P. T. Wangersky, Sarah W. Richards and R. Wade Covill); Guide for Preparing Figures (Y. H. Olsen and James E. Morrow, Jr.), 123
Ochterlony Technique using Antigen or Antiserum labelled with Iodine-131 (Joan M. Rhodes), 793
Octahedral Aquation: Orienting Effects in (Sir Christopher Ingold, Prof. R. S. Nyholm and Dr. M. L. Tobe), 477
Octapeptide related to Bradykinin: Synthesis and Biological Properties of L-Arginyl-L-Prolyl-L-Prolyl-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenylalanyl-L-Arginine, an (E. D. Nicolaides, H. A. DeWald, Patricia G. Shorley and Dr. H. O. J. Collier), 773
Odell, Dr. N. E.: Appointed to the chair of geology in the University of Peshawar, 905
Odonata (British): A New Study of the, *review* by Dr. D. E. Kimmins, 631
Oedipus and Job in West African Religion (Prof. Meyer Fortes), *review* by Michael Argyle, 96
17β-Œstradiol Dehydrogenases: Histochemical Localization of Human, Term Placental—Implications for the Transhydrogenase Reaction (Dr. Donald A. Kellogg and Dr. George G. Glenner), 763
Œstrogens: Urinary Excretion of, in Cases of Chronic Prostato-vesiculitis (Prof. Gunnar Nylander), 154
Officer, Prof. C. B.: Introduction to the Theory of Sound Transmission with Application to the Ocean, *review* by Dr. A. B. Wood, 539
Offshore Waters of the Sierra Leone River: Plankton of the Estuary and (V. Bainbridge), 557
O'Flaherty, Fred, and others (edited by): The Chemistry and Technology of Rubber, Vol. 2, Types of Tannages, *review* by Prof. A. G. Ward, 724
Ogston, Dr. A. G., and Phelps, C. F.: Exclusion of Inulin from Solutions of Hyaluronic Acid, 1024
O'Hara, M. J., and others: A New Phase in a Silicon bearing 17 per cent Chromium, 8 per cent Nickel and 1 per cent Niobium Steel, 407
Oil in Britain: Search for, 1078
Oil Drilling: Submarine (M. L. Kalinko), 903
Oil-immersion, Phase-contrast and Dark-ground Viewing of Thorotrast in Tissue Sections: Combined (Dr. E. W. Baxter), 162
Okada, Hideya, and Ishida, Takeo: Hexagonal Modification of Black Chromium Electro-deposit, 496
Okada, Dr. Minoru: Non-destructive Analysis of Microgram Quantities of Silver by Radioactivation, 57
  Non-destructive Analysis of Selenium by Neutron Activation followed by Gamma-Ray Spectrometry, 594
Olcott, Prof. H. S.: Physico-chemical, Biological and Applied Aspects of Autoxidation (Effects of Tocopherols in Autoxidizing Systems), 747
Oldfield, Prof. R. C.: Experiment in Psychology—a Centenary and an Outlook (Presidential Address to Section J (Psychology) of the British Association for the Advancement of Science), 846
Oldroyd, H.: South African Animal Life, *review*, 1063
Oligocene: The American (Dr. R. M. Stainforth), 678; (F. E. Eames, F. T. Banner, W. H. Blow and W. J. Clarke), 679
Oligochaete Fauna of Three Danish Brackish Water Areas (Ingerlise Dahl), (Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 26), *review* by Dr. A. J. Southward, 360
Oligotrich Protozoa (Rumen): Effect of Penicillin on the Maintenance of (G. S. Coleman), 518
Oliver, D. J., and others: Speed of the Superconducting-Normal Transition in Tin Films, 492
Oliver, Dr. J. H.: *Obituary* by N. Ingram Hendey, 111
Oliver, R., and others: Analysis of Metabolic Rates at the Cellular Level, 919
Oliver Memorial Fund: Annual Award for work on Blood Transfusion, 201
Olivine—Spinel Transition on Nickel Orthosilicate (Dr. A. E. Ringwood), 1019
Olsen, Y. H., and Morrow, Jr., James E.: Oceanography of Long Island Sound—Guide for Preparing Figures, 123
Olson, Prof. Robert E.: *Obituary* of Dr. Eric Ellenbogen, 554
Olsson, Dr. B. (Augustinsson, Dr. K.-B., and): A Genetically Determined Enzyme in the Pig, 924
Olszewska, Dr. M. J. (Brachet, Prof. J., and): Influence of Localized Ultra-violet Irradiation on the Incorporation of Adenine-8-^{14}C and DL-Methionine-^{35}S in *Acetabularia mediterranea*, 954
One-Egg Twins in the Mouse: Dichorial (Dr. A. J. Bateman), 339
O'Neill, Dr. L. A.: Physico-chemical, Biological and Applied Aspects of Autoxidation (Problems of Autoxidation in the Paint Industry), 748
Ontario Research Foundation: Annual Report for 1959, 567
Oosterbaan, R. A., and others: Structures of some Acetyl-serine Peptides from Acetyl-chymotrypsin, 596
Operating on Marine Gastropoda: 'Water Rigour' as an Aid when (Prof. B. J. Krijgsman and A. C. Brown), 69
Opinion: Fact and, *review* by Prof. O. L. Zangwill, 817
Opossum (*Didelphis virginianam*): Wound Healing in the New-Born (Prof. Matthew Block), 340
Oppenheim, A. K., and Stern, P. A.: Combustion and Propulsion—High Mach Number Air-breathing Engines (Applicability of Detonation Wave Studies to Hypersonic Combustion), 21
Optic Stalk in Selachii: Modification of the Neurocranium in *Zygaena malleus* and the Nature of the (Dr. A. R. Hamdy), 257
Optical Lever: Some Developments of the (Prof. R. V. Jones), 905
Optical Radiation in Ruby: Stimulated (Dr. T. H. Maiman), 493
Optical Rotatory Powers of Alkaloids, *review* by Dr. J. Walker, 7
Optical Society of America: English translation of the Russian journal *Optika i Spektroscopiya*, 199
Optical Society of America (Pittsburgh Conference and the): Symposium on New Frontiers in Optics and Spectroscopy, 289
Optically Active Forms of a Derivative of Tetra-substituted Sulphur (M. Barash), 591
Optics and Spectroscopy (English translation of the Russian journal *Optika i Spektroscopiya*), (Optical Society of America), 199
Optics and Spectroscopy: New Frontiers in (Pittsburgh Conference and the Optical Society of America Symposium on), 289
Optika i Spektroscopiya (English translation published by the Optical Society of America), 199
Optimal Games: Theory of (Prof. Alan S. C. Ross), 968
Optimal Protein Synthesis by Ascites Tumour Cells *in vitro* (Dr. M. J. Fraser), 1114

Oral Griseofulvin : Tumour-promoting Effect of Excessively Large Doses of, on Tumours induced in Mice by Methylcholanthrene (Louis L. Barich, Takashi Nakai, Jan Schwarz and Donna Jean Barich), 335
Orbital Period of *Sputnik 4* Satellite : The Sudden Discontinuity in the (B. R May and D. E Smith), 866
'Order of Magnitude'? . 'Dex' or (Prof J. B. S. Haldane), 879
Ore Minerals : Spectral Reflectivity of (I. Gray and Dr. A. P. Millman), 282
Organ (Gene's) in Ticks : Accessory Glands of (Dr B. Feldman-Muhsam and Y. Havivi), 964
Organic Matrix of Tooth Enamel (J. E. Eastoe), 411
Organic and Inorganic Forms Bacterial Effect and Radiophosphorus Assimilation in, in Salmon (Dr. P. N Srivastava), 83
Organism (Test) : Microbial Synthesis of Protein in relation to the Biogenesis of Nucleic Acids with *Azotobacter vinelandii* as the (Maharani Chakravorty), 239
Organism and Milieu : Cell, (edited by Prof. Dorothea Rudnick), (Seventeenth Symposium of the Society for the Study of Development and Growth), *review* by Dr. E. N. Willmer, 450
Organization for European Economic Co-operation (European Productivity Agency) Discussion on Scientific Research into Road Safety, 116
Organization for European Economic Co-operation (European Productivity Agency), and the Centre d'Études Nucléaires : International Information Centre for Food Irradiation, 741
Organization (Internal), of Nucleic Acid in T_2 Bacteriophage : Evidence for (Irwin J. Bendet, David A Goldstein and Max A. Lauffer), 781
Organization and Administration of Materials Research and Development for National Security . More Effective (United States National Academy of Sciences—National Research Council, Publication No. 718), 470
Organization and Financing of Research in Biochemistry and Allied Sciences (Biochemical Society and the British Association for the Advancement of Science Colloquium on), 650
Organs (Chordotonal), in Crustacea (Dr. Mary Whitear), 522
Orgel, Dr. L E. . Structure of the Trinuclear Basic Acetates, 504
Orienting Effects in Octahedral Aquation (Sir Christopher Ingold, Prof. R S. Nyholm and Dr. M. L Tobe), 477
Origin of Angiosperms (Prof T M. Harris), 847
Origin of Lipid Bodies (so-called Golgi Bodies) from Mitochondria Cytochemical Evidence of the (H C. Chopra), 713
Origin of the Solar System (Dr. M. M Woolfson), 47 ; (M. H Briggs), 1102
Origin of Tektites (Prof. H. C. Urey), 855
Origin (Axial), of the Terminal Inflorescence in the Genus *Trifolium* (Yvonne Aitken), 622
Origin (A Possible), of Exo-Electron Emission in Plastically Deformed Metals (Dr. A. H. Meleka and W. Barr), 232
Orians, F Barbara, and Brodie, Dr. Bernard B. . A Suggested Effect on Levels of Catecholamine in Brain produced by Small Doses of Reserpine, 1034
Orr, Lord Boyd : Elected an honorary member of the American Institute of Nutrition, 374
Ortho Effect influencing Fungitoxicity, Electronic Absorption Spectra, and Chemical Reactivity with Mercaptalbumin (Dr. H P. Burchfield and Eleanor E Storrs), 593
Orthosilicate (Nickel) : Olivine—Spinel Transition on (Dr. A. E. Ringwood), 1019
Osbaldiston, G. W . Awarded an A D. Allen Memorial Scholarship by the Animal Health Trust, 904
Oscillators (Caesium-controlled) . The 'GBR Experiment'—a Trans-Atlantic Frequency Comparison between (J. A. Pierce, G. M. R. Winkler and R. L. Corke), 914
Oscillatory Character of Amplitude Curves for Seismic Body Waves (Dr. J. Vanek and J. Stelzner), 491
Osgood, Dr. T. H : Influence of Editors, 121
Osinski, Dr. P. A : Steroid 11β-ol Dehydrogenase in Human Placenta, 777
Osmium . Some New Hydrides of Iron and (Dr J Chatt, F A. Hart and R G. Hayter), 55
Osmium Fixation : Induced Fluorescence with Acridine Orange, after (W. J. Randles), 964
Osmotic Regulation in the Larvae of some Euryhaline Diptera (D W. Sutcliffe), 331
Osteogenic Sarcoma : A Transplantable Spontaneous, observed in the Muscle Tissue of an Albino Mouse (R G. Herne, M Gregoire and G Rona), 1129
Ostrea edulis L. from the Limfjord : Conditioning, for Reproduction out of Season (I. A Aboul-Ela), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 25), *review* by Dr A. J. Southward, 360
Ottawa Symposia on Self-Regulation in Living Systems, 3, Tremor, 297
Ottway, G. C. . Elected president for 1960-61 of the Scientific Instrument Manufacturers' Association, 742
Outlook : Experiment in Psychology—a Centenary and an (Prof. R. C Oldfield), 846
Output of Carbon Dioxide of Excised *Bryophyllum* Leaves : Effects of Light and Darkness on the Rhythm of (Dr Malcolm B Wilkins), 523
Output of Power in Great Britain, 557
Output of Scientists in Scotland, 1600-1950 (R. H S. Robertson), 372
Output (Carbon Dioxide) Effect of Electronarcosis on Oxygen Consumption and (Dr Jaroslav Strmiska and Dr Antonín Vacek), 151
Ovarian Maturation : Breeding of the Rabbit Flea, *Spilopsyllus cuniculi* (Dale)—Requirement of a 'Factor' from a Pregnant Rabbit for (A. R. Mead-Briggs and A J B Rudge), 1136
Ovarioles as a Meristic Character in Coleoptera (Dr. J. G Robertson), 526
Overseas Agricultural and Scientific Research, 556
  Food and Animal Production (British Association for the Advancement of Science, Section M (Agriculture), Discussion on), 1070
  Low-priced Books for, 741
  Welsh Emigration (Prof E. G Bowen), 843
Overseas Civil Service : House of Commons Adjournment Debate on the, 371
  Supplementary Pay and Allowances, 556
Overseas Development : Assistance from the United Kingdom for (H M. Treasury), 266
Oviduct of the Hen : Parallel Distribution of Calcium and Citric Acid in the (Dr. T. G Taylor and F. Hertelendy), 244
Owen, L. N. . A Rapid Method for Studying Tumour Blood Supply using Lissamine Green, 795
Owen, Prof Walter S. (Humphreys, J G., and) : An Iron–Silicon Carbide, 589
Owls in Illinois : Population Trends among Hawks and (Richard R. Graber and Jack S Golden), 999
Oxidase (Monoamine) New Inhibitor of (Dr. J D. Taylor, A A Wykes, Y. C. Gladish and W B Martin), 941
Oxidase (Monoamine) Inhibitor : Anti-Fertility Action of a (W. G. Spector) 514
Oxidase Activity (Polyphenol), of *Nicotiana glutinosa* Leaves infected with Tobacco Mosaic Virus (Dr. Masatake Kikuchi and Akira Yamaguchi), 1048
Oxidation of Coal : Initial Stages of (S. K. Chakrabartty, B. K Mazumdar and A. Lahiri), 502
Oxidation of Metals : The Corrosion and (Dr Ulick R. Evans), *review* by Dr. J. M. West, 182
Oxidation of Quinol Phosphates : Oxidative Phosphorylation—Synthesis of Adenosine Diphosphate by the (Dr V. M. Clark, D. W Hutchinson and Sir Alexander Todd), 59
Oxidation (Radiolytic), of Ferrous Solutions with Standardized Internal Sources of Phosphorus-32 (Dr. M Peisach and J. Steyn), 58
Oxidation (Succinate) in Uncoupled Rat Liver Mitochondria : A High-Energy Phosphate Requirement for (Dr Giovanni Felice Azzone and Dr. Lars Ernster), 65
Oxidative Phosphorylation—Synthesis of Adenosine Diphosphate by the Oxidation of Quinol Phosphates (Dr V. M. Clark, D W. Hutchinson and Sir Alexander Todd), 59
Oxide (Deuterium) . Ultra-violet Absorption Spectra of Proteins in (Dr. Shiro Takashima), 597
Oxide (Titanium) : A Symmetrical Fourfold Helical Fracture in (J. S. Jackson), 1104
Oxosteroids—the Use of Phenolic Hydrazides for Detection, Characterization and Estimation (Dr. Bernard Camber), *review* by Prof. G. A. D. Haslewood, 183
Oxygen : Role of, in the Cross-linking and Degradation of Deoxyribonucleic Acid by Ionizing Radiations (Peter Alexander and J T Lett), 933
Oxygen-15 Metabolism of (C. T. Dollery and J. B West), 1121
Oxygen Atoms : Recombination of, in the Gas Phase (P G Dickens, R D. Gould, Prof. J. W. Linnett and A. Richmond), 686
Oxygen Consumption and Carbon Dioxide Output : Effect of Electronarcosis on (Dr. Jaroslav Strmiska and Dr Antonín Vacek), 151
Oxygen Consumption Changes in Rats during Irradiation : Role of Initial Value of Metabolic Processes in (Dr A Vacek), 76
Oxygen Ions (High Energy), in Carbon Dioxide Mass Spectra (R M. S Hall), 683
Oxygen-18 Water Solutions (Highly Enriched), containing Hydrogen Peroxide-16,16 : Radiolysis of (Dr. Michael Anbar, Shmuel Guttmann and Prof. Gabriel Stein), 57
Oxytocin in the Neurohypophysis of the Laying Hen (Katuhide Tanaka and Prof Seiichi Nakajo), 245
Oxytocin of the Neurosecretory Hypothalamic System . Antigonadotropic Function of the Pineal Gland and the (Prof S.-M. Milcou and S Pavel), 950
Oyenuga, V A. Nigeria's Feeding-Stuffs, second edition, *review* by Dr. Richard Mellanby, 637
Ozaki, Dr., and Howarth, Dr. : Genetic Recombination in *Salmonella typhimurium* occurring during Transmission of Colicinogeny, 649
Ozone : Pure Rotational Absorption of, in the Region 125-500 Microns (Dr. H A. Gebbie, N. W B Stone and C. D Walshaw), 765
Ozone (Atmospheric) : Distribution of—a Preliminary Analysis of some International Geophysical Year Observations (J. MacDowall), 382

PACIFIC Island : Continuity in a Small, *review* by Sir Harry Luke, 816
Packard, A. Electrophysiological Observations on a Sound-producing Fish, 63
Packing of Mixtures of Hard Spheres (Prof Paul C Mangelsdorf, jun., and Elmer L Washington), 930
Packter, N M , and Glover, Dr. J. : Ubiquinone (50) and Ubichromenol in *Aspergillus fumigatus*, Fresenius, 413
Padmini, P. R K. L (Ramachandra Rao, Prof. B., and) : A Relation between Ultra-sonic Velocity and Latent Heat of Vaporization, 311
Page, Irvine H. (edited by) : Connective Tissue, Thrombosis and Atherosclerosis—Proceedings of a Conference held at Princeton, N J , 1958, *review* by Dr. G. S Boyd, 634
Pagot, J. (Bremaud, O , and) : Problems of the Arid Zones (Nomadism in relation to Grazing Resources—Moving of Flocks in the Sahelian Zone), 296
Paine, R. : At the second Annual Conference of the British Computer Society (A Common Computer Language), 655
Paintings (Rock Shelter), near Bauchi, Northern Nigeria (Hamo Sassoon), 200
Paints (Priming), for Metal : Potentiometric Study of (Dr. N. R Bharucha), 756
Pakistan to Ashoka . Early India and (Sir Mortimer Wheeler), *review* by M C. Burkitt, 94
Palmer, Margaret : Expanded Ilio-Sacral Joint in the Toad *Xenopus laevis*, 797
Paludina vivipara Lin (Snail) . Diplodiscus Species Parasitic in the (M. R Honer), 431
Panattoni, C , and others : Structure of $AgSCN.P(n\text{-}C_3H_7)_3$, 772
Pancreatic Ribonuclease A (Bovine) : Activity of, in Mixed Solvent Systems (Dorothy Findlay, Dr. A P. Mathias and Dr. B R. Rabin), 601
Papée, Dr. Henry M , and Montefinale, Dr. Alberto : Change of the Chlorine—Sodium Ratio in the Atmosphere with Altitude and Distance from the Source of Sodium Chloride, and the Distribution of Atmospheric Nitrate over the United States, 1103
Paper : Behaviour of, during Tensile Straining (A. E. Ranger and L F. Hopkins), 1097
Papyrus Swamps : Experimental Breeding of *Anopheles gambiae* Giles in (L. K H. Goma), 1137

- Paradoxical Blocking and Arousal in the Drowsy State (Dr. L. Goldie and Dr. J. M. Green), 952
- Paraffin : Crystal Growth in (R. J. Jaccodine), 498
- Parallel Distribution of Calcium and Citric Acid in the Oviduct of the Hen (Dr T. G Taylor and F Hertelendy), 244
- Parallelism of Changes produced by Cooling and by Drugs known to affect Adrenergic Mechanisms (Prof Eleanor Zaimis), 213
- Paramagnetic Resonance in Solids (William Low), (Solid State Physics—Advances in Research and Applications, Supplement 2), *review* by Dr. R O. Davies, 886
- Parameters (Electrodekinetic), at Metal Surfaces : Simultaneous Measurement of Adsorption and (A. M Peers), 503 ; (Dr. E. A. Blomgren and Dr J O'M. Bockris), 504
- Parasites as Enemies and Allies (Dr. J. Mahon), 203 ; (Prof. T. H. Davey), 203
- Parasites (Insect) : Immunity of Aphids to (D C Griffiths), 346
- Parasitic in the Snail *Paludina vivipara* Lm. : *Diplodiscus* Species (M R. Honer), 431
- Parasitic Helminths, *review* by Dr. G Lapage, 815
- Parasitic and Non-Parasitic Lampreys : Development of the Gonads in (M. W. Hardisty), 341
- Parasitic and Saprophytic Fungi (Obligately) : Incorporation of Acetate into Protein by (Dr. Richard C. Staples and Dr. H. P. Burchfield), 1040
- Parchments (British) : Follicle Remains in some (Dr. M. L. Ryder), 130
- Parent and the State : The Child, the (Dr James Bryant Conant), *review* by Brian Holmes, 635
- Paris Hospitals : Medical Research in the, 26
- Park : The Serengeti National (Sir Landsborough Thomson), 174
- Parker, Prof. Frank S., and Kirschenbaum, Prof Donald M. : Infra-Red Spectra of Amino-acids and related Substances in Water, 386
- Parker, Johnson : Survival of Woody Plants at Extremely Low Temperatures, 1133
- Parker, R. P., and others : Comparison of Fission Product and Beryllium-7 Concentrations in the Atmosphere, 550
- Parkes, Dr. A S. : Appointed to the newly established chair of the physiology of reproduction in the University of Cambridge, 113 ; work of, 113
  - Influence of Editors, 120
- Parrish, F. W., and Perlin, A S : Steric Factors affecting the Specificity of Polyglycosidases, 1110
- Parsons Memorial Lecture (1959) of the Physical Society (Dr C. R. Burch), 854
- Part-Time Courses in Further Education (J. Heywood), 189
- Participation in Photosynthesis : Alkaline C-1 Fructose-1,6-diphosphatase—Evidence for its (Dr. Robert Smillie), 1024
- Particle Board Industries (Pulp and) : The Development of, and their Effect on Forest Management (Society of Foresters of Great Britain Discussion on), 32
- Particle Shape Factors in the Sieve Range : A Method for the Routine Measurement of (Dr. Colin C. Harris), 401 , (D. Howitt), 403
- Particles (Charged), in Matter : Penetration of—Proceedings of an Informal Conference, Gatlinburg, Tennessee, 1958 (edited by A. Vehling), (United States National Academy of Sciences—National Research Council, Nuclear Science Series, Report No. 29), 1086
- Particles (Cytoplasmic), and their Role in Protein Synthesis (Colloid and Biophysics Committee of the Faraday Society Informal Discussion on), 643
- Partington, A. : Mode of Action of Soluble Matrix Antifouling Compositions, 1105
- Partington, Prof. J. R. : A History of Greek Fire and Gunpowder, *review* by Prof. R. J Forbes, 272
- Pascoe, K. J. : The Strength of Solids, 659
- Pascual, Maria Covadonga Rodriguez Awarded a Spanish fellowship by the Ramsay Memorial Fellowship Trustees, 832
- Passion Fruit Juice : An Acid-tolerant and Non-sporulating Yeast from (B. A S. Rao and J. S. Pruthi), 342
- Past : The Peasant and the (Prof. Estyn Evans), 844
- Pastoral Systems in relation to World Food Supplies (Dr. William Davies), 849
- Pasture Grasses : Fatty Acid Composition of the Lipids of (Dr. G. A. Garton), 511
- Paterson, Dr. W. G. : Canadian fellowship renewed by the Ramsay Memorial Fellowship Trustees, 832
- Pathogenicity of *Metarrhizium anisopliae* (Metch.) Sor. and *Beauveria bassiana* (Bals.) Vuill to Two Species of Elateridae (Dr R. D. Tinline and R Y Zacharuk), 794
- Pathology (Plant), in the British Commonwealth (Dr. G. C. Ainsworth), 834
- Pathology (Plant) Laboratory, Harpenden (W. C. Moore), 21
- Patrick, Dr. C. R , and Prosser, G S. : A Molecular Complex of Benzene and Hexafluorobenzene, 1021
- Pattern of Haemopoiesis in the Foetal Liver (D. Brynmor Thomas, P. M. Russell and Prof. J. M. Yoffey), 876
- Pattern (Electrophoretic), during Amphibian Development (H. Denis), 62
- Patterson, A. T. : Title of reader in history in the University of Southampton conferred on, 290
- Patterson, Dr. D. : Use of Reflectance Measurements in assessing the Colour Changes of Ageing Bloodstains, 688
- Patwardhan, V. N. : Elected an honorary member of the American Institute of Nutrition, 374
- Paul, Dr. D. H. : The Membrane Potential of the Anterior Byssus Retractor Muscle of *Mytilus edulis*, 1121
- Paul, Dr. E. B. : Progress in Nuclear Science, *review*, 182
- Paul Instrument Fund : Grant of £1,000 (in supplement of a previous grant) to Prof. J. D. McGee, for the construction of a television system for X-ray image intensification, 291
  - Grant of £500 (in supplement of a previous grant) to Dr. H. Motz, for the construction of a linear accelerator working at 1·6 cm. (*J*-band), 291
  - Grant of £3,230 (in supplement of a previous grant) to Dr. P. M. B. Walker, for the construction of a high-speed integrating microspectrophotometer, 291
  - A Report on its Activities, 733
- Paull, W. : Theory of Relativity (translated from the German by G. Field), *review* by Dr. D. W. Sciama, 4
- Pauling, Prof. Linus : Elected a member of the Chemistry section of the Leopoldina Academy of Natural Sciences, 1079
- Pavel, S. (Milcou, Prof. S. -M., and) : Antigonadotropic Function of the Pineal Gland and the Oxytocin of the Neurosecretory Hypothalamic System, 950
- Pavlovsky, Dr. A , and others : Fertility of Mice treated with Phosphorus-32, 876
- Payne, L. M. (edited by Dr. A. J. Walford, with the assistance of) : Guide to Reference Material, *review* by R. Brightman, 273
- Peace, T. R. : The Dangerous Concept of the Natural Forest (Presidential Address to Section K* (Forestry) of the British Association for the Advancement of Science), 848
- Pearse, Dr. A. G. Everson : Histochemistry—Theoretical and Applied, second edition, *review* by Dr. L. G. E. Bell, 185
- Pearson, Prof. E. S. : Title of professor emeritus of statistics in the University of London conferred on, 466
- Pearson, R., and Langer, G. : Generation of Aerosols by Vapour-Phase Polymerization of Methyl Acrylate, 235
- Peasant and the Past (Prof. Estyn Evans), 844
- Pederson, Carl S., and others : Determination of Fatty Acids of Lower Molecular Weight by Gas Chromatography, 689
- Peers, A. M. : Simultaneous Measurement of Adsorption and Electrodekinetic Parameters at Metal Surfaces, 503
- Peisach, Dr. M , and Steyn, J : Radiolytic Oxidation of Ferrous Solutions with Standardized Internal Sources of Phosphorus-32, 58
- Pelagic Polychaetes of the South Atlantic (N. Tebble), 289
- Pellerin, Pierre (Chanteur, Jean, and) : Localization by Autoradiography at -195° C of Radioactive Areas in Rats exposed to a High Flux of Thermal Neutrons—Importance of Phosphorus-32 in Consecutive Internal Irradiation, 472
- Pendergrast, James, and others : 'Enthalpy Titrations' and Thermochemistry in Molten Salts, 318
- Penetration of Charged Particles in Matter—Proceedings of an Informal Conference, Gatlinburg, Tennessee, 1958 (edited by A. Vehling), (United States National Academy of Sciences—National Research Council, Nuclear Science Series, Report No. 29), 1086
- D-Penicillamine-Cysteine Mixed Disulphide : Formation of, by Reaction of D-Benzylpenicilloic Acid with Cystine (Dr. Bernard B. Levine), 940
- Penicillin : Effect of, on the Maintenance of Rumen Oligotrich Protozoa (G. S. Coleman), 518
  - Formation of 6-Aminopenicillanic Acid from, by Enzymatic Hydrolysis (Dr. G. N. Rolinson, F. R. Batchelor, D. Butterworth, J. Cameron-Wood, Dr M. Cole, G. C Eustace, Marian V. Hart, Dr. M. Richards and Prof E. B Chain), 236
- Penicillin Amidase : Bacterial (Dr. C. A. Claridge, Dr. A. Gourevitch and Dr. J. Lein), 237
- Penman, Dr. H L. : *Obituary* of Dr. R. K. Schofield, 196
  - Laboratory Testing in Soil Engineering, *review*, 891
  - Weather Problems in Agriculture, 995
- Pennella, P., and others : Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture, 238
- *Pennisetum typhoideum* : Pollen Germination in some Gramineae— (Dr. I. K. Vasil), 1134
- People (South Indian) : Potassium Tolerance Tests in (Dr. G. Henrotte, G. Krishnamurthi and G. Ranganathan), 328
- Peptides (Acetyl-serine) . Structures of some, from Acetyl-chymotrypsin (Leo Benoiton, Prof H. N Rydon, R. A. Oosterbaan, M. E. Van Adrichem and Prof J A. Cohen), 596
- Perception (Extra-Sensory) : Experimental Evidence for (Dr. S. G. Soal), 171 ; (C. E. M. Hansel), 172
- Perceptual Anomalies associated with a Single Contour (J. P Wilson), 137
- Perchlorate Ion in Sea-Water . Alleged Occurrence of the (R. Greenhalgh and Dr. J P. Riley), 1107
- Perfection (Different Graphitic) : Dependence on Temperature of the Interlayer Spacing in Carbons of (E. G. Steward, B. P. Cook and E A. Kellett), 1015
- Periodic Magnetic Field Fluctuations in the *Sceptre* Discharge (Dr. N. L. Allen), 279
- Periodic Table : Positions of Thorium and Uranium in the (Dr. A. E. Dwight), 505
- Periodical Publications : Cost of Scientific (Capt. I. R Maxwell), 1052
- Peristaltic Reflex : Effect of Wheat Gluten on the (Dr. R. Schneider, H. Bishop, Dr. B. Shaw and Prof. A C. Frazer), 516
- Peritoneal Fluid of the Guinea Pig : Effect of the, on Strains of Enteric Bacilli (Prof R. J. Rountree and L R. Collis), 1045
- Perlin, A. S. (Parrish, F. W , and) : Steric Factors affecting the Specificity of Polyglycosidases, 1110
- Permanent Gases : An Ionization Detector for (Dr. J. E. Lovelock), 49
- Permeability of Human Arterial Tissue : Effect of Testicular Hyaluronidase on the (Jørgen Matzke), 873
- Permeable Solids : Measurement of Slip (*Ko*) and Viscous (*Bo*) Flow Coefficients of (J. G. Biram), 865
- *Peronospora tabacina* Adam. : Differentiation in (Dr. D. C. Wark, A. V. Hill, M. Mandryk and I. A. M. Cruickshank), 710
- Perrin, Dawn R (Cruickshank, I A. M., and) : Isolation of a Phytoalexin from *Pisum sativum* L., 799
- Perrin, Helen N (Griffin, Dr. D. M., and) : Anastomoses in the Phycomycetes, 1039
- Personnel (Scientific) : Shortages of, in European Countries in Process of Development, 565
- Personnel (Scientific and Engineering) : Direction and Supervision of (Northampton College of Advanced Technology, London, Advanced Course on), 905
- Pessall, Dr. N. : Appointed to a Research Fellowship in physical metallurgy at the University of Birmingham, 465
- Pests (Agricultural) : Chemical Control of, and Conservation of America's Wild-Life (United States National Academy of Sciences—National Research Council Committee on), 114
- Pests (Insect) : Significance of the Type of Host Plant Crop in Successful Biological Control of (D. C. Lloyd), 430
- Petermann, M L. : Cytoplasmic Particles and their Role in Protein Synthesis (Physical Properties of Ribosomes from the Jensen Sarcoma), 644

Peters, Sir Rudolph, and Hall, R. J. · Fluorine Compounds in Nature—the Distribution of Carbon–Fluorine Compounds in some Species of *Dichapetalum*, 573
Petiole of *Mimosa pudica* : Behaviour of a Thread-like Apparatus in the (Dr Hideo Toriyama), 709
Petit, J. : Problems of the Arid Zones (Public Awareness and the Educational Problem—Mineral Resources-Sahara), 296
Petree, M C. (Warfield, R. W , and) : Dependence on Temperature of the Electrical Resistivity of Thermosetting Polymers, 316
Petrogenesis : Average Composition of Granites, the Genesis of Tektites, and (Prof E. H Timothy Whitten), 867
Petroleum Company (British) · Geological Results of Petroleum Exploration in Britain by the, during the Years 1945-57 (N. L Falcon and P. E. Kent), 1078
Petroleum Exploration in Britain by the British Petroleum Company during the Years 1945-47 : Geological Results of (N. L. Falcon and P. E. Kent), 1078
Pfeiffer, Carl C., and Smythies, John R. (edited by) International Review of Neurobiology, Vol 1, *review* by Dr. D. H Brinton, 447
pH : Effects of, and the Nature of the Primary Species in the Radiolysis of Aqueous Solutions (J T Allan and Dr G Scholes), 218
pH Changes during Muscle Twitch and Tetanus (A Distèche), 1119
'pH-Chromatography' of some Amphoteric Antibiotics (Vladimir Betina and Prof. Pavel Nemec), 1111
Phagocytic Activity of the Reticulo-Endothelial System : Effect of some Aromatic Hydroxy Compounds on the (Prof. T. Nicol, C. Druce and C. C. Ware), 422
  Effect of Three Compounds related to Diethylstilboestrol on the (Prof. T. Nicol, G. Brownlee, C. Druce and C C. Ware), 1032
Pharmaceutical Conference (British) Ninety-seventh Meeting, 117
Pharmaceutical Industry (British), Association of the : Report on the Use of Gamma-Radiation Sources for the Sterilization of Pharmaceutical Products, 903
Pharmaceutical Preparations Classification of—a Survey of Existing Legislation (World Health Organization of United Nations), 287
Pharmaceutical Products . Use of Gamma-Radiation Sources for the Sterilization of (Report of the Association of the British Pharmaceutical Industry), 903
Pharmaceutische Wetenschappen, Belgisch Genootschap voor International Symposium on Chromatography, 374
Pharmacological Meeting · First International (Section of Pharmacology of the International Union of Physiological Sciences), 29
Pharmacologically Active Substance : An Unidentified, extracted from Cerebral Hemispheres (P. F L. Andrews, Shirley A. P. Price and Dr. G B. West), 420
Pharmacy : History of Medicine and (Faculty of the History of Medicine and Pharmacy of the Worshipful Society of Apothecaries of London, in co-operation with the Royal College of Physicians, the Royal College of Surgeons of England and the Royal Society of Medicine First British Congress on), 374
  Maccabaean Prize and Medal for an essay on a subject connected with the History of Medicine or (Worshipful Society of Apothecaries of London), 650
Phase (Gas) : Recombination of Oxygen Atoms in the (P. G. Dickens, R D. Gould, Prof. J. W. Linnett and A. Richmond), 686
Phase (A New), in a Silicon bearing 17 per cent Chromium, 8 per cent Nickel and 1 per cent Niobium Steel (M J O'Hara, D. Wilkinson and R T. Allsop), 407
Phase (The Sulphide), in some Iron Meteorites (Dr. H. J. Axon), 406
Phase-contrast and Dark-ground Viewing of 'Thorotrast' in Tissue Sections : Combined Oil-immersion, (Dr. E. W Baxter), 162
Phase-Shifts (Scattering) Distorted Wave Approximation for (Dr. P. Swan), 585
Phelps, C F. (Ogston, Dr. A. G., and) : Exclusion of Inulin from Solutions of Hyaluronic Acid, 1024
Phemister, Dr. J . Scotland—the Northern Highlands (Handbook of Regional Geology), third edition, 831
Phenomena : Photoperiodic, *review* by Prof. L. J. Audus, 96
Phenomena (Photoperiodism and related), in Plants and Animals (edited by Robert B. Withrow)—Proceedings of the Conference on Photoperiodism, 1957, sponsored by the Committee on Photobiology of the National Academy of Sciences—National Research Council, supported by the National Science Foundation, *review* by Prof. L. J. Audus, 96
Phenomenon The Exploding Wire, *review* by Dr. B. A. Thrush, 726
Phenomenon (Sickling), in Deer (E. Undritz, K. Betke and Dr. H Lehmann), 333
Phillips, Dr. F. C. : The Use of Stereographic Projection in Structural Geology, second edition, *review* by John Sutton, 729
Phillips, V A., and Cannon, P . Dislocations in Layer Structures, 313
Philosophy of Cosmology, *review* by Dr. C. W Kilmister, 634
Philosophy of Science : Logic, Methodology and (International Union for History and Philosophy of Science International Congress for), 201
Philosophy of Science, British Society for the . Fifth Annual Conference, 559
Philosophy of Science, International Union for History and · International Congress for Logic, Methodology and Philosophy of Science, 201
Phlogiston or Atoms ?, 627
Phosphatase (Acid) : A Simple Azo-Dye Method for Histochemical Demonstration of (Dr. Tibor Barka), 248
Phosphatase (Acid) (Rat Serum) : Total and *l* (+) Tartaric Acid Inhibited (Dr. Z Laron and B. Epstein Halberstadt), 67
Phosphate (High-Energy Bound), and Diabetes Mellitus (Dr Yoshio Goto, Isao Ito, Akihiko Kuwano and Yukio Ujiie), 702
Phosphate Esters produced by Mammalian Skin from 2-Deoxy-D-glucose (Dr. S. A. Brooks, Dr. J. C. Lawrence and Dr C R. Ricketts), 1028
Phosphate Requirement (A High-Energy), for Succinate Oxidation in Uncoupled Rat Liver Mitochondria (Dr. Giovanni Felice Azzone and Dr. Lars Ernster), 65
Phosphates (Quinol) . Oxidative Phosphorylation—Synthesis of Adenosine Diphosphate by the Oxidation of (Dr. V. M. Clark, D. W Hutchinson and Sir Alexander Todd), 59
Phosphodiesterase (Micrococcal) Mode of Action of (Dr. K. K. Reddi), 74
Phosphoproteins and Mitochondrial and Cell Water (Dr. J. D. Judah), 506
Phosphorus-32 : Fertility of Mice treated with (E. A D. Holmberg, Dr. A. Pavlovsky, C. D de Pasqualini and S L. Rabasa), 876
  Radiolytic Oxidation of Ferrous Solutions with Standardized Internal Sources of (Dr. M. Pessach and J. Steyn), 58
Phosphorus-32 in Consecutive Internal Irradiation : Localization by Autoradiography at -195° C of Radioactive Areas in Rats exposed to a High Flux of Thermal Neutrons—Importance of (Jean Chanteur and Pierre Pellerin), 472
Phosphorylated Glucides : Cori's Ester and (First International Symposium on), 117, 290
Phosphorylation . Oxidative—Synthesis of Adenosine Diphosphate by the Oxidation of Quinol Phosphates (Dr. V. M. Clark, D. W. Hutchinson and Sir Alexander Todd), 59
Photochemical Formation and Stability of the CF_3 Radical (Dr. J. P Simons and A J Yarwood), 316
Photoelasticity (Illinois Institute of Technology International Symposium on), 650
Photographie Corpusculaire : Premier Colloque International de (Strasbourg, 1957), *review* by D. L Allan, 636
Photo-Injection of Charge into Dielectric Liquids (M J Morant), 48
Photolysis (Liquid-Phase), of Fluorinated Ketones . Cage Effect in the (R Bowles, Dr. J. R Majer and Prof J C Robb), 314
Photoperiodic Phenomena, *review* by Prof L J Audus, 96
Photoperiodic Response of *Xanthium* : Effect of Glutathione and Alloxan on the (J Nitsan), 81
Photoperiodism and related Phenomena in Plants and Animals (edited by Robert B Withrow)—Proceedings of the Conference on Photoperiodism, 1957, sponsored by the Committee on Photobiology of the National Academy of Sciences—National Research Council, supported by the National Science Foundation, *review* by Prof. L. J. Audus, 96
Photo-reactivation (Dye-sensitized), of X-Ray Damage in Diploid Yeast (Dr. David Freifelder and Prof. Robert B Uretz), 953
Photosynthesis : Alkaline C-1 Fructose-1,6-diphosphatase—Evidence for its Participation in (Dr Robert Smillie), 1024
Photosynthetic Reductase from a Green Plant . Crystallization of a (Dr. R. Hill and Fay Bendall), 417
Phycomycetes · Anastomoses in the (Dr D. M. Griffin and Helen N Perrin), 1039
Physical Chemistry of Aerosols (Faraday Society General Discussion on), 201
Physical Incompleteness of Influenza Virus propagated in De-embryonated Eggs (Martin Hanig and Joseph M. Stein), 40
Physical Nature of Plastic Flow (Dr. J J Gilman), 374
Physical Properties (Chemical and), of the Small Deoxyribonucleic Acid Component of Crystalline Cytochrome B_2 (Dr. M D Montague and Prof. R K Morton), 916
Physical Sciences : Probability and related Topics in (Prof. Mark Kac), *review* by Prof M. S Bartlett, 1060
Physical Society Year Book for 1959, 853
  Presidential Address, Recent Trends in the Theory of the Ionosphere (J A. Ratcliffe), 853
  Guthrie Lecture, Collisions (Sir Harrie Massey), 853
  Charles Vernon Boys Prize Address, The Method of Observing π-Mesonic X-Rays (Dr D. West), 853
  Duddell Medal Addresses, The Application of Computer Techniques to Nuclear Physics Instruments (G G. Scarrott), and 'Memories' for Nuclear Physics (G. W. Hutchinson), 854
  Parsons Memorial Lecture, Aspheric Imaging Systems (Dr. C. R. Burch), 854
  Thomas Young Oration, Problems of Visual Discrimination (Prof R. W. Ditchburn), 854
Physical Society (Institute of Physics and the) : Conference on Nuclear Physics, 832
  Conference on Diamond Physics, 905
  Duddell Medal Address, Some Developments of the Optical Lever (Prof R. V. Jones), 905
  Conference on Statistical Mechanics (with special reference to Irreversibility), 1079
Physical Society of Japan : Publication of a volume of papers on the Theory of Atomic Nuclei, 743
Physical Swelling of Lithium Montmorillonite : Effect of Surface Density of Charge on the (Dr. J. P. Quirk and B. K G. Theng), 967
Physicians, Royal College of, and others First British Congress on the History of Medicine and Pharmacy, 374
Physicist : The Faith of a (Dr. H E. Huntley), *review* by Dr H. D Anthony, 1063
Physicists (Technical), Swedish Association of (Royal Swedish Academy of Engineering Sciences and the) : Fifth International Instruments and Measurements Conference and Exhibition, 374
Physico-chemical, Biological and Applied Aspects of Autoxidation (Colloid and Biophysics Committee of the Faraday Society Symposium on), 746
Physics at University College, London, 555
Physics : Diamond (Institute of Physics and the Physical Society Conference on), 905
  High-Energy (Commission on High Energy Physics of the International Union of Pure and Applied Physics Tenth Annual International Conference on), 29
  Nuclear (Institute of Physics and the Physical Society Conference on), 832
  Probability and, *review* by Prof M. S Bartlett, 1060
  Semiconductor (Czechoslovak Academy of Science International Conference on), 29
  Solid State (Società Italiana di Fisica International Summer Course on), 201
  Solid State, *review* by Dr. R. O. Davies, 886
  Solid State—Advances in Research and Applications (edited by Frederick Seitz and David Turnbull), Vols 7, 8, 9 and 10, *review* by Dr. R. O Davies, 886
  Solid State—Advances in Research and Applications, Supplement 2, Paramagnetic Resonance in Solids (William Low), *review* by Dr. R. O. Davies, 886
Physics, American Institute of : To publish the *Physics of Fluids* monthly starting in 1961, 832

Physics, Institute of, and the Physical Society : Conference on Nuclear Physics, 832
  Conference on Diamond Physics, 905
  Duddell Medal Address, Some Developments of the Optical Lever (Prof. R. V. Jones), 905
  Conference on Statistical Mechanics (with special reference to Irreversibility), 1079
Physics, Swedish National Committee for : Tenth General Physics Conference, 557
Physics of Electrostatic Forces and their Applications (Centre National de la Recherche Scientifique International Colloquium on), 466
Physics of Fluids To be published monthly starting in 1961 (American Institute of Physics), 832
Physics of Mass, Length and Time : An Introduction to the (Prof. Norman Feather), *review* by G. R. Noakes, 183
Physics (Chemical) : Advances in (edited by Prof. I. Prigogine), Vols. 1 and 2, *review* by Prof. C. A. Coulson, 812
Physics (Chemical), Comes of Age, *review* by Prof. C. A. Coulson, 812
Physics (Crystal), at Cambridge, 25
Physics (Health Instrumentation (John S. Handloser), *review* by B. S. Smith, 9
Physics (Marine) : Studies in, *review* by Dr. G. E. R. Deacon, 183
Physics (Mathematical), at Birmingham, 197
Physics (Mathematical) : Manual of (Paul I. Richards), *review* by Prof. R. Eisenschitz, 445
Physics (Nuclear) : 'Memories' for (G. W. Hutchinson), 854
Physics (Nuclear) Instruments : Application of Computer Techniques to (G. G. Scarrott), 854
Physics (Pure and Applied), International Union of : Tenth Annual International Conference on High-Energy Physics, 29
Physics (Semiconductor) : A Source-Book of, *review* by Prof. G. F. J. Garlick, 885
Physics (Solid State) : Covalent Super-Exchange in (Prof. W. S. Fyfe and Prof. J. Verhoogen), 1108
Physics (Theoretical) : Reference Book of, *review* by Prof. R. Eisenschitz, 445
Physics and Chemistry of the Earth (edited by Prof. L. H. Ahrens, Frank Press, Kalervo Rankama and Prof. S. K. Runcorn), Vol. 3, *review* by B. E. Leake, 544
Physics and Design of Semiconductor Devices : The Properties, (John N. Shive), *review* by Dr. J. R. Tillman, 1058
Physiological Action of Rotenone : Mechanism of the (Prof. P. E. Lindahl and K. E. Öberg), 784
Physiological Media for Tissues of *Helix* (C. K. Goddard), 68
Physiological Role of Fast Transfer Reactions (Massachusetts Institute of Technology Seminar Lectures on), 904
Physiological Sciences, International Union of (Section of Pharmacology) : First International Pharmacological Meeting, 29
Physiological Society (Moscow), (U.S.S.R.–Great Britain Society and the) : Joint Meeting to celebrate the centenary of the births of W. M. Bayliss and J. S. Haldane, 912
Physiological Stimulus : Summative Action of Acetylcholine with, on the Generator Potential in the Lateral Eye of the Horseshoe Crab (R. Kikuchi, K. Naito and S. Minagawa), 1118
Physiology at University College, London 371
Physiology in University Education : The Place of (Prof. J. A. B. Gray), 719
Physiology : Plant (edited by F. C. Steward), Vol. 2, Plants in relation to Water and Solutes, *review* by Prof. Walter Stiles, 889
Physiology of Hearing (Prof. W. Burns), 845
Physiology of Marine Animals, *review* by Prof. C. M. Yonge, 630
Physiology of Reproduction : Marshall Chair of the, Cambridge, 113
Physiology (Plant) : A New Treatise on, *review* by Prof. Walter Stiles, 889
Physique (Chimie), Société de : Annual Meeting (Structure, Synthesis and Function of Deoxyribonucleic Acid), 1079
Phytoalexin from *Pisum sativum* L. : Isolation of a (I. A. M. Cruickshank and Dawn R. Perrin), 799
π-Mesonic X-Rays : The Method of Observing (Dr. D. West), 853
Piccotto, Prpf. E., and others : Isotopic Composition and Temperature of Formation of Antarctic Shows, 857
Picric Acid : Interaction of, with Sodium Hydroxide in Water (Takehiro Abe), 234
Pierce, J. A., and others : The 'GBR Experiment'—a Trans-Atlantic Frequency Comparison between Caesium-controlled Oscillators, 914
Pig : A Genetically Determined Enzyme in the (Dr. K.-B. Augustinsson and Dr. B. Olsson), 924
Piganiol, P. : Problems of the Arid Zones, 295
Pigment : Association of, with the Cell Envelope of *Serratia marcescens* (*Chromobacterium prodigiosum*), (Mrs. Purkayastha and Prof. R. P. Williams), 349
Pigment (Beetroot), (Betanin) : Race Differences in the Ability to excrete (Dr. P. H. Saldanha, L. E. Magalhaes and Wanda A. Horta), 806
Pigments (Flavonoid), of *Lathyrus odoratus* (J. B. Harborne), 240
Pileri, Alessandro, and others : Proliferative Capacity of Acute Leukaemia Cells, 611
Pincus, Gregory (edited by) : Hormones and Atherosclerosis—Proceedings of the Conference held in Brighton, Utah, 1958, *review* by Dr. G. S. Boyd, 634
Pineal Gland : Antigonadotropic Function of the, and the Oxytocin of the Neurosecretory Hypothalamic System (Prof. S.-M. Milcou and S. Pavel), 950
Pinene (α-) : Microbiological Transformation of Terpenes—Hydroxylation of (P. K. Bhattacharyya, B. R. Prema, B. D. Kulkarni and S. K. Pradhan), 689
Pinene (α- and β-) : Radiolysis of Terpene Hydrocarbons—Isomerization and Polymerization of (T. H. Bates and Dr. T. Ffrancon Williams), 665
Pirie, Dr. Antoinette, and van Heyningen, Dr. Ruth, : Comparison between the Effects of Cysteine and of Anoxia on the Rate of Mitosis in Lens Epithelium, 947
Pisum sativum L. : Isolation of a Phytoalexin from (I. A. M. Cruickshank and Dawn R. Perrin), 799
Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy : Twelfth, 289
Pittsbrugh Conference and the Optical Society of America : Symposium on New Frontiers in Optics and Spectroscopy, 289
Pituitary (Human) : Polypeptides of the, with Direct Action on Metabolism (Dr. J. Bornstein and Deirdre Hyde), 125
Pituitary Portal System in Elasmobranchs : Presence of a (Patrick Meurling), 336
Piltdown Skull : Artificial Thickening of Bone and the (Prof. Ashley Montagu), 174 ; (Dr. Kenneth P. Oakley), 174
Place of Physiology in University Education (Prof. J. A. B. Gray), 719
Place (Africa's), in the Emergence of Civilization (Prof. Raymond A. Dart), *review* by M. C. Burkitt, 891
Placenta (Human) : Steroid 11β-ol Dehydrogenase in (Dr. P. A. Osinski), 777
Placental (Human, Term) 17β-Œstradiol Dehydrogenases : Histochemical Localization of—Implications for the Transhydrogenase Reaction (Dr. Donald A. Kellogg and Dr. George G. Glenner), 763
Plackett, R. L. : Appointed reader in mathematical statistics in the University of Liverpool, 117
Plain Man's Guide to Atomic Energy (P. J. Duncton), 1076
Planas, Prof. Jose, and de Castro, Santo : Serum Iron and Total Iron-binding Capacity in certain Mammals, 1126
Planes of Cleavage : Thermal Conduction in Mica along the (H. J. Goldsmid and A. E. Bowley), 864
Plankton of the Estuary and Offshore Waters of the Sierra Leone River (V. Bainbridge), 557
Plankton (Marine) : Abundance of (R. M. Cassie), 289
Planning for the Changing World Population, *review* by M. K. Milne, 816
Plant (Chemical) Instrumentation—some Notes on the Use of Measuring Instruments (Association of British Chemical Manufacturers), 1079
Plant (Green) : Crystallization of a Photosynthetic Reductase from a (Dr. R. Hill and Fay Bendall), 417
Plant (Rice) : Relative Lengths of Leaf Sheath and Blade with reference to the Developmental Stages of the (Dr. B. Saha), 259
Plant Breeding : The Two R's of, *review* by Dr. G. Haskell, 184
Plant Crop (Host), in Successful Biological Control of Insect Pests : Significance of the Type of (D. C. Lloyd), 430
Plant Design (Nuclear Power) : Evolution of (Sir Christopher Hinton), 1064
Plant Geography : Foundation of, 904
Plant-Growth Activity of α-Alkylphenylacetic Acids and 1,2-Benzo-1-*cyclo*alkene-3-carboxylic Acids (Kazuyoshi Kawazu, Toshio Fujita, Tetsuo Mitsui, Jiro Kato and Masayuki Katsumi), 694
Plant Growth Systems : Ethionine and (R. L. Lowther and W. G. Boll), 832
Plant Hormone Activity—Stilboestrol applied to the Wheat Seedling (Dr. J. J. C. Hinton and Dr. T. Moran), 258
Plant Nutrition : Aspects of, *review* by Prof. Walter Stiles, 815
Plant Pathology in the British Commonwealth (Dr. G. C. Ainsworth), 834
Plant Pathology Laboratory, Harpenden (W. C. Moore), 21
Plant Physiology (edited by F. C. Steward), Vol. 2, Plants in relation to Water and Solutes, *review* by Prof. Walter Stiles, 889
Plant Physiology : A New Treatise on, *review* by Prof. Walter Stiles, 889
Plant Protein : Enzymatic Synthesis of Formylglutamic Acid by a (Ernest H. Byers, Jun., and T. J. Bond), 416
Plant Protoplasts and Vacuoles : A Method for the Isolation of (Dr. E. C. Cocking), 962
Plant Research Centre, Brisbane : The David North (K. T. Glasziou), 745
Plant Tissue (Embryonic) : Stabilization by Manganous Ions of Ribosomes from (Dr. J. W. Lyttleton), 1026
Plant Tissue Cultures, *review* by A. Allsopp, 976
Plant Virus : Activation of One, by Another (B. Kassanis and H. L. Nixon), 713
Plant Viruses : Freeze-drying of (M. Hollings and R. A. Lelliott), 1078
Plant and Equipment (Gas) : Protection of, from Corrosion (Institution of Gas Engineers and the Corrosion Group of the Birmingham and Midlands Section of the Society of Chemical Industry Symposium on), 466
Plant- and Soil- Water Relations : Terminology in (Dr. R. O. Slatyer and Prof. S. A. Taylor), 922
Plantation Crops, Commonwealth Bureau of Horticulture and : Technical Communication No. 25, Abstract Bibliography of Fruit Breeding and Genetics to 1955—*Rubus* and *Ribes*, a Survey (Dr. R. L. Knight and Elizabeth Keep), *review* by Dr. G. Haskell, 184
Plantes : Géographie des (Alexander von Humboldt et A. Bonpland), facsimile edition (Society for the Bibliography of Natural History), 904
Plants : Utilization of Nitrogen and its Compounds by—Symposia of the Society for Experimental Biology, No. 13 (edited by H. K. Porter), *review* by Prof. Walter Stiles, 815
Plants in relation to Water and Solutes (Plant Physiology, edited by F. C. Steward, Vol. 2), *review* by Prof. Walter Stiles, 889
Plants (Australian Native), for Home Gardens (A. E. Brooks), *review* by Dr. R. Melville, 637
Plants (Autotetraploid) : Frequency of Quadrivalents in (Dr. J. W. Morrison and Dr. T. Rajhathy), 528
Plants (Virus-infected) : Possible Occurrence of Interference Systems in (A. D. Thomson), 761
Plants (Woody) : Survival of, at Extremely Low Temperatures (Johnson Parker), 1133 ; (Dr. Akira Sakai), 1134
Plants and Animals : Photoperiodism and related Phenomena in (edited by Robert B. Withrow)—Proceedings of the Conference on Photoperiodism, 1957, sponsored by the Committee on Photobiology of the National Academy of Sciences—National Research Council, supported by the National Science Foundation, *review* by Prof. L. J. Audus, 96
Plants and Bones : Radioactivity of Soils, (Sir Ernest Marsden), 192
Plasma Confinement Geometry : A New (James L. Tuck), 863
Plasma Proteins in Normal Urine (Dr. I. Berggård), 776
Plasma (Human) : Staining for Iodine in Chromatograms of—an Artefact due to Thiourea or Thiouracils (A. Dimitriadou, Prof. T. Russell Fraser, Dr. J. D. H. Slater and P. C. R. Turner), 691 ; *erratum*, 1079
Plasmas (Gaseous) : Diamagnetic Moment of, measured by Spin Resonance Techniques (T. C. Marshall, R. A. Kawcyn and Prof. L. Goldstein), 584
Plaster (Gypsum) : Effect of Temperature on the Expansion on Setting of (P. J. Sereda), 929
Plastic Flow : The Physical Nature of (Dr. J. J. Gilman), 374
Plastically Deformed Metals : A Possible Origin of Exo-Electron Emission in (Dr. A. H. Meleka and W. Barr), 232
Plastics Exhibition : Second International, 559
Plastics Institute : Training Grants for Plastics Technology, 28
  Swinburne Medal awarded to Prof. G. Gee, 740

Plastics Processing : The Technology of (Association for the Advancement of the Knowledge of Materials, the Royal Institute of Engineers, the Royal Netherlands Chemical Federation and the International Union of Pure and Applied Chemistry International Congress on), 559
Plastics Technology : Training Grants for (Plastics Institute), 28
Plastids of the *Avena* Coleoptile (Helen P. Sorokin and Prof. Kenneth V. Thimann), 1038
Platelet-Count Differences in Blood of the Rabbit Right and Left Heart Ventricles (Dr J. George Sharnoff and Dr. Vito Scardino), 334
Pleistocene History of the Irish Sea (G F. Mitchell), 842
Plenderleith, Dr. Harold J : The Enkomi Silver Cup, 1052
Ploidy (Chromosome), and Radiosensitivity of Tumours (László Révész and Ulla Norman), 861
Plumage (Breeding), of the Weaver Finch, *Quelea quelea* : Effects of Whole-body Irradiation on the (Dr. R. Lofts, Prof. A J. Marshall and Prof. J. Rotblat), 615
Plutonium, Neptunium (Uranium, Thorium,) : Crystal Chemistry of Simple Compounds of (E S. Makarov), translated from the Russian by E. B. Uvarov, *review* by Dr. L. E. J. Roberts, 728
Podnebi (Atlas) Ceskoslovenské Republiky (Climatic Atlas of the Czechoslovak Republic), *review* by G. A Bull, 543
Poisoning (Experimental), by Cadmium and other Metals : An Abnormal Serum Protein in (D. J. Lawford), 946
Poisoning (Liver) Levels of Pyridine Nucleotides in (Dr. C. H. Gallagher and Dr K R Rees), 148
Poisoning (Potassium Cyanide) : Effect of, on the γ-Aminobutyric Acid-Level in the Brain (Dr. T Tursky), 322
Polar Research in the U S.S.R , 287
Polarization : Interstellar Extinction and (R. Wilson), 288
Polarization (Anodal) · Restoration of Membrane Excitability of Calcium-deficient Muscles by (Prof. K. Koketsu and K. Noda), 243
Polarographic Determination of the Lanthanides : Use of Azo Dyestuffs for the (T. M Florence and L E. Smythe), 771
Pole (South) Observations of 'Whistlers' and 'Chorus' at the (Dr. L. H. Martin), 1018
Policy (Book-buying), of the National Central Library (S P. L. Filon), 992
Policy (British Agricultural) : Principles for—a Study sponsored by the Nuffield Foundation (edited by H T. Williams), *review* by Sir John Russell, 721
Policy (Monetary), in England . Monetary Thought and (Prof. R. S Sayers), 844
Policy (Population) : Population Growth, Fertility and (Prof. D. V. Glass), 849
Pollen Germination in some Gramineae—*Pennisetum typhoideum* (Dr. I. K. Vasil), 1134
Polley, D. · At the second Annual Conference of the British Computer Society (Installation of Data-processing Schemes for Insurance Records), 656
Polluted Waters The Biology of (Dr H B N Hynes), *review* by Dr. G C. Ware, 1061
Pollution Biology of, *review* by Dr. G C Ware, 1061
  The Effects of, on Living Material (edited by W. B. Yapp), *review* by Dr G. C Ware, 1061
Polonium-210 in Grass · Lead-210 and (C. R Hill), 211
Polson, Alfred : Viscosity Increments of Non-Ionized Molecules, 482
Polwarth Wools (Merino and) · Abnormal Crimping in (R. E. Chapman, B. F Short and P. G. Hyland), 960
Poly-β-benzyl-L-aspartate Screw Sense of the α-Helix in (E. M. Bradbury, A. R Downie, Dr. A. Elliott and W. E. Hanby), 321
Polychaete Family Longosomidae in New Zealand (Prof. G. A. Knox), 1131
Polychaete Fauna of South Africa (Prof J. H Day), Part 5, 199
Polychaetes (Pelagic), of the South Atlantic (N. Tebble), 289
Polyenoic Acid in Hypercholesterolaemia induced by Pyridoxine Deficiency in Rats (Ajit Goswami and Prof. D P. Sadhu), 786
Polyglycosidases Steric Factors affecting the Specificity of (F W Parrish and A. S. Perlin), 1110
Polymer Science : Colloid and (Seminar at University College, London, on), 378
Polymer (High) Forum · Tenth Canadian (National Research Council of Canada and the Chemical Institute of Canada), 117
Polymerization of α- and β-Pinene Radiolysis of Terpene Hydrocarbons—Isomerization and (T. H. Bates and Dr. T. Ffrancon Williams), 665
Polymerization (Vapour-Phase), of Methyl Acrylate : Generation of Aerosols by (R Pearson and G. Langer), 235
Polymers : High-Temperature Resistance and Thermal Degradation of (Plastics and Polymer Group of the Society of Chemical Industry Symposium on), 466
  Rheology of (British Society of Rheology Discussion on), 290
Polymers (Thermosetting) . Dependence on Temperature of the Electrical Resistivity of (R W Warfield and M. C Petree), 316
Polymorphism (β-Globulin), in Chimpanzees (Prof. Samuel H. Boyer and Dr. William J. Young), 1035
Polyoma Virus : Production of Tumours in *Rattus* (*Mastomys*) *natalensis* by (Dr Alan S. Rabson, William J. Branigan and Frances Y. Legallais), 423
Polyoma Virus Mutant with a Reduction in Tumour Formation (Dr Leo Sachs and Dan Medina), 715
Polypeptides of the Human Pituitary with Direct Action on Metabolism (Dr J Bornstein and Deirdre Hyde), 125
Polyphenol Oxidase Activity of *Nicotiana glutinosa* Leaves infected with Tobacco Mosaic Virus (Dr Masatake Kikuchi and Akira Yamaguchi), 1048
Polyploidizing Principle in the Spleen (I. Bouvier, Prof R. Rigler and W. Rosenkranz), 965
Polyploidy in Human Tumours (N B Atkin and Angela J. Ross), 579
Polysaccharide (Starch-like), of *Streptococcus pyogenes* (Dr. H Baum and Dr. N Crowley), 413
Polystyrene (Isotactic) · Homogeneous Synthesis of, using *n*-Butyllithium Initiator (Dr. R. J. Kern), 410
Polyvalent Immunological Tolerance in Homologous Radiation Chimaeras (Alena Lengerová), 160
Pople, J. A., and others : High-resolution Nuclear Magnetic Resonance, *review* by Dr. L M Jackman, 358
Population (American), of the Shore Crab, *Carcinus maenas* (L.) : Albinism in an (Anthony J Provenzano, jun), 521
Population (Bacterial), of the Nose and Skin (H. William Smith and W. E. Crabb), 288
Population (Swedish Rural) · A Clinical and Genetico-Statistical Study of Schizophrenia and Low-Grade Mental Deficiency in a Large (Bertil Hallgren and Torsten Sjogren, 291
Population (World) . Planning for the Changing, *review* by M. K. Milne, 816
Population Growth, Fertility and Population Policy (Prof D. V. Glass), 849
Population Policy : Population Growth, Fertility and (Prof D. V. Glass), 849
Population Studies : Earthworm—a Comparison of Sampling Methods (F. Raw), 257
Population Trends among Hawks and Owls in Illinois (Richard R Graber and Jack S. Golden), 999
Population Variances may be Unequal : Significance of the Difference between Two Means when the (John B. de V. Weir), 438
Pore Radius (Equivalent), of Kidney Slices from *Necturus* . Effect of Anti-Diuretic Hormone and Calcium on the (G Whittembury, N. Sugino and Dr. A. K. Solomon), 699
Porphyrin (Halogenated), in Mouse Tumours : Localization of a (K. I. Altman and Prof. K. Salomon), 1124
Portal System (Pituitary), in Elasmobranchs Presence of a (Patrick Meurling), 336
Porter, H. K. (edited by) . Utilization of Nitrogen and its Compounds by Plants—Symposia of the Society for Experimental Biology, No. 13, *review* by Prof. Walter Stiles, 815
Porter, R. R (Press, Elizabeth M , and) : N-Terminal Amino-Acids of Bovine Antibody, 59
Position (The Present), of Leather Science, *review* by Prof. A G. Ward, 724
Position (Systematic), of the Australian Brown Alga, *Notheia anomala* : Structure and (M. Nizamuddin and Dr. H. B S. Womersley), 673
Positions of Thorium and Uranium in the Periodic Table (Dr A. E. Dwight), 505
Possibilities (Technical), of a Thames Flood Barrier, 294
Possibility of Detecting Ionospheric Drifts from the Occurrence of Spread F Echoes at Low Latitudes (R. W Knecht), 927
Possible Discovery of Ion-Pairs by Interferometry (Prof. R. N. O'Brien and C. Rosenfeld), 935
Possible Means of Predicting the Nitrogen-supplying Power of Soils : Ammonia released on Treating Soils with *N* Sodium Hydroxide as a (A. H. Cornfield), 260
Possible Occurrence of Interference Systems in Virus-infected Plants (A. D. Thomson), 761
Possible Origin of Exo-Electron Emission in Plastically Deformed Metals (Dr A H Meleka and W Barr), 232
Post Office (General) . Appointment of Dr. R. L Smith-Rose as chairman of the Frequency Advisory Committee, 466
Postgraduate Course on Recent Advances in Steroid Chemistry (Kingston Technical College), 905
Potash in Wet and Dry Soils, *review* by Dr. P. W. Arnold, 976
Potash Institute (International) : Potassium Symposium, 1958—Twelve Papers read at the Fifth Congress, *review* by Dr. P W. Arnold, 976
Potassium Symposium, 1958—Twelve Papers read at the Fifth Congress of the International Potash Institute, *review* by Dr. P. W. Arnold, 976
Potassium Symposium (Japanese)—Nine Papers read at the First Japanese Symposium, 1957, *review* by Dr. P. W Arnold, 976
Potassium in Mitochondrial Membrane Fractions : Sodium and (Dr. Frank Ulrich), 949
Potassium-supplying Power of some British Soils (Dr. P W. Arnold), 436
Potassium-Argon Ages of some Rocks from the South Atlantic (John A. Miller), 1019
Potassium Cyanide Poisoning Effect of, on the γ-Aminobutyric Acid-Level in the Brain (Dr. T Tursky), 322
Potassium Gibberellate : Effect of Autumn Applications of, on Fruit Production of the Strawberry (Prof Carter R Smith), 620
Potassium Tolerance Tests in South Indian People (Dr J. G. Henrotte, G. Krishnamurthi and G. Ranganathan), 328
Potassium Transport . A Bacterial Mutant with Impaired (Dr. Stanley G. Schultz and Dr A K. Solomon), 802
$K_2Ti_2O_5$: Five Co-ordinated Titanium in (Dr. Sten Andersson and Dr. A. D Wadsley), 499
Potato Research, European Association for Series of Triennial Conferences, 466
Potatoes : Determination of Nonanol Residues in (W. F. van Vliet and W. H Schriemer), 235
Potatoes stored in the Cold and at Room Temperature Biosynthesis of Sucrose by Preparations from (Dr Sigmund Schwimmer and Edward S Rorem), 1113
Potency (Haematopoietic), of Liver of Mice fed on a Meat Diet : Lack of (Judith Ilan and Prof K. Guggenheim), 698
Potent New Benzothiadiazine Diuretic (Dr. Richard M. Taylor and Martin M. Winbury), 603
Potential (Earth's Gravitational) : Evaluation of the Second, Fourth and Sixth Harmonics in the (D G King-Hele), 490
Potential (Galactic Gravitational) · Gravitational Red Shift of Hydrogen 21-cm Radiation as a Method to measure (L. F Landovitz and L. Marshall), 223
Potential (Generator), in the Lateral Eye of the Horseshoe Crab · Summative Action of Acetylcholine with Physiological Stimulus on the (R. Kikuchi, K Naito and S. Minagawa), 1118
Potential (The Membrane), of the Anterior Byssus Retractor Muscle of *Mytilus edulis* (Dr D. H. Paul), 1121
Potentialities . Human (Dr Gardner Murphy), *review* by Dr D J. West, 270
Potentiation of Contractility in the Heart Muscle of the Rat and some other Mammals (Dr V. Kruta and Dr P Braveny), 327
Potentiation of Hair-Growth by Ultra-Violet Light (B. E. Johnson), 159
Potentiometric Study of Priming Paints for Metal (Dr N R Bharucha), 756
Potter, B J. : Use of Diodone in Renal Studies in Sheep, 698
Poultry Science (British), Vol. 1, No 1, 465
Powell, Dr. D. W : Stress-Dependent Magnetization in some Quartz-Dolerites, 225
Power in Great Britain : Output of, 557
Power : Nuclear (Ministry of Power Programme), 1055
  Understanding and, 809

Power, Ministry of : The Nuclear Power Programme, 1055
  Capital Investment in the Coal, Electricity and Gas Industries, 1055
  Safety in Mines Research Establishment Bibliography, 1960 (compiled by E. B. Smith), second edition, *review* by Prof. S. G. Ward, 1063
Power (Fuel and) : Advisory Council for Research and Development in, 286
Power (Nitrogen-supplying), of Soils : Ammonia released on Treating Soils with *N* Sodium Hydroxide as a Possible Means of Predicting the (A. H. Cornfield), 260
Power Plant Design (Nuclear) : Evolution of (Sir Christopher Hinton), 1064
Practical Vertebrate Morphology : A Manual of (J. T. Saunders and Dr. S. M. Manton), third edition, *review* by Dr. N. B. Marshall, 9
Practice : Ferrimagnetism in Theory and, *review* by Dr. G. E. Bacon, 974
Practice of Television Engineering : Principles and, *review* by Dr. R. L. Smith-Rose, 358
Practice (Laboratory) : The Anti-Globulin (Coombs) Test in (Dr. L. Dunsford and Jean Grant), *review* by Dr. R. Drummond, 357
Pradhan, S. K., and others : Microbiological Transformation of Terpenes—Hydroxylation of α-Pinene, 689
Pre-cancerous Mouse Skin : Mast Cells and 5-Hydroxytryptamine in (Dr. R. E. Coupland and Dr. J. F. Riley), 1128
Pre-Natal Growth in Mammals Control of (Dr. Anne McLaren and Dr. Donald Michie), 363
Precipitating Components in Sera from Pregnant Women : Immuno-electrophoretic Demonstration of (Dr. Jan Hirschfeld and Dr. Ulf Soderberg), 332
Precipitation (Differential), of Nucleic Acids from Aqueous Solutions : A New Method for the (William G. Aldridge), 323
Precipitation Processes in Steels—Report of a Conference held in the University of Sheffield, 1958, *review* by Prof. F. C. Thompson, 9
Precipitins from *Ricinus communis* Seeds : Anti-Pneumococcus Type XIV Activity of (Lieut.-Col. G. W. G. Bird), 415
Precision Intercomparisons of Lead Isotope Ratios—Broken Hill and Mount Isa (F. Koller, Prof. R. D. Russell and T. J. Ulrych), 754
Predicting the Nitrogen-supplying Power of Soils : Ammonia released on Treating Soils with *N* Sodium Hydroxide as a Possible Means of (A. H. Cornfield), 260
Preference (Taste), in the Monkey : Effects of Medial Temporal Lesions on (Dr. L. Weiskrantz), 879
Pregnant Rabbit : Breeding of the Rabbit Flea, *Spilopsyllus cuniculi* (Dale)—Requirement of a 'Factor' from a, for Ovarian Maturation (A. R. Mead-Briggs and A. J. B. Rudge), 1136
Pregnant Women : Immuno-electrophoretic Demonstration of Precipitating Components in Sera from (Dr. Jan Hirschfeld and Dr. Ulf Soderberg), 332
  Inhibition of Glucuronosyl Transferase by Progestational Agents from Serum of (Dr. David Yi-Yung Hsia, Robert M. Dowben, Ralph Shaw and Aaron Grossman), 693
Prehistoric India, *review* by M. C. Burkitt, 94
Prehistoric Man in Europe (Frank C. Hibben), *review* by M. C. Burkitt, 729
Prehistory : North African, *review* by M. C. Burkitt, 1062
Preliminary Analysis of some International Geophysical Year Observations : Distribution of Atmospheric Ozone—a (J. MacDowall), 382
Preliminary Psychomotor Stress Studies with Subnormal Psychopathic Subjects (Dr. J. E. Tong, I. C. Murphy and F. R. Adams), 172
Prema, B. R., and others : Microbiological Transformation of Terpenes—Hydroxylation of α-Pinene, 689
Premature Neonatal Humans : Delayed-type Hypersensitivity in (Jonathan W. Uhr, Joseph Dancis and Charlotte Grantz Neumann), 1130
Preparation of Active Cellular Fractions : Homotransplant Antigens—(L. T. Mann, jun., J. M. Corson and Prof. G. J. Dammin), 774
Preparation and Use of Case Studies : Research Necessary for the (South London Committee of the British Institute of Management Conference on), 660
Preparations from Potatoes stored in the Cold and at Room Temperature : Biosynthesis of Sucrose by (Dr. Sigmund Schwimmer and Edward S. Rorem), 1113
Preparations (Pharmaceutical) : Classification of—a Survey of Existing Legislation (World Health Organization of United Nations), 287
Preparing Figures : Oceanography of Long Island Sound—Guide for (Y. H. Olsen and James E. Morrow, Jr.), 123
Presence of Chloramphenicol : Recovery in the, of *Escherichia coli* B (H) Irradiated with Ultra-violet Light (Kenshi Suzuki and Yukiko Iwama), 347
Presence of Immunologically Active Fragments after Proteolytic Degradation of Human γ-Globulin (L. A. Hanson and B. G. Johansson), 599
Presence of Neutral Carbohydrates in Human Aortic Tissue (Dr. Sv. Bertelsen), 411
Presence of a Pituitary Portal System in Elasmobranchs (Patrick Meurling), 336
Present Position of Leather Science, *review* by Prof. A. G. Ward, 724
Preservation of the Countryside (Council for the Preservation of Rural England twenty-first National Conference for the), 559
Preservation of Films of Historical Value, 199
Preservation of Rural England, Council for the : Twenty-first National Conference for the Preservation of the Countryside, 559
Preservation (Bird), International Council for : Annual Report for 1959, 287
Press, Elizabeth M., and Porter, R. R. : N-Terminal Amino-Acids of Bovine Antibody, 59
Press, Frank, and others (edited by) : Physics and Chemistry of the Earth, Vol. 3, *review* by B. E. Leake, 544
Press, J. J. (edited by) : Man-Made Textile Encyclopedia, *review* by Prof. C. S. Whewell, 2
Pressure (High) Chemical Plant : The Design and Construction of (Harold Tongue), second edition, *review* by Dr. K. E. Bett, 541
Pressure (High-) Forms of Ice—Ice-III : Crystal Structures of the (Prof. W. Barclay Kamb and Sankar K. Datta), 140
Pressure (High-) Technology, *review* by Dr. K. E. Bett, 541
Prestarved *Escherichia coli* : Capacity of Extracts from, to Incorporate Thymidine into Deoxyribonucleic Acid (Dr. Daniel Billen), 1044
Pretreatment with Reserpine : Influence on the Effect of Vasoconstrictor Amines by (H. C. Sabelli), 784
Prevention : Decay of Timber and its (K. St. G. Cartwright and W. P. K. Findlay), *review* by Prof. F. W. Jane, 977
Prevention and Artificial Induction of the Imaginal Diapause in *Coccinella 7-punctata* L. (I. Hodek and J. Cerkasov), 345
Price, Dr. J. R. : The Chemistry of Natural Products (Australian Natural Product Research), 1080
Price, Shirley A. P., and others : An Unidentified Pharmacologically Active Substance extracted from Cerebral Hemispheres, 420
Priestley, Dr. C. H. B. : Turbulent Transfer in the Lower Atmosphere, *review* by Prof. P. A. Sheppard, 974
Prigogine, Prof. I. (edited by) : Advances in Chemical Physics, Vols. 1 and 2, *review* by Prof. C. A. Coulson, 812
'Primary' Effects (Delayed), in *Chara vulgaris* L. subjected to X-Rays (C. M. Gillet), 874
Primary Species in the Radiolysis of Aqueous Solutions : Effects of *p*H and the Nature of the (J. T. Allan and Dr. G. Scholes), 218
Primary Tuberculous Infection : Effect of a, on the Resistance of Male and Female Mice to Ectromelia (Dr. A. W. Gledhill and Dr. R. J. W. Rees), 703
Primates : The Jaws and Teeth of (W. Warwick James), *review* by Sir Wilfrid Le Gros Clark, 891
Priming Paints for Metal : Potentiometric Study of (Dr. N. R. Bharucha), 756
Primitive Mythology : The Masks of God— (Dr. Joseph Campbell), *review* by Dr. K. O. L. Burridge, 7
Principle (Frog Water-Balance), and Arginine Vasotocin : Evidence for the Identity of Natriferin, the (Prof. Wilbur H. Sawyer), 1030
Principle (New), in Weaving, 27
Principle (A Polyploidizing), in the Spleen (L. Bouvier, Prof. R. Rigler and W. Rosenkranz), 965
Principles for British Agricultural Policy—a Study sponsored by the Nuffield Foundation (edited by H. T. Williams), *review* by Sir John Russell, 721
Principles of Sugar Technology (edited by Pieter Honig), Vol. 2, Crystallization, *review* by H. C. S. de Whalley, 979
Principles and Practice of Television Engineering, *review* by Dr. R. L. Smith-Rose, 358
Prins-van der Meulen, P. Y. F., and Schuringa, G. J. : Evidence for Multiple Nature of Cellulase of *Myrothecium verrucaria*, 695
Pritchard, J. P. : The Development of Pulp and Particle Board Industries and their Effect on Forest Management (Prospects of Greater Demand from the Furniture Industry), 33
Proactivator Activity : Isolation of Material with, from Human Serum (H. B. W. Greig and Elsie M. Cornelius), 1125
Probability and Physics, *review* by Prof. M. S. Bartlett, 1060
Probability and related Topics in Physical Sciences (Prof. Mark Kac), *review* by Prof. M. S. Bartlett, 1060
Probable Functions of Betaine Esters in Brain Metabolism : Isolation and (Prof. E. A. Hosein and Peter Proulx), 321
Problem of the 'Abominable Snowman' (S. V. Obruchev), 558
Problem (Cyprus) : Land Use and the, *review* by Prof. M. J. Wise, 628
Problem (Neglected) : Suicide—a, 207
Problems of the Arid Zones (Unesco Symposium on), 295
Problems of Radioactivity at Water and Sewage Works (Manchester College of Science and Technology Course of Lectures on), 743
Problems of Visual Discrimination (Prof. R. W. Ditchburn), 854
Problems (Boundary), in Differential Equations—Proceedings of a Symposium conducted by the Mathematics Research Center of the United States Army at the University of Wisconsin, 1959 (edited by Prof. Rudolph E. Langer), *review* by Prof. E. T. Copson, 451
Problems (Engineering) : Unification of Analytical Approaches to, *review* by Prof. J. Greig, 359
Problems (Non-Linear) : A Study of, *review* by K. Krickeberg, 727
Problems (Nonlinear), in Random Theory (Prof. Norbert Wiener), *review* by K. Krickeberg, 727
Problems (Trained Manpower) : The Public Service in New States—a Study of some (Kenneth Younger), 971
Problems (Weather), in Agriculture (Royal Meteorological Society Summer Meeting), 995
Process of Development : Shortages of Scientific Personnel in European Countries in, 565
Process (Cucumber Mosaic Virus Infection) : Direct Infra-Red Spectral Analysis of the (Prof. G. W. Cochran, G. W. Welkie and J. L. Chidester), 1049
Processes : Ecological (Dr. Alan Mozley), *review* by W. H. Dowdeswell, 451
  Redox (Chemical Research Committee of the Indian Council of Scientific and Industrial Research Symposium on), 650
Processes (Metabolic) : Role of Initial Value of, in Oxygen Consumption Changes in Rats during Irradiation (Dr. A. Vacek), 76
Processes (Precipitation), in Steels—Report of a Conference held in the University of Sheffield, 1958, *review* by Prof. F. C. Thompson, 9
Processing (Information) Societies, International Federation of : Formation of an, 655
Processing (Plastics) : The Technology of (Association for the Advancement of the Knowledge of Materials, the Royal Institute of Engineers, the Royal Netherlands Chemical Federation and the International Union of Pure and Applied Chemistry International Congress on), 559
Procházka, Dr. Z., and others : Biogenesis of Ascorbigen, 3-Indolylacetonitrile and Indole-3-carboxylic Acid from D,L-Tryptophan-3-^{14}C in *Brassica oleracea* L., 61
Procter Memorial Lecture of the Society of Leather Trades Chemists : Ninth (Prof. W. T. Astbury), 905
Proctor, B. A. : Strengths of Acid-etched Glass Rods, 492
Product (Fission), and Beryllium-7 Concentrations in the Atmosphere : Comparison of (W. Anderson, R. E. Bentley, R. P. Parker, J. O. Crookall and L. K. Burton), 550
Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture (F. Arcamone, C. Bonino, Prof. E. B. Chain, A. Ferretti, P. Pennella, A. Tonolo and Lidia Vero), 238
Production of Muscular Weakness in Rats by a Creatine Analogue (Coy D. Fitch and Prof. James S. Dinning), 421
Production of Tuberculin Sensitivity (Prof. Hubert Bloch and Albert A. Nordin), 434
Production of Tumours in *Rattus (Mastomys) natalensis* by Polyoma Virus (Dr. Alan S. Rabson, William J. Branigan and Frances Y. Legallais), 423
Production (Food and Animal) : Overseas (British Association for the Advancement of Science, Section M (Agriculture), Discussion on), 1070

Production (Fruit), of the Strawberry : Effect of Autumn Applications of Potassium Gibberellate on (Prof. Carter R. Smith), 620
Production (Gas), of Sensitive and Resistant L1210 Mouse Leukaemia Cells : Effect of 6-Mercaptopurine on the Net *in vitro* (Dr. H. J. Woodliff), 156
Productivity (Grassland) : The Measurement of—Proceedings of the University of Nottingham Sixth Easter School in Agricultural Science, 1959 (edited by Prof. J. D. Ivins), *review* by Dr. G. W. Cooke, 544
Products . Flat Rolled—Rolling and Treatment (edited by T. E. Dancy and E. L. Robinson), *review* by Prof. F. C. Thompson, 273
Products of the Rare Earth Groups (Johnson, Matthey and Co., Ltd.), 832
Products (Meat) : The Science of Meat and (Members of the Research Staff of the American Meat Institute Foundation), *review* by Prof. J. Hawthorn, 888
Products (Natural) : The Chemistry of (Symposium on, sponsored by the International Union of Pure and Applied Chemistry, organized by the Australian Academy of Science), 1080
Products (Pharmaceutical) · Use of Gamma-Radiation Sources for the Sterilization of (Report of the Association of the British Pharmaceutical Industry), 903
Professional Radio and Electronics Engineers : Education and Training of (British Institution of Radio Engineers Report on), 115
Profile (Soil) : C Horizon of the (Dr. S. G. Willimott and D. W. Gilchrist Shirlaw), 966
Progestational Agents from Serum of Pregnant Women · Inhibition of Glucuronosyl Transferase by (Dr David Yi-Yung Hsia, Robert M. Dowben, Ralph Shaw and Aaron Grossman), 693
Programming Programme for the BESM Computer (A. P. Ershov), translated from the Russian by M. Nadler, edited by J. P. Cleave, *review* by R. J. Ord Smith, 92
Programming (Automatic), in the U.S S.R., *review* by R. J. Ord Smith, 92
Progress in the Endocrinology of Reproduction : Recent—Proceedings of the Conference held in Syracuse, 1958, *review* by Prof P L. Krohn, 5
Progress in English Education : Sixty Years of (Prof. H. C. Dent), 848
Progress in Inorganic Chemistry (edited by F. Albert Cotton), Vol. I, *review* by Dr. I. R. Beattie, 4
Progress in Nuclear Science, *review* by Dr. E. B. Paul, 182
Progress of Science Abroad : The Royal Society and the (Prof. R. J. Forbes), 100
Progress in Semiconductors (edited by Dr. Alan F. Gibson, Prof R. E. Burgess and Dr. F A. Kroger), Vol. 4, *review* by Dr. J. R. Tillman, 185
Progress (Economic) . The Conditions of (Colin Clark), 537
Progress (Man's Technological), from Steam Engine to Satellite Science as History—the Story of (Heinz Gartmann), translated from the German by Alan G. Readett, *review* by J. L. Stollery, 8
Progress (Research), in General Medical Sciences, 1959 : Highlights of (United States Department of Health, Education and Welfare, Publication No. 739), 200
Projection (Stereographic) : Use of, in Structural Geology (Dr. F. C. Phillips), second edition, *review* by John Sutton, 729
Proliferative Capacity of Acute Leukaemia Cells (Dr. Felice Gavosto, Giovanni Maraini and Alessandro Pileri), 611
Propagate a Fatigue Crack in Mild Steel : Correlation of the Alternating Stresses required to Initiate and (N. E. Frost), 233
Propagation (Ionospheric), of Electromagnetic Waves, *review* by Sir Harrie Massey, 810
Properties of the Two-Neuron Arc (Hind-Limb Reflexes in the Kitten), (Dr. Stan Skoglund), 134
Properties (Biological) : Synthesis and, of L-Arginyl-L-Prolyl-L-Prolyl-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenylalanyl-L-Arginine, an Octapeptide related to Bradykinin (E. D Nicolaides, H. A. DeWald, Patricia G. Shorley and Dr H. O J Collier), 773
Properties (Chemical and Physical), of the Small Deoxyribonucleic Acid Component of Crystalline Cytochrome b_5 (Dr. M. D. Montague and Prof R K. Morton), 916
Properties (Magnetic), of Tektites and Glasses formed by Fusion of Terrestrial Rocks . Comparison of the Chemical Composition and (Dr. Irving Friedman, Dr. Arthur Thorpe and Dr. Frank E. Senftle), 1089
Properties (Scattering), of the Moon : Radar Determination of the (Dr. Fred B Daniels), 399
Properties, Physics and Design of Semiconductor Devices (John N Shive), *review* by Dr. J. R Tillman, 1058
Property (Industrial), International Association for the Protection of : Twenty-fourth Congress (H. C. Miller), 202
Proportion of Noradrenaline to Adrenaline in the Adrenal Glands of Littermate Cats (Dr K. R Butterworth and Dr Monica Mann), 785
Proposal (New) . Valance-Bond Structures—a (Dr J. W. Linnett), 859
Proposals for Space Flight, *review* by D G. King-Hele, 811
Proprioceptive Hind-Limb Reflexes : Velocity of Conduction and Spinal Transmission of (Hind-Limb Reflexes in the Kitten), (Dr. Stan Skoglund), 132
Propulsion Combustion and (AGARD fourth Colloquium on—High Mach Number Air-breathing Engines), 18
6-*n*-Propylthiouracil : Differential Reactivity of Saliva from 'Tasters' and 'Non-Tasters' of (Frances Griffin and Prof. Roland Fischer), 417
Prosser, G. S. (Patrick, Dr C. R., and) : A Molecular Complex of Benzene and Hexafluorobenzene, 1021
Prostato-vesiculitis (Chronic) . Urinary Excretion of Œstrogens in Cases of (Prof. Gunnar Nylander), 154
Protandry and Self-Fertilization in the Calyptraeidae (Dr H. V. Wyatt), 520
Processes : Enzymatic Activation of a Hormone-like Response in *Hydra* by (Dr. Howard M. Lenhoff and John Bovaird), 671
Protection of Gas Plant and Equipment from Corrosion (Institution of Gas Engineers and the Corrosion Group of the Birmingham and Midlands Section of the Society of Chemical Industry Symposium on), 466
Protection of Industrial Property, International Association for the : Twenty-fourth Congress (H. C. Miller), 202
Protection against Liver Injury due to Murine Hepatitis Virus (Dr. J. D. Judah, G Bjotvedt and T. Vainio), 507
Protection against Tidal Flooding in London (N. B. Webber) 293
Protective Effect of Cysteine against Retinal Degeneration induced by Iodate and Iodoacetate (Prof. Arnold Sorsby and Ronald Harding), 608
Protein : Incorporation of Acetate into, by Obligately Parasitic and Saprophytic Fungi (Dr. Richard C. Staples and Dr. H. P. Burchfield), 1040
  Microbial Synthesis of, in relation to the Biogenesis of Nucleic Acids with *Azotobacter vinelandii* as the Test Organism (Maharani Chakravorty), 239
Protein (An Abnormal Serum), in Experimental Poisoning by Cadmium and other Metals (D. J. Lawford), 946
Protein (Plant) : Enzymatic Synthesis of Formylglutamic Acid by a (Ernest H. Byers, Jun., and T. J Bond), 416
Protein (Tobacco Mosaic Virus) : A Difference between the Sub-Units of ? (Dr H G. Aach), 75
Protein Content : Urinary Amino-Acid Pattern of Cats on Diets of varying (Dr. J. P. Greaves and Dr. Patricia P. Scott), 242
Protein Synthesis . Cytoplasmic Particles and their Role in (Colloid and Biophysics Committee of the Faraday Society Informal Discussion on), 643
Protein Synthesis (Optimal), by Ascites Tumour Cells *in vitro* (Dr. M. J. Fraser), 1114
Protein-bound Aminoazo Dyes : Distribution of, in the Rat Liver Microsome (Dr T. Yamada, M. Matsumoto, S. Kanda and Prof. H. Terayama), 943
Proteins : Transiodination of, during Enzymic De-iodination of Thyroxine (Dr. J R. Tata), 1025
Proteins in Deuterium Oxide : Ultra-violet Absorption Spectra of (Dr. Shiro Takashima), 597
Proteins (Cornea) : Infra-red Examination of the Association of, with Water (Dr S. Bakerman and C. Mitchell), 1033
Proteins (The Plasma), in Normal Urine (Dr. L Berggård), 776
Proteins (Wheat) Starch-Gel Electrophoresis of (Dr. G. A. H. Elton and J. A. D. Ewart), 600
Proteolytic Degradation of Human γ-Globulin : Presence of Immunologically Active Fragments after (L. A. Hanson and B. G. Johansson), 599
Proteolytic Enzyme from *Bacillus subtilis* : Amino-Acid Sequence about the Reactive Serine of a (Dr. F. Sanger and D. C. Shaw), 872
Proterozoic in the U S.S.R., 742
Proton Magnetic Resonance Spectroscopy : Structure Determination with the Help of (Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives), (C. F. Blakely, Dr R. F. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662
Protoplasts (Plant), and Vacuoles : A Method for the Isolation of (Dr. E. C. Cocking), 962
Protozoa (Rumen Oligotrich): Effect of Penicillin on the Maintenance of (G. S. Coleman), 518
Proulx, Peter (Hosein, Prof. E. A., and) : Isolation and Probable Functions of Betaine Esters in Brain Metabolism, 321
Provenzano, jun., Anthony J. . Albinism in an American Population of the Shore Crab, *Carcinus maenas* (L.), 521
Provisional Embryonic Cuticle of a Lepidopteran : Occurrence and Function of the (Dr. R. K. Sharan), 1040
Pruthi, J. S. (Rao, B A. S., and) . An Acid-tolerant and Non-sporulating Yeast from Passion Fruit Juice, 342
Pseudocoelomic Membranes of *Ascaris lumbricoides* : Use of Collagenase in the Characterization of (Barbara Dawson), 798
Pseudomonad : A Growth Factor for *Haemophilus* Species secreted by a (Moshe Shifrine and Prof Ernst L. Biberstein), 623
Pseudomonas Species · Egg-Yolk Reactions of (Dr. A. T. Willis and G. Gowland), 432
Psychiatry : Existential, *review* by Dr. Clifford Allen, 1062
Psychiatry, Korsakov Journal of Neuropathology and : English translation of, 649
Psychoanalysis and Medicine : The Wish to Fall Ill—a Study of (Dr. Karin Stephen), *review* by Dr. Clifford Allen, 978
Psychology at Leicester, 901
Psychology . Experiment in—a Centenary and an Outlook (Prof R. C. Oldfield), 846
Psychomotor Stress Studies with Subnormal Psychopathic Subjects : Preliminary (Dr. J. E. Tong, I. C Murphy and F R Adams), 172
Psychopathic Subjects (Subnormal) : Preliminary Psychomotor Stress Studies with (Dr. J E. Tong, I C. Murphy and F. R. Adams), 172
Pteridological Society (British) : Work of the, 902
Pterin Synthesis in the Amphibian Neural Crest Cell (Tadao Hama and Masataka Obika), 326
Public : Science and the, 371
Public Service in New States : The—a Study in some Trained Manpower Problems (Kenneth Younger), 971
Publications : Cost of Scientific Periodical (Capt L. R. Maxwell), 1052
Publications (Indian Scientific and Technical) Bibliography of (Council of Scientific and Industrial Research, New Delhi), 199
Publications (Russian Biological) . Translations of (American Institute of Biological Sciences), 558
Publications (Scientific) Council : Discussion on the Influence of Editors, 120
Published Books : United States Record of, 116
Pugh, Sir William . Triassic Salt—Discoveries in the Cheshire–Shropshire Basin, 278
Pugsley, Sir Alfred : Statics and the Engineer (Presidential Address to Section G (Engineering) of the British Association for the Advancement of Science), 844
Pulp and Board Industries in Britain : Scope for Expanding (J. J MacGregor), 32
Pulp and Particle Board Industries : The Development of, and their Effect on Forest Management (Society of Foresters of Great Britain Discussion on), 32
Pulse-shortening in Electron Linear Accelerators (M. G. Kelliher and R. Beadle), 1099
Pump Fluids for Higher Vacuums (Kenneth Hickman), 405
Pupal Mortality (Late Larval and), in the Wild · Radioactive Labelling of Lepidopterous Larvae—a Method of estimating (L. M Cook and Dr H. B. D. Kettlewell), 301
Pupil : Effect of Size of, on Visual Acuity (Dr. F. W. Campbell and Dr. A. H. Gregory), 1121
Purchase, I F. H. Awarded a Research Training Scholarship by the Animal Health Trust, 904
Pure Lines of Rice : Secondary Selection in (T. K. Van), 169
Pure Rotational Absorption of Ozone in the Region 125-500 Microns (Dr. H. A. Gebbie, N. W. B. Stone and C. D. Walshaw), 765

Pure Water: Changes in Conductivity of, caused by X-Irradiation (K. Schmidt), 931
Pure and Applied Chemistry (International Union of Pure and Applied Chemistry Seventeenth International Congress of), 29, *erratum*, 117
Pure and Applied Chemistry, International Union of: Seventeenth International Congress of Pure and Applied Chemistry, 29, *erratum*, 117
Pure and Applied Chemistry, International Union of (sponsored by the): Symposium on the Chemistry of Natural Products (organized by the Australian Academy of Science), 1080
Pure and Applied Chemistry, International Union of, and others: International Congress on the Technology of Plastics Processing, 559
Pure and Applied Physics, International Union of: Tenth Annual International Conference on High-Energy Physics, 29
Purified Human Growth Hormone: Immunoelectrophoretic Studies on (Dr. Jan Hirschfeld, Carl-Axel Gemzell and Leif Wide), 64
Purkayastha, Mira, and Williams, Prof. R. P.: Association of Pigment with the Cell Envelope of *Serratia marcescens* (*Chromobacterium prodigiosum*), 349
Pursuit of World Health: In, *review* by Christine Cockburn, 722
Purver, Margery, and Bowen, Dr. E. J.: The Beginning of the Royal Society, *review* by Dr. William P. D. Wightman, 356
Pusey, J. G.: Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Botany), 742
Pyridine Nucleotides in Liver Poisoning: Levels of (Dr. C. H. Gallagher and Dr. K. R. Rees), 148
Pyridoxine Deficiency in Rats: Polyenoic Acid in Hypercholesterolaemia induced by (Ajit Goswami and Prof. D. P. Sadhu), 786
Pyrosoma: Occurrence of, on the Continental Slope (P. J. Whitehead), 878
Pyruvate: Effect of, upon Nucleated and Enucleated Fragments of *Amoeba proteus* (Dr. Edmund Guttes and Sophie Guttes), 432

QUADRIVALENTS in Autotetraploid Plants: Frequency of (Dr. J. W. Morrison and Dr. T. Rajhathy), 528
Quaglino, Dennis, and Hayhoe, Dr. F. G. J.: Acetone Fixation for the Cytochemical Demonstration of Dehydrogenases in Blood and Bone Marrow Cells, 85
Qualifications and Attitudes of Students entering Training Colleges: Recruits to Teaching—a Study of the Attainments, (F. W. Land), 750
Qualitative Distribution (Quantitative and), of Zooplankton in the Southern Part of the Norwegian Sea: Investigations on the (V. K. Hansen), (Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 23), *review* by Dr. A. J. Southward, 360
Quantitative Biology: Cold Spring Harbor Symposia on, Vol. 24, Genetics and Twentieth Century Darwinism, *review* by Dr. H. Kalmus, 726
Quantitative Genetics: Introduction to (Dr. D. S. Falconer), *review* by Prof. Kenneth Mather, 813
Quantitative Investigation of the Echinoderm Fauna of the Central North Sea (Dr. Erik Ursin), (Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 24), *review* by Dr. A. J. Southward, 360
Quantitative and Qualitative Distribution of Zooplankton in the Southern Part of the Norwegian Sea: Investigations on the (V. K. Hansen), Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 23), *review* by Dr. A. J. Southward, 360
Quantities (Microgram), of Silver: Non-destructive Analysis of, by Radioactivation (Dr. Minoru Okada), 57
Quantum Chemistry—Methods and Applications (R. Daudel, R. Lefebvre and C. Moser), *review* by Prof. H. C. Longuet-Higgins, 541
Quarrell, Prof. A. G.: The Newer Metals, *review*, 725
Quarries: Accidents in Mines and, 1076
Quarries (Mines and), H.M. Inspectors of: Annual Reports for 1959—Scottish Division; Northumberland and Cumberland Division; Durham Division; North Eastern Division; North Western Division; East Midland Division; West Midland and Southern Division; South Western Division, 1076
Quartz-Dolerites: Stress-Dependent Magnetization in some (Dr. D. W. Powell), 225
Queen Elizabeth College, London: Grant of £3,800 from the Leverhulme Trust Fund, to enable a sociological research programme to be started in the Department of Nutrition, 201
  Appointment of Dr. Paul Morpurgo as Leverhulme Research Fellow in the sociology of nutrition, 201
  Grant of £56,000 from the London Research Foundation, to further the research work of the Department of Nutrition, with special reference to its work on fertility control, 201
Queen Mary College, London: Title of professor of organic chemistry in the University of London conferred on Dr. W. J. Hickinbottom, 466
  Title of reader in mechanical engineering in the University of London conferred on Dr. C. R. Webb, 904
Queen's University, Belfast: Appointment of Dr. D. W. R. Mackenzie to a lectureship in microbiology, 117
  Appointment of Dr. N. T. Dunwoody as lecturer in engineering mathematics, 465
  Appointment of R. G. A. Stretch as lecturer in psychology, 465
  Grant of £15,005 to Prof. D. R. Bates for Space Research (upper atmospheric rocket research, including artificial air-glow, altitudes of night-glow layers, and a study of micrometeorites), 744
Quelea quelea (Weaver Finch): Effects of Whole-body Irradiation on the Breeding Plumage of the (Dr. B. Lofts, Prof. A. J. Marshall and Prof. J. Rotblat), 615
Questions of Science and Faith (Dr. Hawthorne), 28
Quinic and Shikimic Acids: Excretion of Catechol after Ingestion of (Dr. A. N. Booth, D. J. Robbins, M. S. Masri and F. DeEds), 691
Quinol Phosphates: Oxidative Phosphorylation—Synthesis of Adenosine Diphosphate by the Oxidation of (Dr. V. M. Clark, D. W. Hutchinson and Sir Alexander Todd), 59
Quirk, Dr. J. P., and Theng, B. K. G.: Effect of Surface Density of Charge on the Physical Swelling of Lithium Montmorillonite, 967
Quirk, Dr. J. P. (Aylmore, L. A. G., and): Domain or Turbostratic Structure of Clays, 1046
Quisenberry, Walter B.: Culture, Society and Health (Socio-Cultural Factors in Cancer), 658

R'S (The Two), of Plant Breeding, *review* by Dr. G. Haskell, 184
Rabess, S. L., and others: Fertility of Mice treated with Phosphorus-32, 876
Rabbit (Pregnant). Breeding of the Rabbit Flea, *Spilopsyllus cuniculi* (Dale)—Requirement of a 'Factor' from a, for Ovarian Maturation (A. R. Mead-Briggs and A. J. B. Rudge), 1136
Rabbit Anti-Mouse Erythrocyte Serum: Electrophoretic Separation of certain *in vitro* and *in vivo* Reactions of (Chang-Ling Lee, Tamon Takahashi and Israel Davidsohn), 157
Rabbit Flea, *Spilopsyllus cuniculi* (Dale): Breeding of the—Requirement of a 'Factor' from a Pregnant Rabbit for Ovarian Maturation (A. R. Mead-Briggs and A. J. B. Rudge), 1136
Rabbit Right and Left Heart Ventricles: Platelet-Count Differences in Blood of the (Dr. J. George Sharnoff and Dr. Vito Scardino), 334
Rabi, Prof. I. I.: Awarded the Barnard Medal for 1960 of Columbia University, New York, 24; work of, 24
Rabin, Dr. B. R., and others: Activity of Bovine Pancreatic Ribonuclease A in Mixed Solvent Systems, 601
Rabson, Dr. Alan S., and others: Production of Tumours in *Rattus* (*Mastomys*) *natalensis* by Polyoma Virus, 423
Race Differences in the Ability to excrete Beetroot Pigment (Betanin), (Dr. P. H. Saldanha, L. E. Magalhaes and Wanda A. Horta), 806
Racemization (Catalytic), of *tris*(Ethylenediamine)Cobalt (III) Ion (Dr. F. P. Dwyer and Dr. A. M. Sargeson), 1022
Radar Determination of the Scattering Properties of the Moon (Dr. Fred B. Daniels), 399
Radar Reflector: Roughness of the Moon as a (Dr. B. H. Briggs), 466, 490
Radiation: Ageing and (Dr. G. J. Neary), 10
Radiation (Atomic): The Biological Effects of—Summary Reports from a Study by the National Academy of Sciences (United States National Academy of Sciences—National Research Council), 380
Radiation (Cosmic): Local Increase of Intensity of (J.-P. Legrand and A. Helary), 397
Radiation (Cosmic), Latin American Council of: Meeting in Rio de Janeiro, 648
Radiation (Cosmic) Studies in South America, 648
Radiation (Hydrogen 21-cm.): Gravitational Red Shift of, as a Method to measure Galactic Gravitational Potential (L. F. Landovitz and L. Marshall), 223
Radiation (Intense): Biological Effects of Exposure to, 910
Radiation (Optical), in Ruby: Stimulated (Dr. T. H. Maiman), 493
Radiation and the Broad Bean, *review*, 8
Radiation Biology of *Vicia faba* in relation to the General Problem (Dr. John Read), *review*, 8
Radiation Chimaeras: Identification of Transplanted Bone Marrow Cells in (P. Czerski, O. Rosiek and J. Sablinski), 955
Radiation Chimaeras (Homologous): Polyvalent Immunological Tolerance in (Alena Lengerová), 160
Radiation Flux from a Heated Tube: Effect of Specular Reflexions on the (Sir K. S. Krishnan), 135
γ-Radiation Sources: Use of, for the Sterilization of Pharmaceutical Products (Report of the Association of the British Pharmaceutical Industry), 903
Radiation-induced Nitration of Aliphatic Hydrocarbons (Dr. Tyson Rigg), 933
Radiations (Ionizing): Chemical Effects of, on Nucleic Acids and Nucleoproteins (P. Emmerson, Dr. G. Scholes, D. H. Thomson, J. F. Ward and Prof. J. Weiss), 319
  Role of Oxygen in the Cross-linking and Degradation of Deoxyribonucleic Acid by (Peter Alexander and J. T. Lett), 933
Radic, a New British Analogue Computer (The Redifon Company), 288
Radical (CF_3): Photochemical Formation and Stability of the (Dr. J. P. Simons and A. J. Yarwood), 316
Radio Astronomy Observatory (National), Green Bank, West Virginia: Financial support from the United States National Science Foundation for the construction of, 910
Radio Emission from Jupiter: Ionospheric Modification of the (Prof. Alex G. Smith, T. D. Carr, H. Bollhagen, N. Chatterton and F. Six), 568
Radio Engineers, British Institution of: Report on the Education and Training of Professional Radio and Electronics Engineers, 115
Radio Engineers, Institute of (Benelux Section), in co-operation with others: International Symposium on Data Transmission, 290
Radio Engineers, Institute of (Group on Communications Systems), and others: International Symposium on Data Transmission, 290
Radio Frequency Control in Space Telecommunications (Edward Wenk, Jun.), 373
Radio Navigation (Avionics Panel of AGARD Symposium on), 1079
Radio and Electronics Engineers: Education and Training of Professional (British Institution of Radio Engineers Report on), 115
Radioactivation: Non-destructive Analysis of Microgram Quantities of Silver by (Dr. Minoru Okada), 57
Radioactive Areas in Rats exposed to a High Flux of Thermal-Neutrons: Localization by Autoradiography at −195° C. of—Importance of Phosphorus-32 in Consecutive Internal Irradiation (Jean Chanteur and Pierre Pellerin), 472
Radioactive Fall-out in Ghana (Dr. A. H. Ward and J. D. Marr), 299
Radioactive Griseofulvin: Behaviour of, in Skin (Dr. A. Scott), 705
Radioactive Labelling of Lepidopterous Larvae—a Method of Estimating Late Larval and Pupal Mortality in the Wild (L. M. Cook and Dr. H. B. D. Kettlewell), 301
Radioactive Labelling of Membrane Filters for the Assay of Air-borne Material (Dr. G. Kubie and Dr. K. Spurny), 930
Radioactive and Natural Strontium in Human Bone (J. W. Arden, F. J. Bryant, E. H. Henderson, G. D. Lloyd and A. G. Morton), 994
Radioactivity of Soils, Plants and Bones (Sir Ernest Marsden), 192
Radioactivity at Water and Sewage Works: Problems of (Manchester College of Science and Technology Course of Lectures on), 743
Radiobiology and Radiology: Genetics,—Proceedings, Mid-Western Conference (edited by Dr. Wendell G. Scott and Dr. Titus Evans), *review* by Dr. Lorna J. Lilly, 97
Radiocaesium in Milk: Radiostrontium and, during 1959 (W. Anderson, L. K. Burton and J. O. Crookall), 108
Radioisotopes: Industrial Uses of (United Kingdom Atomic Energy Authority Course for Trade Union Officials), 905

Radiological Health and Safety : Training in (Prof. J. E. Roberts), 471
Radiology : Genetics, Radiobiology and—Proceedings, Mid-Western Conference (edited by Dr. Wendell G. Scott and Dr. Titus Evans), *review* by Dr. Lorna J. Lilly, 97
Radiolyses of Aqueous Solutions : Effects of *p*H and the Nature of the Primary Species in the (J. T. Allan and Dr. G. Scholes), 218
Radiolyses of Highly Enriched Oxygen-18 Water Solutions containing Hydrogen Peroxide-16,16 (Dr. Michael Anbar, Shmuel Guttmann and Prof. Gabriel Stein), 57
Radiolysis of Terpene Hydrocarbons—Isomerization and Polymerization of α- and β-Pinene (T. H. Bates and Dr. T. Ffrancon Williams), 665
Radiolysis of Water and Heavy Water : Effects of Linear Energy Transfer on the (Dr. E. Collinson, Prof. F. S. Dainton and J. Kroh), 475
Radiolytic Oxidation, of Ferrous Solutions with Standardized Internal Sources of Phosphorus-32 (Dr. M. Pesach and J. Steyn), 58
Radiophosphorus Assimilation in Organic and Inorganic Forms in Salmon : Bacterial Effect and (Dr. P. N. Srivastava), 83
Radiosensitivity of Mouse Kidney undergoing Compensatory Hypertrophy (Lieut. V. J. Rosen, jun., and Dr. L. J. Cole), 612
Radiosensitivity of Tumours : Chromosome Ploidy and (László Revész and Ulla Norman), 861
Radiostrontium and Radiocaesium in Milk during 1959 (W. Anderson, L. K. Burton and J. O. Crookall), 108
Radius (Equivalent Pore), of Kidney Slices from *Necturus* : Effect of Anti-Diuretic Hormone and Calcium on the (G. Whittembury, N. Sugino and Dr. A. K. Solomon), 699
Radley, J. M., and others : Alpha Activity of certain Botanical Materials, 208
Raising (Silkworm), on Artificial Food (Toshifumi Fukuda, Mitsumasa Suto and Yoshikichi Higuchi), 669
Rajhathy, Dr. T. (Morrison, Dr. J. W., and) : Frequency of Quadrivalents in Autotetraploid Plants, 528
Ramachandra Rao, Prof. B., and Padmini, P. R. K. L. : A Relation between Ultrasonic Velocity and Latent Heat of Vaporization, 311
Ramachandran, E. G., and Dasarathy, C. : Stabilization of Austenite by Hydrogen, 684
Ramamurti, K. (Jackson, Dr. C. P., and) : Syntheses of Glucose, Cellobiose and other Saccharides by *Acetobacter acetigenum* in a Lactate-buffered Glycerol Medium, 942
Ramsay Memorial Fellowship Trust : Awards in Chemistry for 1960-61, 832
Rana temporaria (Common Frog) : Cyclical Changes in the Distribution of the Testis Lipids in the (Dr. B. Lofts and C. Boswell), 708
Randles, W. J. : Induced Fluorescence with Acridine Orange, after Osmium Fixation, 964
Random Theory : Nonlinear Problems in (Prof. Norbert Wiener), *review* by K. Krickeberg, 727
Ranganathan, G., and others : Potassium Tolerance Tests in South Indian People, 328
Range (Sieve) : A Method for the Routine Measurement of Particle Shape Factors in the (Dr. Colin C. Harris), 401 ; (D. Howitt), 403
Ranger, A. E., and Hopkins, L. F. : Behaviour of Paper during Tensile Straining, 1097
Rankama, Kalervo, and others (edited by) : Physics and Chemistry of the Earth, Vol. 3, *review* by B. E. Leake, 544
Rankin, K. N. : The Development of Pulp and Particle Board Industries and their Effect on Forest Management, 33
Rao, B. A. S., and Pruthi, J. S. : An Acid-tolerant and Non-sporulating Yeast from Passion Fruit Juice, 342
Rao, C. N. R. : Is Hyperconjugation Necessary ?, 913
Rapid Method for Studying Tumour Blood Supply using Lissamine Green (L. N. Owen), 795
Rapid Rates of Crystallization : A New Technique for following (J. H. Magill), 770
Rare Earth Groups : Products of the (Johnson, Matthey and Co., Ltd.), 832
Rare Modes in the Spontaneous Fission of Californium-252 (Prof. E. W. Titterton and T. A. Brinkley), 228
Rare and Dispersed Chemical Elements in Soils : The Geochemistry of (A. P. Vinogradov), second edition (translated from the Russian), *review* by A. H. Debnam, 629
Rat : Comparison of Iodine-124 and Iodine-131 in Inhibition of Goitrogenesis in the (Dr. I. Doniach and Dr. P. E. Francois), 704
  Effect of Reserpine on the Nucleotide and Catecholamine Content of the Denervated Adrenal Medulla of the (Prof. Nils-Åke Hillarp), 1032
  Hunger Reduction produced by Injecting Glucose into the Lateral Ventricle of the (L. J. Herberg), 245
  Metabolism of ^{14}C-Meso-inositol in the (Dr. D. A. Nixon), 77
  Strain Differences in Acetylcholine Concentration in the Brain of the (Edward L. Bennett, James Crossland, David Krech and Mark R. Rosenzweig), 787
Rat adapted to a Fat Diet : An Inverse Relation between the Liver Glycogen and the Blood Glucose in the (Dr. P. A. Mayes), 325
Rat Embryos : Effect of Trypan Blue on (F. Beck, Dr. B. Spencer and Prof. J. S. Baxter), 605
Rat Glomerulus and Nephritogenic Streptococci : Immunological Relationships between the (A. S. Markowitz, S. Howard Armstrong, jun., and Daniel S. Kushner), 1095
Rat Liver Microsome : Distribution of Protein-bound Aminoazo Dyes in the (Dr. T. Yamada, M. Matsumoto, S. Kanda and Prof. H. Terayama), 943
Rat Liver Mitochondria : A High-Energy Phosphate Requirement for Succinate Oxidation in Uncoupled (Dr. Giovanni Felice Azzone and Dr. Lars Ernster), 65
Rat Serum Acid Phosphatase : Total and $l(+)$ Tartaric Acid Inhibited (Dr. Z. Laron and B. Epstein Halberstadt), 67
Rat and some other Mammals : Potentiation of Contractility in the Heart Muscle of the (Dr. V. Kruta and Dr. P. Braveny), 327
Rat's Ventricle : Effect of Nitrate Ion on the Distribution of Sucrose in the (S. T. Taketa, C. G. Alexander and Prof. G. A. Feigen), 419
Ratcliffe, J. A. : The Magneto-Ionic Theory and its Applications to the Ionosphere, *review* by Sir Harrie Massey, 810
  Recent Trends in the Theory of the Ionosphere (Presidential Address to the Physical Society, 853
Rate of Mitosis in Lens Epithelium : Comparison between the Effects of Cysteine and of Anoxia on the (Dr. Antoinette Pirie and Dr. Ruth van Heyningen), 947
Rates (Metabolic), at the Cellular Level : Analysis of (Dr. L. G. Lajtha, R. Oliver, R. J. Berry and Elizabeth Hell), 919
Rates (Rapid), of Crystallization : A New Technique for following (J. H. Magill), 770
Ratio (Chlorine—Sodium), in the Atmosphere : Change of the, with Altitude and Distance from the Source of Sodium Chloride, and the Distribution of Atmospheric Nitrate over the United States (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Ratio (Sex), of Ammocoetes (M. W. Hardisty), *erratum*, 29
Ratios (Lead Isotope) : Precision Intercomparisons of—Broken Hill and Mount Isa (F. Kollar, Prof. R. D. Russell and T. J. Ulrych), 754
Rats : Dextran and Insulin in (Dr. L. H. Marshall and C. H. Hanna), 1118
  Polyenoic Acid in Hypercholesterolaemia induced by Pyridoxine Deficiency in (Ajit Goswami and Prof. D. P. Sadhu), 786
  Production of Muscular Weakness in, by a Creatine Analogue (Coy D. Fitch and Prof. James S. Dinning), 421
Rats exposed to a High Flux of Thermal Neutrons : Localization by Autoradiography at −195° C. of Radioactive Areas in—Importance of Phosphorus-32 in Consecutive Internal Irradiation (Jean Chanteur and Pierre Pellerin), 472
Rats during Irradiation : Role of Initial Value of Metabolic Processes in Oxygen Consumption Changes in (Dr. A. Vacek), 76
Rats in Sewers : Control of (Dr. W. E. Bentley), 288
Rats (Irradiated) : Synthesis of Diphosphopyridine Nucleotide in (Dr. D. K. Myers), 1124
Rats (Metacorticoid Hypertensive) : Electro-shock Seizure Threshold of (Dr. F. M. Sturtevant), 874
Rats (Young) : Influence of Different Types of Malnutrition on the ^{14}C-Lysine Metabolism in (Prof. Kurt Schreier and Corinna Kassens), 1117
Rattus (*Mastomys*) *natalensis* : Production of Tumours in, by Polyoma Virus (Dr. Alan S. Rabson, William J. Branigan and Frances Y. Legallais), 423
Rauen, Prof. H. M., and others : Action of Nucleic Acids on the Inhibition of Growth of Actinomycin of *Neurospora crassa*, 60
Raw, F. : Earthworm Population Studies—a Comparison of Sampling Methods, 257
Rawlins, F. I. G. : Introduction to Symbolic Logic and its Applications, *review*, 729
  The Hollow Universe, *review*, 890
γ-Ray Measurements : Fall-out Caesium in Surface Sea Water off the California Coast (1959-60) by (Dr. Theodore R. Folsom, Dr. G. J. Mohanrao and Parrin Winchell), 480
γ-Ray Spectrometry : Non-destructive Analyses of Selenium by Neutron Activation followed by (Dr. Minoru Okada), 594
γ-Ray Spectroscopy : Gallium Arsenide for (W. R. Harding, C. Hilsum, M. E. Moncaster, D. C. Northrop and Dr. O. Simpson), 405
Rayner, M. J., and others : Speed of the Superconducting-Normal Transition in Tin Films, 492
Rayon Research Association (British) : Open Days (L. A. Wiseman), 121
Rays (Cosmic): Dependence on Latitude of the Amplitude of the Diurnal Variation of (Arne Eld Sandstrom, Eric Dyring and Stig Lindgren), 1099
Réacteurs Nucléaires : Évacuation et Récupération de la Chaleur des (Richard Alami et Paul Ageron), *review* by R. J. Syme, 636
Reaction with D-Benzylpenicilloic Acid with Cystine : Formation of D-Penicillamine-Cysteine Mixed Disulphide by (Dr. Bernard B. Levine), 940
Reaction (Transhydrogenase) : Histochemical Localization of Human, Term Placental 17β-Oestradiol Dehydrogenases— Implications for the (Dr. Donald A. Kellogg and Dr. George G. Glenner), 763
Reaction Rate : Control of, in Dust Flames (J. M. Beér and Dr. R. H. Essenhigh), 1106
Reaction Time (Choice) : Time Uncertainty and (Paul Bertelson and Jean-Paul Boons), 531
Reactions (*in vitro* and *in vivo*), of Rabbit Anti-Mouse Erythrocyte Serum : Electrophoretic Separation of certain (Chang-Ling Lee, Tamon Takahashi and Israel Davidsohn), 157
Reactions (Chemical) : Initiation of, by Mechanical Forces (Dr. Robert Schnurmann and Ivor S. Stringer), 587
Reactions (Egg-Yolk), of *Pseudomonas* Species (Dr. A. T. Willis and G. Gowland), 432
Reactions (Fast Transfer) : Physiological Role of (Massachusetts Institute of Technology Seminar Lectures on), 904
Reactions (Non-Enzymic), of Indoles with Coenzyme I (Prof. S. G. A. Alivisatos, G. A. Mourkides and A. Jibril), 374
Reactivation (Dye-sensitized Photo-), of X-Ray Damage in Diploid Yeast (Dr. David Freifelder and Prof. Robert B. Uretz), 953
Reactive Serine of a Proteolytic Enzyme from *Bacillus subtilis* : Amino-Acid Sequence about the (Dr. F. Sanger and D. C. Shaw), 872
Reactivity of the Disulphide Bond in Wool (Dr. L. J. Wolfram and Prof. J. B. Speakman), 595
Reactivity (Chemical), with Mercaptalbumin : An Ortho Effect influencing Fungitoxicity, Electronic Absorption Spectra, and (Dr. H. P. Burchfield and Eleanor E. Storrs), 593
Reactivity (Differential), of Saliva from 'Tasters' and 'Non-Tasters' of 6-*n*-Propylthiouracil (Frances Griffin and Prof. Roland Fischer), 417
Reactor Accident at Windscale in October 1957 : The Deposition of Strontium-89 and Strontium-90 on Agricultural Land and their Entry into Milk after the (United Kingdom Atomic Energy Authority and the Agricultural Research Council joint Report on), 1077
Reactor (Atomic), (*Moata*) : Australia's Second, 741
Reactor (Nuclear) Chemistry (Oak Ridge National Laboratory Conference on), 994
Reactor (Nuclear) Technology : Analytical Chemistry in (Oak Ridge National Laboratory Conference on), 994
Reactor (Research) : *Hector*, a New (United Kingdom Atomic Energy Authority), 992
Read, Dr. John : Radiation Biology of *Vicia faba* in relation to the General Problem, *review*, 8
Rebman, Carole A., and others : A Bleached Variant of *Euglena gracilis* showing a Doubling of the Content of Deoxyribonucleic Acid, 1037
Recapture in the River Tweed of a Sea-Trout marked in Devonshire (A. Swain, I. R. H. Allan and M. J. Bulleid), 877

Recherche Scientifique, Centre National de la : International Colloquium on the Physics of Electrostatic Forces and their Applications, 466
  Colloques Internationaux No. 79, Premier Colloque International de Photographie Corpusculaire (Strasbourg, 1957), *review* by D. L. Allen, 636
Recherches Enzymologiques, Centre Inter-Universitaire de : Colloquium on Intracellular Localization of Enzymes, 836
Reciprocal Theorem and Theory of Statically Indeterminate Frameworks : A Historical Note on the (T. M. Charlton), 231
Recognition of Nulliparous Mosquitoes without Dissection (Dr. Philip S. Corbet), 525
Recombination of Oxygen Atoms in the Gas Phase (P. G. Dickens, R. D. Gould, Prof. J. W. Linnett and A. Richmond), 686
Recombination (Genetic), in *Salmonella typhimurium* occurring during Transmission of Colicinogeny (Dr. Ozeki and Dr. Howarth), 649
Reconstruction and Development, International Bank for : Articles of Agreement of the proposed International Development Association, as approved for submission to Governments by the Executive Directors of the, 266
Records : World Weather, 1941-50 (United States Weather Bureau), *review* by H. H. Lamb, 727
Records (Weather), of the World, *review* by H. H. Lamb, 727
Recovery of Capsules from *Discoverer* Satellites, 741
Recovery of Leukaemogenic Agent from Non-Leukaemic Tissues of Thymectomized Mice (J. F. A. P. Miller), 703
Recovery in the Presence of Chloramphenicol of *Escherichia coli* B (H) Irradiated with Ultra-violet Light (Kenshi Suzuki and Yukiko Iwama), 347
Recovery (Delayed), of Airborne *Serratia marcescens* after Short-Time Exposure to Ultra-violet Irradiation (Dr. R. L. Dimmick), 251
Recruits to Teaching—a Study of the Attainments, Qualifications and Attitudes of Students entering Training Colleges (F. W. Land), 750
Récupération de la Chaleur des Réacteurs Nucléaires : Évacuation et (Richard Alami et Paul Ageron), *review* by R. J. Syme, 636
Red Blood Cell Membrane : Chemical Constitution of the (Dr. T. Fehér and Dr. Béla Matkovics), 701
Red Cells (Human) : Adenosine Triphosphate and Maintenance of Shape of the (Makoto Nakao, Toshiko Nakao and Saburo Yamazoe), 945
Red Cross Society (Japanese) : Eighth International Congress of Blood Transfusion, 201
Red Executive : The (David Granick), 537
Red Shift of Hydrogen 21-cm. Radiation : Gravitational, as a Method to measure Galactic Gravitational Potential (L. F. Landovitz and L. Marshall), 223
Reddi, Dr. K. K. : Mode of Action of Micrococcal Phosphodiesterase, 74
Reddish, V. C. : New American Observatories, 910
Redifon Company : A New British Analogue Computer (*Radic*), 288
Redox Processes (Chemical Research Committee of the Indian Council of Scientific and Industrial Research Symposium on), 650
Reduced Jaspilite (Roast) : Formation of Fayalite in (J. B. Lean, K. J. Tucker, B. O. Holland and T. R. Thomson), 683
Reductase (Photosynthetic), from a Green Plant : Crystallization of a (Dr. R. Hill and Fay Bendall), 417
Reduction of the Intestinal Absorption of Glucose, Methionine and Sodium Butyrate by the Cation Trimethylhexadecylammonium (Dr. J. A. Nissim), 308
Reduction in Tumour Formation : Polyoma Virus Mutant with a (Dr. Leo Sachs and Dan Medina), 715
Reduction (Hunger), produced by Injecting Glucose into the Lateral Ventricle of the Rat (L. J. Herberg), 245
Reduction Method (Ferricyanide), for Reducing Sugars (Dr. Richard L. Mateles), 241
Reducing Sugars : Ferricyanide Reduction Method for (Dr. Richard L. Mateles), 241
Rees, Sir J. Frederick (Chairman of the Editorial Committee) : The Cardiff Region—a Survey (prepared for the meeting of the British Association in Cardiff), *review*, 851
Rees, Dr. K. R. (Gallagher, Dr. C. H., and) : Levels of Pyridine Nucleotides in Liver Poisoning, 148
Rees, L. V. C. (Barrer, Prof. R. M., and) : Energies of Activation for Self-diffusion of Alkali Metal Ions in Analcite, 768
Rees, Dr. R. J. W. (Gledhill, Dr. A. W., and) : Effect of a Primary Tuberculous Infection on the Resistance of Male and Female Mice to Ectromelia, 703
Reference Book of Theoretical Physics, *review* by Prof. R. Eisenschitz, 445
Reference Material : Guide to (edited by Dr. A. J. Walford, with the assistance of L. M. Payne), *review* by R. Brightman, 273
Reflectance Measurements : Use of, in assessing the Colour Changes of Ageing Bloodstains (Dr. D. Patterson), 688
Reflectivity (Spectral), of Ore Minerals (L. Gray and Dr. A. P. Millman), 282
Reflector (Radar) : Roughness of the Moon as a (Dr. B. H. Briggs), 466, 490
Reflex (Peristaltic) : Effect of Wheat Gluten on the (Dr. R. Schneider, H. Bishop, Dr. B. Shaw and Prof. A. C. Frazer), 516
Reflexes (Hind-Limb), in the Kitten—Velocity and Conduction and Spinal Transmission of Proprioceptive Hind-Limb Reflexes (Dr. Sten Skoglund), 132 ; Properties of the Two-Neuron Arc (Dr. Sten Skoglund), 134
Reflexes (Proprioceptive Hind-Limb) : Velocity of Conduction and Spinal Transmission of (Hind-Limb Reflexes in the Kitten), (Dr. Sten Skoglund), 132
Reflexion of Signals from Satellite *Echo* I, 901
Reflexions (Specular) : Effect of, on the Radiation Flux from a Heated Tube (Sir K. S. Krishnan), 135
Regional Geology : Handbook of—Scotland, the Northern Highlands (Dr. J. Phemister), third edition, 831
Registration and Education, Illinois Department of : Biological Notes No. 41, Population Trends among Hawks and Owls in Illinois (Richard R. Graber and Jack S. Golden), 999
Regulation (Osmotic), in the Larvae of some Euryhaline Diptera (D. W. Sutcliffe), 331
Regulation (Self-) in Living Systems : Ottawa Symposia on, 3, Tremor, 297
Reichenow, Prof. Eduard : *Obituary* by Prof. P. C. C. Garnham, 554
Reid, E. T., and others : Attachment of Immature Simuliidae to other Arthropoda, 618
Reid, J. H., and others : The Solar Flare of June 1, 1960, 926
Reith Lectures, 1959 : The B.B.C. (Prof. P. B. Medawar), *review* by Dr. J. D. Nisbet, 446
Relation between Ultra-sonic Velocity and Latent Heat of Vaporization (Prof. B. Ramachandra Rao and P. R. K. L. Padmini), 311
Relation (An Inverse), between the Liver Glycogen and the Blood Glucose in the Rat adapted to a Fat Diet (Dr. P. A. Mayes), 325
Relations (Plant- and Soil- Water) : Terminology in (Dr. R. O. Slatyer and Prof. S. A. Taylor), 922
Relationship between Nucleus and Cytoplasm—Proceedings of the Symposium held at the Université Libre de Bruxelles, 1958 (edited by Dr. R. J. C. Harris), *review* by Dr. E. N. Willmer, 450
Relationships (Immunological), between the Rat Glomerulus and Nephritogenic Streptococci (A. S. Markowitz, S. Howard Armstrong, Jun., and Daniel S. Kushner), 1095
Relationships (Major Element), in Tektites (R. D. Cherry, Dr. S. R. Taylor and Maureen Sachs), 680
Relative Availability of some Strontium-90 Compounds in Soil (Dr. R. L. Uhler and Dr. F. P. Hungate), 252
Relative Lengths of Leaf Sheath and Blade with reference to the Developmental Stages of the Rice Plant (Dr. B. Saha), 259
Relativity, *review* by Dr. D. W. Sciama, 4
Relativity : Theory of (W. Pauli), translated from the German by G. Field, *review* by Dr. D. W. Sciama, 4
Relativity of 'Meaning' (Dr. W. Ross Ashby), 532
Relaxin : Analyses of (Edward H. Frieden), 200
Relic-Soil on Limestone in South Wales (D. F. Bell), 497
Religion (West African) : Oedipus and Job in (Prof. Meyer Fortes), *review* by Michael Argyle, 96
Religion and Social Structure, *review* by Michael Argyle, 96
Remfry, Jennifer : Appointed Junior Universities Federation for Animal Welfare (UFAW) Research Fellow, to assist Dr. Phyllis G. Croft at the Royal Veterinary College in research relating to anaesthetics and relaxants, 743
Removal of Internally Deposited Americium by Chelating Agents (Dr. F. D. Sowby and Dr. D. M. Taylor), 612
Renal Function in Extracorporeal Circulation : Influence of 5-Hydroxytryptamine on (Dr. M. H. Frick), 609
Renal Studies in Sheep : Use of Diodone in (B. J. Potter), 698
Rendle, B. J. : The Development of Pulp and Particle Board Industries and their Effect on Forest Management (Anatomical Criteria for Industrial Use), 33
Rensch, Prof. Bernhard : Evolution above the Species Level, *review* by C. S. Elton, 446
Reports (Scientific and Technical) : Indexes for (ASLIB Survey on), 372
Reproduction : Endocrinology of, *review* by Prof. P. L. Krohn, 5
  Marshall Chair of the Physiology of, Cambridge, 113
  Recent Progress in the Endocrinology of—Proceedings of the Conference held in Syracuse, 1958, *review* by Prof. P. L. Krohn, 5
Reproduction Out of Season : Conditioning *Ostrea edulis* L. from Limfjord for (L. A. Abou-Ela), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 25), *review* by Dr. A. J. Southward, 360
Republic (Czechoslovak) : Climatic Atlas of the, *review* by G. A. Bull, 543
Requirement of a 'Factor' From a Pregnant Rabbit for Ovarian Maturation : Breeding of the Rabbit Flea, *Spilopsyllus cuniculi* (Dale)— (A. R. Mead-Briggs and A. J. B. Rudge), 1136
Research : Animal Experiments in, *review* by Dr. W. Lane-Petter, 977
  Dental, 556
  Mellon Institute (1959-1960)—the Annual Report to the Board of Trustees of the Institute for the Fiscal Year 1959-1960 (Matthew R. Ridgway), 908
  Road, 464
  Space, *review* by Sir Harold Spencer Jones, 268
Research in Biochemistry and Allied Sciences : Organization and Financing of (Biochemical Society and the British Association for the Advancement of Science Colloquium on), 650
Research in Case Studies, 659
Research in any branch of Chemistry : Grants for assistance in (Chemical Society), 466
Research in Dairying, National Institute for : Report for 1959, 909
Research in Tinplate in Australia, 904
Research in the Use of Electronic Computers (Unesco Fellowships for), 465
Research Necessary for the Preparation and Use of Case Studies (South London Committee of the British Institute of Management Conference on), 660
Research (Agricultural and Scientific), Overseas, 556
Research (Atmospheric), United States National Centre of : Appointment of Dr. Walter Orr Roberts as director, 200
Research (Atomic Energy), in Denmark, 33
Research (Atomic Energy and Space) : Resources for, 1055
Research (Basic), in the Navy (United States Department of Defense, Department of the Navy, Naval Research Advisory Committee), (Report prepared by Arthur D. Little, Inc.), 178
Research (Defence), and Development : British, 177
Research (Educational) : The Need for, 883
Research (Geological), in the Northern Highlands of Scotland, 831
Research (Lipid), at the Rowett Institute, 1951-59 (Dr. G. A. Garton), 115
Research (Medical), National Institute for : Appointment of Prof. P. B. Medawar as director, 374, 991
Research (Medical), in the Paris Hospitals, 26
Research (Nuclear), in the U.S.S.R., *review* by Dr. S. C. Curran, 630
Research (Oceanographic) : Intergovernmental Conference on, 647
Research (Oceanographic and Fisheries), by the Submarine *Severyanka* (V. P. Zaitzev), 559
Research (Polar), in the U.S.S.R., 287
Research (Potato), European Association for : Series of Triennial Conferences, 466
Research (Recent American), in Neuropsychiatry, *review* by Dr. D. H. Brinton, 447
Research (Scientific), in East Africa, 206
Research (Scientific), in the United States : Control of, *review* by R. Brightman, 181
Research (Scientific) : Satellites and (Desmond King-Hele), *review* by Sir Harold Spencer Jones, 268

Research (Scientific), into Road Safety (European Productivity Agency of the Organization for European Economic Co-operation Discussion on), 116
Research (Scientific), and Development—a Comparative Study (S. Dedijer), 458
Research (Scientific and Industrial) : Co-operation and, 89
Research (Space), in Britain · Grants to Universities, 744
Research Center : A New Gas Chromatography (Barber-Colman Company, Houston), 289
Research Committee on Archaeological Field Experiments, 289
Research Council of Alberta : Fortieth Annual Report (1959), 660
Research Defence Society · *Conquest* Pamphlet No. 11, Vaccination against Whooping Cough, Diphtheria and Tetanus, 649
Research Equipment Exhibit · Tenth Annual Instrument Symposium and (United States National Institutes of Health), 559
Research Fellowship (Armourers and Brasiers'), awarded to Dr. J. H. Brunton, 291
Research Fellowship (Foulerton Gift), awarded by the Royal Society to Dr. J Seed, 291
Research Institute for the Study of Man (Division of Anthropology of the New York Academy of Sciences and the) · Conference on Culture, Society and Health, 658
Research Laboratories (Graduate) : Grants for (United States National Science Foundation), 559
Research Progress in General Medical Sciences, 1959 : Highlights of (United States Department of Health, Education and Welfare, Publication No. 739), 200
Research Reactor : *Hector*, a New (United Kingdom Atomic Energy Authority), 992
Research Studentship (Mackinnon), awarded by the Royal Society to Dr. D. T. Edmonds, 291
Research Studentships for postgraduate training in Ecology (Nature Conservancy Awards for 1960), 742
Research Study Group on the Use of Toxic Chemicals in Agriculture and Food Storage : Request for evidence, 290
Research and Development in Fuel and Power : Advisory Council for, 286
Research and Development in Industry (Dr. E. J Solvay), 830
Research and Development (Aeronautical), Advisory Group for—see under AGARD
Research and Development (Materials), for National Security : More Effective Organization and Administration of (United States National Academy of Sciences—National Research Council, Publication No. 718), 470
Reserpine : Effect of, on the Nucleotide and Catecholamine Content of the Denervated Adrenal Medulla of the Rat (Prof. Nils-Åke Hillarp), 1032
  Influence on the Effect of Vasoconstrictor Amines by Pretreatment with (H. C. Sabelli), 784
  A Suggested Effect on Levels of Catecholamine in Brain produced by Small Doses of (F. Barbara Orlans and Dr. Bernard B Brodie), 1034 ; (Herbert Sheppard and Joseph H. Zimmerman), 1035
Residues (Nonanal), in Potatoes : Determination of (W. F. van Vliet and W. H. Schriemer), 235
Resistance to 8-Azaguanine in *Diplococcus pneumoniae* : Transformation of (Francis M. Sirotnak, Ramona B. Lunt and Dorris J Hutchison), 800
Resistance of Male and Female Mice to Ectromelia · Effect of a Primary Tuberculous Infection on the (Dr. A. W. Gledhill and Dr. R. J. W. Rees), 703
Resistance (High-Temperature), and Thermal Degradation of Polymers (Plastics and Polymer Group of the Society of Chemical Industry Symposium on), 466
Resistant *L*1210 Mouse Leukaemia Cells : Effect of 6-Mercaptopurine on the Net *in vitro* Gas Production of Sensitive and (Dr. H. J. Woodliff), 156
Resisting Couple : Effect of a, on the Rotational Motion of a Rigid Body (T. Nonweiler), 311
Resistivity (Electrical), of Thermosetting Polymers : Dependence on Temperature of the (R. W. Warfield and M. C. Petree), 316
Resonance : Nuclear Magnetic, *review* by Dr. L. M. Jackman, 358
  High-resolution Nuclear Magnetic (J. A. Pople, W. G. Schneider and H. J. Bernstein), *review* by Dr. L. M. Jackman, 358
Resonance (Paramagnetic), in Solids (William Low), (Solid State Physics—Advances in Research and Applications, Supplement 2), *review* by Dr. R. O. Davies, 886
Resonance (Spin) Techniques : Diamagnetic Moment of Gaseous Plasmas measured by (T. C. Marshall, R. A. Kawcyn and Prof. L. Goldstein), 584
Resonance Spectroscopy (Proton Magnetic) : Structure Determination with the Help of (Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives), (C. F. Blakely, Dr. R. F. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662
Resources : Managerial—an International Survey, 535
Resources for Atomic Energy and Space Research, 1055
Resources (Natural), American Institute of Geonomy and : John Fleming Medal awarded to Dr. Maurice Ewing, 905
Resources (Water), in the United States (Prof. W. G. V. Balchin), 562
Respiration (Carbon Monoxide-sensitive) : Absence of, in a Streptomycin-dependent Mutant of *Escherichia coli* grown in Limited Amount of Streptomycin (Hanna Engelberg and Dr. M. Artman), 801
Respiratory-chain Enzymes : Effect of Heavy Water on (Dr. H. Laser and Prof. E. C. Slater), 1115
Response (Hormone-like), in *Hydra* : Enzymatic Activation of a, by Proteases (Dr. Howard M. Lenhoff and John Bovaird), 671
Response (Photoperiodic), of *Xanthium* : Effect of Glutathione and Alloxan on the (J. Nitsan), 81
Responses (Antibody), of the Domestic Fowl to Two Soluble Bacterial Antigens (Dr. G. Gowland), 624
Responsiveness (Immunological) : 6-Mercaptopurine in (Dr. John L. Robinson and Dr. Charles L. Christian), 796
Restoration of Membrane Excitability of Calcium-deficient Muscles by Anodal Polarization (Prof K. Koketsu and K. Noda), 243
Results (Geological), of Petroleum Exploration in Britain by the British Petroleum Company during the Years 1945-57 (N. L. Falcon and P. E. Kent), 1078
Retained Austenite and the Tempering of Martensite (S. Matas and Prof. R. F. Hehemann), 685
Reticulo-Endothelial System : Depressing Activity of Meprobamate on the (Prof. A. Del Vecchio and L. Bolis), 513
  Effect of some Aromatic Hydroxy Compounds on the Phagocytic Activity of the (Prof T. Nicol, C. Druce and C. C. Ware), 422
  Effect of Three Compounds related to Diethylstilboestrol on the Phagocytic Activity of the (Prof. T. Nicol, G. Brownlee, C. Druce and C. C. Ware), 1032
Retinal Degeneration induced by Iodate and Iodoacetate : Protective Effect of Cysteine against (Prof. Arnold Sorsby and Ronald Harding), 608
Retractor Muscle (Anterior Byssus), of *Mytilus edulis* : The Membrane Potential of the (Dr D H Paul), 1121
Reversibility of an Inherited Metabolic Block (Inborn Error of Metabolism), (Dr. Herman Zondek, Dr Hannah E Leszynsky and Dr. Joseph A. Stein), 515
Reversible Dissociation of Ribonucleic Acid (R. A. Brown, K. A. O. Ellem and Dr. J. S Colter), 509
Révész, László, and Norman, Ulla · Chromosome Ploidy and Radiosensitivity of Tumours, 861
Revised Geological Time-Scale (Prof. Arthur Holmes), 27
Revised Name for *Musa ensetaeformis* Berry : *Ensete berryi*— (R. K. Jain), 342
Rey, Prof. L · Freezing and Drying of Biological Materials, 749
Rh Factor C in South African Bantu (Dr. A. Zoutendyk and Dr. H. Teodorczuk), 790
Rhenium · Work-Hardening and Ductility of, and their relation to the Behaviours of other Metals having a Hexagonal Structure (R. A. Jaffery and E. Smith), 52
Rheology of Polymers (British Society of Rheology Discussion on), 290
Rheology, British Society of . Discussion on Rheology of Polymers, 290
Rhizosphere Microflora of *Camellia sinensis* : Foliar Application of Nutrients and (Dr. C. S. Venkata Ram), 621
Rhoderick, E. H., and others : Speed of the Superconducting-Normal Transition in Tin Films, 492
Rhodes, Joan M. : The Ouchterlony Technique using Antigen or Antiserum labelled with Iodine-131, 793
Rhodesia (Southern) : Environment and Culture in (Roger Summers), 993
Rhythm of Output of Carbon Dioxide of Excised *Bryophyllum* Leaves : Effects of Light and Darkness on the (Dr. Malcolm B. Wilkins), 523
Ribonuclease : Effect of, on Erythrocyte Antigens (Prof. Emanuel Hackel and Robert E. Smolker), 1036
Ribonuclease A (Bovine Pancreatic) : Activity of, in Mixed Solvent Systems (Dorothy Findlay, Dr. A. P. Mathias and Dr. B. R. Rabin), 601
Ribonucleic Acid · Reversible Dissociation of (R. A. Brown, K. A. O. Ellem and Dr. J. S. Colter), 509
Ribonucleic Acid (Infective), from the Viruses of Talfan and Teschen Diseases (F Brown and Doreen L. Stewart), 714
Ribosomes from Embryonic Plant Tissue : Stabilization by Manganous Ions of (Dr. J. W Lyttleton), 1026
Rice : Secondary Selection in Pure Lines of (T. K. Yen), 169
  Viability and Germination Inhibitor of the Seed of (Prof. S. M. Sircar and Manjula Biswas), 620
Rice Plant : Relative Lengths of Leaf Sheath and Blade with reference to the Developmental Stages of the (Dr. B. Saha), 259
Richards, Dr. Audrey I. : Elected president for 1960-61 of the Royal Anthropological Institute, 114
Richards, Dr. M., and others : Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis, 236
Richards, Paul I. : Manual of Mathematical Physics, *review* by Prof. I. Estermann, 445
Richards, Sarah W., and others · Oceanography of Long Island Sound, 123
Richards, Dr. T. G. : Appointed to a senior lectureship in physiology in the University of Liverpool, 117
Richardson, D. A., and others : Gamma Irradiation of Lead Silicate Glass, 135
Richardson, Prof. F. D. : The Extraction of Metals and the Chemistry of Metals (Fourth Robert Horne Memorial Lecture of the Society of Chemical Industry), 466
Richardson, I. D , and others : Echo Sounding Experiments in the Barents Sea, 855
Richardson (L. F.) Prize of the Royal Meteorological Society, 28
Richmond, A., and others : Recombination of Oxygen Atoms in the Gas Phase, 686
Richmond, J. Wendy (Daniels, Dr. N. W. R., and) : Gas Liquid Chromatography of Conjugated Fatty Acids, 55
Richter, Dr. D. : Influence of Editors, 120
Ricinus communis Seeds : Anti-Pneumococcus Type XIV Activity of Precipitins from (Lieut.-Col. G. W. G. Bird), 415
Ridgway, Matthew R. : Mellon Institute Research 1959-1960—the Annual Report to the Board of Trustees of the Institute for the Fiscal Year 1959-1960, 908
Ricketts, Dr. C. R., and others : Phosphate Esters produced by Mammalian Skin from 2-Deoxy-D-Glucose, 1028
Rifkind, Richard A., and others : Use of Ferritin-conjugated Antibody to Localize Antigen by Electron Microscopy, 1094
Rigaux, Fernand : Les Observatoires Astronomiques et les Astronomes, *review* by Dr. R. v. d. R. Woolley, 1063
Rigby, B. J., and Spikes, Dr. J. D. : Hydroxyproline and the Shrinkage Temperature of Collagen, 150
Riggs, Dr. Tyson : Radiation-induced Nitration of Aliphatic Hydrocarbons, 933
Rigid Body : Effect of a Resisting Couple on the Rotational Motion of a (T. Nonweiler), 311
Rigler, Prof. R., and others : A Polyploidizing Principle in the Spleen, 965
Riley, Gordon A., and others : Oceanography of Long Island Sound, 123
Riley, Dr. J. F. (Coupland, Dr. R. E., and) : Mast Cells and 5-Hydroxytryptamine in Precancerous Mouse Skin, 1128
Riley, Dr. J. P. (Greenhalgh, R., and) : Alleged Occurrence of the Perchlorate Ion in Sea-Water, 1107
Rimington, Prof. C., and Miley, Dr. R. A. : The Fourth International Goitre Conference, 651
Rimmer, R., and others : Gamma Irradiation of Lead Silicate Glass, 135
Rinfret, Dr. A. P. : Freezing and Drying of Biological Materials, 749
Ringwood, Dr. A. E. : Olivine—Spinel Transition on Nickel Orthosilicate, 1019
Ritchie, J. N. : Tuberculosis in Animals, 996

River (Sierra Leone) : Plankton of the Estuary and Offshore Waters of the (V. Bainbridge), 557
River Tweed : Recapture in the, of a Sea-Trout marked in Devonshire (A. Swain, I. R. H. Allan and M. J. Bulleid), 877
Rivers Memorial Medal of the Royal Anthropological Institute awarded to Prof. J. C. Mitchell, 114
Road Accidents during Christmas 1959 (Road Research Laboratory, Technical Paper No. 49), 1000
Road Research, 464
Road Research Laboratory : Road Research Technical Paper No. 49, Report on Road Accidents during Christmas 1959, 1000
Road Safety : Scientific Research into (European Productivity Agency of the Organization for European Economic Co-operation Discussion on), 116
Roantree, Prof. R. J., and Collis, L. R. : Effect of the Peritoneal Fluid of the Guinea Pig on Strains of Enteric Bacilli, 1045
Roast Reduced Jaspilite : Formation of Fayalite in (J. B. Lean, K. J. Tucker, B. O. Holland and T. R. Thomson), 683
Robb, Prof. J. C. : Physico-chemical, Biological and Applied Aspects of Autoxidation (New Method in work on Autoxidation of Hydrocarbons in the Liquid Phase), 746
Robb, Prof. J. C., and others : Cage Effect in the Liquid-Phase Photolysis of Fluorinated Ketones, 314
Robbins, Dr. A. B. : Appointed a lecturer in physics at the University of Birmingham, 117
Robbins, D. J., and others : Excretion of Catechol after Ingestion of Quinic and Shikimic Acids, 691
Roberts, Prof. J. E. : Training in Radiological Health and Safety, 471
Roberts, Dr. L. E. J. : Crystal Chemistry of Simple Compounds of Uranium, Thorium, Plutonium, Neptunium, *review*, 728
Roberts, Dr. Walter Orr : Appointed director of a United States National Centre of Atmospheric Research, 200
Robertson, Prof. Alexander : Appointed a member of the Agricultural Research Council, 290
Robertson, Dr. J. G. : Ovarioles as a Meristic Character in Coleoptera, 526
Robertson, R. H. S. : The Output of Scientists in Scotland, 1600-1950, 372
Robertson, Prof. R. N. : Appointed to the chair of botany in the University of Adelaide, 740 ; work of, 740
Robinson, Dr. C. : Colloid and Polymer Science (Liquid Crystals of Synthetic Polypeptide), 378
Robinson, E. L. (edited by T. E. Dancy and) : Flat Rolled Products—Rolling and Treatment, *review* by Prof. F. C. Thompson, 273
Robinson, H. W. : Obituary by Prof. E. N. da C. Andrade, 23
Robinson, Dr. John L., and Christian, Dr. Charles L. : 6-Mercaptopurine in Immunological Responsiveness, 796
Robinson, Sir Robert : The Chemistry of Natural Products, 1080
  Degree of D.Sc., *honoris causa*, of the University of Sydney conferred on, 1081
Robinson, Roy : Occurrence of a Brown Mutation in the Syrian Hamster, 170
Robson, Prof. W. : Retirement from the chair of biochemistry at King's College, London, 286 ; work of, 286
Rochereil : La Grotte de (P. E. Jude), 903
Rock-Shelter Art in Malaya : Newly Discovered (J. M. Matthews), 373
Rock Shelter Paintings near Bauchi, Northern Nigeria (Hamo Sassoon), 200
Rockefeller Institute : Promotion of Dr. Edward H. Ahrens, Jun., and Dr. James G. Hirsch to professors and members, 290
  Appointment of Dr. G. Jones to the Sophie Fricke Royal Society Research Fellowship, 1079
Rocket (Skylark) Sodium Experiment : Upper-Atmosphere Wind Studies by (Dr. G. V. Groves), 1001
Rocks from the South Atlantic : Potassium—Argon Ages of some (John A. Miller), 1019
Rocks (Terrestrial) : Comparison of the Chemical Composition and Magnetic Properties of Tektites and Glasses formed by Fusion of (Dr. Irving Friedman, Dr. Arthur Thorpe and Dr. Frank E. Senftle), 1089
Roddy, William T., and others (edited by) : The Chemistry and Technology of Leather, Vol. 2, Types of Tannages, *review* by Prof. A. G. Ward, 724
Rodionov, V. N., and Tsikulin, M. A. : The Tunguska Meteorite, 1077
Rodley, G. A. : Awarded a New Zealand fellowship by the Ramsay Memorial Fellowship Trustees, 832
Rods (Glass) : Strengths of Acid-etched (B. A. Proctor), 492
Roentgen Prize of the Justus Liebig University of Giessen awarded to J. B. Adams, 201
Roessler, F. (Behrens, H., and) : Combustion and Propulsion—High Mach Number Air-breathing Engines (Experiments with Supersonic Diffusion Flames), 20
Role of Initial Value of Metabolic Processes in Oxygen Consumption Changes in Rats during Irradiation (Dr. A. Vacek), 76
Role of Mucoid Substances of the Aorta in the Deposition of Lipids (Dr. S. Gero, Dr. J. Gergely, Dr. T. Dévényi, Dr. L. Jakab, Dr. J. Székely and Dr. S. Virág), 152
Role of Oxygen in the Cross-linking and Degradation of Deoxyribonucleic Acid by Ionizing Radiations (Peter Alexander and J. T. Lett), 933
Role in Protein Synthesis : Cytoplasmic Particles and their (Colloid and Biophysics Committee of the Faraday Society Informal Discussion on), 643
Role (Physiological), of Fast Transfer Reactions (Massachusetts Institute of Technology Seminar Lectures on), 904
Rolinson, Dr. G. N., and others : Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis, 236
Rolled Products : Flat—Rolling and Treatment (edited by T. E. Dancy and E. L. Robinson), *review* by Prof. F. C. Thompson, 273
Romanoff, Prof. L. Alexis : The Avian Embryo, *review* by Prof. C. H. Waddington, 814
Roos, G., and others : A Transplantable Spontaneous Osteogenic Sarcoma observed in the Muscle Tissue of an Albino Mouse, 1129
Rongine de Fekete, Dr. Maria A., and others : Mechanism of Starch Biosynthesis, 918
Roodyn, D. B. : Cytoplasmic Particles and their Role in Protein Synthesis (Requirements for the Incorporation of Amino-Acids into Proteins of Mitochondria and of Microsomes), 645
Room Temperature : Biosynthesis of Sucrose by Preparations from Potatoes stored in the Cold and at (Dr. Sigmund Schwimmer and Edward S. Rorem), 1113
Rorem, Edward S. (Schwimmer, Dr. Sigmund, and) : Biosynthesis of Sucrose by Preparations from Potatoes stored in the Cold and at Room Temperature, 1113
Rosbaud, Dr. P. : Obituary of Prof. Max von Laue, 738, *erratum*, 905
Rose, Harry M., and others : Use of Ferritin-conjugated Antibody to Localize Antigen by Electron Microscopy, 1094
Rosen, Jun., Lieut. V. J., and Cole, Dr. L. J. : Radiosensitivity of Mouse Kidney undergoing Compensatory Hypertrophy, 612
Rosenberg, Dr. H., and Ennor, Prof. A. H. : Occurrence of Free D-Serine in the Earthworm, 617
Rosenfeld, Prof. L. : Newton's Correspondence, *review*, 537
Rosenfield, C. (O'Brien, Prof. R. N., and) : Possible Discovery of Ion-Pairs by Interferometry, 935
Rosenkranz, W., and others : A Polyploidizing Principle in the Spleen, 965
Rosenzweig, Mark R., and others : Strain Differences in Acetylcholine Concentration in the Brain of the Rat, 787
Rosiek, O., and others : Identification of Transplanted Bone Marrow Cells in Radiation Chimaeras, 955
Ross, Angela J. (Atkin, N. B., and) : Polyploidy in Human Tumours, 579
Ross, Prof. Alan S. C. : Theory of Optimal Games, 968
Ross, Dr. J. M. : Tuberculosis in Animals, 996
Ross (Ian Clunies) Animal Research Laboratory, Prospect, New South Wales (Dr. Ian W. McDonald), 980
Rosser, Prof. J. Barkley : Appointed chairman of the Mathematics Division of the United States National Academy of Sciences—National Research Council, 647
Rotating Array (A Highly Directive), for 16 Mc./s. (Prof. J. A. Thomas and Dr. R. W. E. McNicol), 398
Rotation of Satellite 1958δ1 : Effect of Upper Atmosphere Wind on the (Dr. C. R. Faulkner), 926
Rotational Absorption (Pure), of Ozone in the Region 125-500 Microns (Dr. H. A. Gebbie, N. W. B. Stone and C. D. Walshaw), 765
Rotational Motion of a Rigid Body : Effect of a Resisting Couple on the (T. Nonweiler), 311
Rotatory Powers (Optical), of Alkaloids, *review* by Dr. J. Walker, 7
Rotblat, Prof. J., and others : Effects of Whole-body Irradiation on the Breeding Plumage of the Weaver Finch, *Quelea quelea*, 615
Rotenone : Mechanism of the Physiological Action of (Prof. P. E. Lindahl and K. E. Öberg), 784
Rothamsted Experimental Station : Report for 1959, 661
Rothschild, Rt. Hon. Lord : X and Y Spermatozoa, 253
Roubinek, L., and others : Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives—Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy, 662
Roughness of the Moon as a Radar Reflector (Dr. B. H. Briggs), 466, 490
Routine Measurement of Particle Shape Factors in the Sieve Range : A Method for the (Dr. Colin C. Harris), 401 ; (D. Hewitt), 403
Rowe, Dr. G. W. : Appointed lecturer in industrial metallurgy at the University of Birmingham, 465
Rowe, J. J. : Awarded a Nature Conservancy Diploma Course in Conservation and Ecology at University College, London, 742
Rowe, Dr. T. W. G. : Freezing and Drying of Biological Materials, 749
Rowell, D. A. (Scott, C. G., and) : Gas-Solid Chromatographic Separation of Hydrocarbons of High Molecular Weight, 143
Rowett Research Institute : Collected Papers of the, 115
Royal Anthropological Institute : Huxley Memorial Medal for 1961 awarded to Dr. A. E. Mourant, 114
  Rivers Memorial Medal awarded to Prof. J. C. Mitchell, 114
  Wellcome Medal for 1959 awarded jointly to E. M. Chilver and Dr. P. Kaberry, 114
  Election of Officers for 1960-61, 114
Royal Botanic Gardens, Kew (F. Ballard), 119
Royal Cancer Hospital, London : Appointment of E. J. Ambrose to the University of London readership in physical chemistry at the Institute of Cancer Research, 904
  Title of reader in chemistry in the University of London conferred on G. M. Timmis, 904
Royal College of Physicians, and others : First British Congress on the History of Medicine and Pharmacy, 374
Royal College of Science and Technology, Glasgow : Annual Report (1958-59), 115
Royal College of Surgeons of England : New Laboratory Building, 118
Royal College of Surgeons of England, and others : First British Congress on the History of Medicine and Pharmacy, 374
Royal Commission for the Exhibition of 1851 : Studentship and Scholarship Awards for 1960, 116
Royal Free Hospital School of Medicine, London : Appointment of Dr. C. B. B. Downman to the Sophia Jex-Blake chair of physiology, 466
Royal Geographical Society : Research Series No. 3, The Making of the Broads (Dr. J. M. Lambert, J. N. Jennings, C. T. Smith, Charles Green and J. N. Hutchinson), *review* by Miles Burkitt, 636
Royal Grammar School (Lancaster) Natural History Society : *The New Biologian*, No. 9, 649
Royal Greenwich Observatories : Integration of the Cape and, 464
Royal Institute of Chemistry (Manchester and District Section), and the Society of Chemical Industry (Manchester Section and Fine Chemicals Group) : Symposium on Drugs for the Treatment of Hypertension, 743
Royal Institute of Engineers, and others : International Congress on the Technology of Plastics Processing, 559
Royal Meteorological Society : L. F. Richardson Prize, 28
  Summer Meeting (Weather Problems in Agriculture), 995
Royal Naval College, Greenwich : Nuclear Training Facilities at the (Prof. J. Edwards), 545
Royal Navy Hydrographic Department : Retirement of Rear Admiral K. St. B. Collins as hydrographer to the Navy, 286
  Appointment of Rear Admiral E. G. Irving as hydrographer to the Navy, 286
Royal Netherlands Chemical Federation, and others : International Congress on the Technology of Plastics Processing, 559
Royal Society of Edinburgh : Year Book for 1959-60, 25

Royal Society of London : Appointment of Dr. Dorothy C. Hodgkin as the first Holder of the Wolfson Research Professorship, 24
  Year Book (1960), *review*, 97
  New Foreign Members, 112
  Three hundredth Anniversary, 265
  Presidential Address at the Formal Opening of the Tercentenary Celebrations (Sir Cyril Hinshelwood), 274
  First Award of the Medal of the Iron and Steel Institute made to the, 286
  Appointment of Dr. J Seed to a Foulerton Gift Research Fellowship, at the Department of Radiotherapeutics, University of Cambridge, 291
  Appointment of Dr. D. T. Edmonds to a Mackinnon Research Studentship, at the Clarendon Laboratory, Oxford, 291
  Exhibition at the Science Museum, London, to illustrate the first Forty Years of the Royal Society, 374
  The Beginning of the (Margery Purver and Dr. E. J. Bowen), *review* by Dr. William P. D. Wightman, 356
  A Brief History of the (Prof. E. N. da C. Andrade), *review* by Dr. William P. D. Wightman, 356
  Appointment of Prof. A. Schluter to the first visiting professorship, 463
  Tercentenary Lecture, Evolution of Nuclear Power Plant Design (Sir Christopher Hinton), 1064
  Appointment of Dr. G. Jones to the Sophie Fricke Research Fellowship in the Rockefeller Institute, 1079
Royal Society, its Origins and Founders (edited by Sir Harold Hartley), *review* by Dr William P. D Wightman, 356
Royal Society and the Progress of Science Abroad (Prof. R. J. Forbes), 100
Royal Society and the Armourers and Brasiers' Company : Appointment of Dr. J. H. Brunton to the Armourers and Brasiers' Research Fellowship at the Laboratory for the Physics and Chemistry of Solids, Cavendish Laboratory, Cambridge, 291
Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme : Awards, 291
Royal Society of Medicine, and others : First British Congress on the History of Medicine and Pharmacy, 374
Royal Swedish Academy of Engineering Sciences and the Swedish Association of Technical Physicists : Fifth International Instruments and Measurements Conference and Exhibition, 374
Royal Veterinary College, London : Appointment of Jennifer Remfry as Junior Universities Federation for Animal Welfare (UFAW) Research Fellow, to assist Dr Phyllis G Croft in research relating to anaesthetics and relaxants, 743
  Appointment of Dr. F. A. Holton to the University of London readership in veterinary biochemistry, 904
Rubber : Analysis of Solubility Data to estimate Small Amounts of Chain Fracture during the Cross-linking of (L. Mullins and D T. Turner), 145
Rubber Industry, Institution of the : Colwyn Medal awarded to Dr. Erich Konrad, 464
  Hancock Medal for 1960 awarded to C. B. Copeman, 464
Rubber Technology, *review* by Dr. W. F. Watson, 359
  Introduction to (edited by Maurice Morton), *review* by Dr. W F. Watson, 359
Rubio-Huertos, Miguel, and Desjardins, Paul R : A Vacuolar System in Cells of *Agrobacterium tumefaciens* as shown by Electron Microscopy of Ultra-thin Sections, 1043
Ruby : Stimulated Optical Radiation in (Dr T H. Maiman), 493
Rudebeck, Gustav, and others (edited by) : South African Animal Life—Results of the Lund University Expedition in 1950-1951, Vol. 6, *review* by H. Oldroyd, 1063
Rudge, A J. B (Mead-Briggs, A. R , and) : Breeding of the Rabbit Flea, *Spilopsyllus cuniculi* (Dale)—Requirement of a 'Factor' from a Pregnant Rabbit for Ovarian Maturation, 1136
Rudnick, Prof Dorothea (edited by) : Cell, Organism and Milieu—Seventeenth Symposium of the Society for the Study of Development and Growth, *review* by Dr. E. N. Willmer, 450
Rumen Oligotrich Protozoa : Effect of Penicillin on the Maintenance o (G. S Coleman), 518
Runcorn, Prof S K. : I.G.Y.—Year of Discovery, *review*, 185
Runcorn, Prof. S. K., and others (edited by) : Physics and Chemistry of the Earth, Vol. 3, *review* by B E Leake, 544
Rural England, Council for the Preservation of Twenty-first National Conference for the Preservation of the Countryside, 559
Rural Land Use Pattern in Cyprus : The Evolution of the (Dr Demetrious Christodoulou), *review* by Prof. M. J Wise, 628
Rural Life (English), Museum of . Report for 1959, 26
Rural Population (Swedish) : A Clinical and Genetico-Statistical Study of Schizophrenia and Low-Grade Mental Deficiency in a Large (Bertil Hallgren and Torsten Sjogren), 298
Rusanov, F. N. Botanical Garden in Tashkent, 902
Russell, Prof Dorothy S. Title of professor emeritus of morbid anatomy in the University of London conferred on, 466
Russell, Sir John : Future of British Agriculture, *review*, 721
Russell, P. M., and others : Pattern of Haemopoiesis in the Foetal Liver, 876
Russell, Prof. R. D., and others Precision Intercomparisons of Lead Isotope Ratios—Broken Hill and Mount Isa, 754
Russia · Engineering Education in (S. P. Timoshenko), 537
Russian Biological Publications · Translations of (American Institute of Biological Sciences), 558
Russian Earth Satellite 1960λ, 830
Rycroft, Prof H B : Given an Award under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme, 291
Ryder, Dr. M L. Follicle Remains in some British Parchments, 130
Rydon, Prof H. N., and others · Structures of some Acetyl-serine Peptides from Acetyl-chymotrypsin, 596
Ryle, G. B The Development of Pulp and Particle Board Industries and their Effect on Forest Management, 33
Ryle, Prof. M. . Grant of £2,678 for Space Research (for the recording and the interpretation of Doppler and Faraday effects in the radiations from artificial satellites), 744

SABELLI, H C. · Influence on the Effect of Vasoconstrictor Amines by Pretreatment with Reserpine, 784
Sablifiski, J., and others : Identification of Transplanted Bone Marrow Cells in Radiation Chimaeras, 955
Saccharides : Syntheses of Glucose, Cellobiose and other, by *Acetobacter acetigenum* in a Lactate-buffered Glycerol Medium (Dr. C P. Jackson and K. Ramamurti), 942
Sachs, Dr. Leo, and Medina, Dan : Polyoma Virus Mutant with a Reduction in Tumour Formation, 715
Sachs, Maureen, and others : Major Element Relationships in Tektites, 680
Sacks, T. G., and others : Host-Range of *Lactobacillus* Bacteriophages, 348
Sadhu, Prof D. P. (Goswami, Ajit, and) · Polyenoic Acid in Hypercholesterolaemia induced by Pyridoxine Deficiency in Rats, 786
Saev, Dr. G K , and others : Adaptive Chain in the Conversion of Anti-metabolites into Metabolites, 1041
Safety in Mines Research Establishment Bibliography, 1960 (compiled by E. B. Smith), second edition, *review* by Prof. S. G. Ward, 1063
Safety (Nuclear), Advisory Committee on : Appointment of an, 113
Safety (Radiological Health and) : Training in (Prof. J E. Roberts), 471
Safety (Road) : Scientific Research into (European Productivity Agency of the Organization for European Economic Co-operation Discussion on), 116
Saffman, Dr. P. G. : Appointed reader in mathematics at King's College, London, 117
Saha, Dr. B. : Relative Lengths of Leaf Sheath and Blade with reference to the Developmental Stages of the Rice Plant, 259
Sakai, Dr Akira : Survival of Woody Plants at Extremely Low Temperatures, 1134
Sakharov, D A. : Centenary Celebrations of W M. Bayliss and J S Haldane in Moscow, 912
Saldanha, Dr P. H., and others . Race Differences in the Ability to excrete Beetroot Pigment (Betanin), 806
Salicylate : Anti-Inflammatory Activity of (Dr. V. Marks and Dr. M. J. H. Smith), 610
Saliva from 'Tasters' and 'Non-Tasters' of 6-n-Propylthiouracil : Differential Reactivity of (Frances Griffin and Prof. Roland Fischer), 417
Salmon · Bacterial Effect and Radiophosphorus Assimilation in Organic and Inorganic Forms in (Dr. P. N. Srivastava), 83
Salmonella typhimurium · Genetic Recombination in, occurring during Transmission of Colicinogeny (Dr. Ozaki and Dr. Howarth), 649
Salomon, Prof. K. (Altman, K. I., and) : Localization of a Halogenated Porphyrin in Mouse Tumours, 1124
Salt (Triassic)—Discoveries in the Cheshire-Shropshire Basin (Sir William Pugh), 278
Salters' Company Election of Officers for 1960-61, 29
Salts (Molten) 'Enthalpy Titrations' and Thermochemistry in (Prof. Joseph Jordan, Jurg Meier, Edward J. Billingham, jun., and James Pendergrast), 318
Saltpeter, Prof. E. E. : Elected to an Overseas Fellowship of Churchill College, Cambridge, 742
Sampling Methods : Earthworm Population Studies—a Comparison of (F. Raw), 257
Sandell, Prof. E B. : Colorimetric Determination of Traces of Metals, third edition, *review* by A. M. G Macdonald, 3
Sanders, J., and others : Isotopic Analysis of Silicon by Solid-Source Mass Spectrometry using Negative Ions, 683
Sandstrom, Arne Eld, and others : Dependence on Latitude of the Amplitude of the Diurnal Variation of Cosmic Rays, 1099
Sanger, Dr. F., and Shaw, D. C. : Amino-Acid Sequence about the Reactive Serine of a Proteolytic Enzyme from *Bacillus subtilis*, 872
Sanitation in Aviation : Guide to Hygiene and (World Health Organization of the United Nations), 911
Sanity and Madness : The Divided Self—a Study of (Dr R D Laing), *review* by Dr Clifford Allen, 1062
Sanjana, N H., and others . New Compounds for the Control of Water Evaporation, 870
Sankar, Dr. D. V. Siva, and others Effect of Lysergic Acid Diethylamide on Larval Growth, 153
Sap-Transmissible Viruses associated with Diseases of Grape Vines in Europe and North America (C. H Cadman, H. F. Dias and B. D. Harrison), 577
Saprophytic Fungi (Obligately Parasitic and) · Incorporation of Acetate into Protein by (Dr. Richard C Staples and Dr. H. P. Burchfield), 1040
Saratovkin, D. D. : Dendritic Crystallization (translated from the Russian by Dr. J. E. S. Bradley), second edition, *review* by A. F. Wells, 93
Sarcoma : A Transplantable Spontaneous Osteogenic, observed in the Muscle Tissue of an Albino Mouse (R G Herne, M. Gregoire and G. Rona), 1129
Sargeson, Dr. A M. (Dwyer, Dr F. P., and) · Catalytic Racemization of *tris* (Ethylenediamine) Cobalt (III) Ion, 1022
Sarin, P. S · Awarded an Overseas Scholarship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Sarker, A. Q. : Awarded an Overseas Scholarship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Sassoon, Hamo : Rock Shelter Paintings near Bauchi, Northern Nigeria, 200
Satellite : Science as History—the Story of Man's Technological Progress from Steam Engine to (Heinz Gartmann), translated from the German by Alan G. Readett, *review* by J L. Stollery, 8
Satellite 1958δ1 · Effect of Upper Atmosphere Wind on the Rotation of (Dr. C R. Faulkner), 926
Satellite 1960λ : The Russian Earth, 830
Satellite *Echo* I (1960ι), 741
  Reflexion of Signals from, 901
Satellite Signals : Ionospheric Information from (Dr. G. H. Munro), 1017
Satellite *Sputnik* 3 : Final Months and Descent of (B. R. May and D. E. Smith), 456
Satellite *Sputnik* 4 : The Sudden Discontinuity in the Orbital Period of (B R. May and D. E. Smith), 866
Satellite *Tiros* I : Cloud Pictures from, 647
Satellites (*Discoverer*) · Recovery of Capsules from, 741
Satellites and Scientific Research (Desmond King-Hele), *review* by Sir Harold Spencer Jones, 268
Saunders, J. T., and Manton, Dr. S M. : A Manual of Practical Vertebrate Morphology, third edition, *review* by Dr. N. B. Marshall, 9
Sawhney, B. L. : Aluminium Interlayers in Clay Minerals, Montmorillonite and Vermiculite—Laboratory Synthesis, 261
Sawyer, Prof. Wilbur H : Evidence for the Identity of Natriferin, the Frog Water-Balance Principle and Arginine Vasotocin, 1030
Saxl, H. (Hall, Dr. D. A., and) : Human and other Animal Cellulose, 547

Sayers, Prof. J. : Grant of £26,000 for Space Research (electron and ion-population studies of the upper atmosphere and interplanetary space), 744
Sayers, Prof. R. S. : Monetary Thought and Monetary Policy in England (Presidential Address to Section F (Economics) of the British Association for the Advancement of Science), 844
Sayre, Dr. D., and Friedlander, Dr. P. H. : Crystal Structure of 9:10-Dimethyl-1:2-benzanthracene, 139
Scale (The Helium-4), of Temperature (F. C. Brickwedde, H. van Dijk, M. Durieux, J. R. Clement and J. K. Logan), 1077
Scale (Small-) Turbulent Diffusion in the Atmosphere (Dr. L. A. Clarenburg and C. E. Spaans-v. d. Tang), 586
Scale (Time-) : A Revised Geological (Prof. Arthur Holmes), 27
Scardino, Dr. Vito (Sharnoff, Dr. J. George, and) : Platelet-Count Differences in Blood of the Rabbit Right and Left Heart Ventricles, 334
Scarrott, G. G. : Application of Computer Techniques to Nuclear Physics Instruments (Duddell Medal Address to the Physical Society), 854
Scattering Phase-Shifts : Distorted Wave Approximation for (Dr. P. Swan), 585
Scattering Properties of the Moon : Radar Determination of the (Dr. Fred B. Daniels), 399
Sceptre Discharge : Periodic Magnetic Field Fluctuations in the (Dr. N. L. Allen), 279
Schiff, Leonard L. (edited by Emilio Segrè and, in association with Gerhart Friedlander and Walter E. Meyerhof) : Annual Review of Nuclear Science, Vol. 9, *review* by Dr. E. B. Paul, 182
Schilder, Peter, and others : Effect of Lysergic Acid Diethylamide on Larval Growth, 153
Schizophrenia and Low-Grade Mental Deficiency in a Large Swedish Rural Population : A Clinical and Genetico-Statistical Study of (Bertil Hallgren and Torsten Sjogren), 298
Schlüter, Prof. A. : Appointed to the first visiting professorship of the Royal Society, 463 ; work of, 463
Schmidt, Prof. B., and others : Non-specific Haemagglutinin from Cellulose and Cellulose Ion Exchanger, 790
Schmidt, K. : Changes in Conductivity of Pure Water caused by X-Irradiation, 931
Schmidt, Dr. Karl Rudolf : Nutzenergie aus Atomkernen, *review* by K. R. E. Smith, 979
Schmoyer, L. F., and Case, L. C. : A New Method for the Synthesis of Cyclic Ethers, 592
Schneider, Dr. R., and others : Effect of Wheat Gluten on the Peristaltic Reflex, 516
Schneider, W. G., and others : High-resolution Nuclear Magnetic Resonance, *review* by Dr. L. M. Jackman, 358
Schnurmann, Dr. Robert, and Stringer, Ivor S. : Initiation of Chemical Reactions by Mechanical Forces, 587
Schofield, Dr. J. A. : Appointed lecturer in organic chemistry at University College, Swansea, 117
Schofield, Dr. R. K. : *Obituary* by Dr. H. L. Penman, 196
Scholarship Awards (United Kingdom Commonwealth Scholarship Commission), 464
Scholarship Awards (Studentship and), for 1960 (Royal Commission for the Exhibition of 1851), 116
Scholarship Commission (United Kingdom Commonwealth) : Scholarship Awards, 464
Scholes, Dr. G. (Allan, J. T., and) : Effects of *p*H and the Nature of the Primary Species in the Radiolysis of Aqueous Solutions, 218
Scholes, Dr. G., and others : Chemical Effects of Ionizing Radiations on Nucleic Acids and Nucleoproteins, 319
School (Non-residential Summer), on Numerical Analysis (Delegacy for Extra-Mural Studies, University of Oxford), 374
School (Summer), in Modern Methods of Crystal Structure Determination (Manchester College of Science and Technology), 201
School Society (British and Foreign) : Grant of £75,000 towards the general expansion of the Borough Road College, Isleworth, 371
Schools (Graduate), in British Universities (Prof. W. R. Niblett), 560
Schools (Secondary Modern) : Science Teaching in (Science Masters' Association Survey on), 206
Schreier, Prof. Kurt, and Kazassis, Corinna : Influence of Different Types of Malnutrition on the ^{14}C-Lysine Metabolism in Young Rats, 1117
Schriemer, W. H. (van Vliet, W. F., and) : Determination of Nonanol Residues in Potatoes, 235
Schubert, Dr. J. (Lindenbaum, Dr. A., and) : Sustained Action of Injected Chelating Agents, 575
Schultz, Dr. Stanley G., and Solomon, Dr. A. K.: A Bacterial Mutant with Impaired Potassium Transport, 802
Schuringa, G. J. (Prins-van der Meulen, P. Y. F., and) : Evidence for Multiple Nature of Cellulase of *Myrothecium verrucaria*, 695
Schurr, Henry M., and others : Oceanography of Long Island Sound, 123
Schwarz, Jan, and others : Absence of Local Cytotoxic Change in Man from Griseofulvin, 335
  Tumour-promoting Effect of Excessively Large Doses of Oral Griseofulvin on Tumours induced in Mice by Methylcholanthrene, 335
Schwimmer, Dr. Sigmund, and Rorem, Edward S. : Biosynthesis of Sucrose by Preparations from Potatoes stored in the Cold and at Room Temperature, 1113
Sciama, Dr. D. W. : Relativity, *review*, 4
Science—Chemistry, Physics, Astronomy (editorial board : Dr. J. Bronowski, with Sir Gerald Barry, James Fisher and Sir Julian Huxley), *review* by Dr. D. R. Dickinson, 978
Science : British Men of—a New Series to be published by Nelson, 374
  Francis Bacon, the First Statesman of (J. G. Crowther), *review* by Prof. B. Farrington, 817
  Colloid and Polymer (Seminar at University College, London, on), 378
  Logic, Methodology and Philosophy of (International Union for History and Philosophy of Science International Congress for), 201
  A Mythical, *review* by Dr. K. O. L. Burridge, 7
  Soviet Space (Ari Shternfeld), translated by the United States Air Force, *review*, 884
  The Two Aspects of (Sir George Thomson), 837
Science Abroad : The Royal Society and the Progress of (Prof. R. J. Forbes), 100
Science and Christianity : Bridging the Gap between, *review* by R. Brightman, 818
Science and Education in Britain, 906
Science and Faith : Questions of (Dr. Hawthorne), 28
Science for the Family, *review* by Dr. D. R. Dickinson, 978
Science of High Explosives (Prof. Melvin A. Cook), *review* by Dr. W. L. Murray, 539
Science as History—the Story of Man's Technological Progress from Steam Engine to Satellite (Heinz Gartmann), translated from the German by Alan G. Readett, *review* by J. L. Stollery, 8
Science and Meat, *review* by Prof. J. Hawthorn, 888
Science of Meat and Meat Products (Members of the Research Staff of the American Meat Institute Foundation), *review* by Prof. J. Hawthorn, 888
Science and the Public, 371
Science and State Government—a Study of the Scientific Activities of State Government Agencies in Six States (Dr. Frederic N. Cleaveland), *review* by R. Brightman, 181
Science and Technology : Interactions of, with Society, 1
  National Lending Library for, 992
Science and Technology in Africa South of the Sahara, 198
Science and Technology, Manchester College of : Summer School in Modern Methods of Crystal Structure Determination, 201
  Course of lectures on Problems of Radioactivity at Water and Sewage Works, 743
Science and Technology, Royal College of (Glasgow) : Annual Report (1958-59), 115
Science and Technology (Food) : International Congress of, 905
Science, Australian Academy of : Selby Fellowship for 1960 awarded to Dr. W. Deuchars, 464
  Symposium on the Chemistry of Natural Products (sponsored by the International Union of Pure and Applied Chemistry), 1080
Science, British Society for the Philosophy of : Fifth Annual Conference, 559
Science, Czechoslovak Academy of : International Conference on Semiconductor Physics, 29
Science, International Union for History and Philosophy of : International Congress for Logic, Methodology and Philosophy of Science, 201
Science (Agricultural) : Proceedings of the University of Nottingham Sixth Easter School in (1959)—The Measurement of Grassland Productivity (edited by Prof. J. D. Ivins), *review* by Dr. G. W. Cooke, 544
Science (Applied), of Victoria (Museum of), Melbourne : Annual Report for 1958-59, 372
Science (Eighteenth-Century) : The Transits of Venus—a Study of (Prof. Harry Woolf), *review* by Dr. David S. Evans, 636
Science (Leather) : The Present Position of, *review* by Prof. A. G. Ward, 724
Science (Modern) : Causation and, *review* by Dr. J. O. Wisdom, 92
Science (Nuclear) : Annual Review of (edited by Emilio Segrè and Leonard L. Schiff, in association with Gerhart Friedlander and Walter E. Meyerhof), Vol. 9, *review* by Dr. E. B. Paul, 182
  Progress in, *review* by Dr. E. B. Paul, 182
Science (Social) : Medicine as a, *review* by Prof. E. Maurice Backett, 633
Science (Soviet), in English Catalogue, 1960 (Program for Science Translations, Jerusalem), 832
Science (Veterinary) : Advances in (edited by C. A. Brandly and E. L. Jungherr), Vol. 5, *review* by Prof. H. Burrow, 448
Science Broadcasting in Sound and Television (A. B. Oldfield Davies), 850
Science Fiction : Beyond, *review* by Dr. D. J. West, 270
Science *Horizons* : Title of *Atoms for Peace Digest* changed to (United States Information Service), 902
Science Masters' Association : Survey on Science Teaching in Secondary Modern Schools, 206
Science Museum, London : Operation of a Star-Projector, 117
  Presentation to the Library of a collection of Japanese scientific and technical books and dictionaries on behalf of the Prime Minister of Japan, Nobusuke Kishi, 201
  Exhibition to illustrate the first Forty Years of the Royal Society of London, 374
Science *News, French* : No. 1, January-March 1960, Special article on Medical Research in the Paris Hospitals, 26
Science Teaching in Secondary Modern Schools (Science Masters' Association Survey on), 206
Sciences, New York Academy of : Annals, Vol. 85, Article 2, Freezing and Drying of Biological Materials (Dr. Harold T. Meryman, and 12 other Authors), 748
Sciences, New York Academy of (Division of Anthropology), and the Research Institute for the Study of Man : Conference on Culture, Society and Health, 658
Sciences (Allied) : Organization and Financing of Research in Biochemistry and (Biochemical Society and the British Association for the Advancement of Science Colloquium on), 650
Sciences (Biological), American Institute of : Translations of Russian Biological Publications, 558
Sciences (Biological), International Union of (International Union of Biochemistry and the) : Symposium on Biological Structure and Function, 905
Sciences (Engineering), Royal Swedish Academy of, and the Swedish Association of Technical Physicists : Fifth International Instruments and Measurements Conference and Exhibition, 374
Sciences (General Medical) : Highlights of Research Progress in, 1959 (United States Department of Health, Education and Welfare, Publication No. 739), 200
Sciences (Nuclear), Boris Kidrich Institute of : Bulletin, Vol. 10, 831
Sciences (Nutritional), International Union of, of the United States National Academy of Sciences—National Research Council, and others : Fifth International Congress on Nutrition, 201
Sciences (Physical) : Probability and related Topics in (Prof. Mark Kac), *review* by Prof. M. S. Bartlett, 1060
Sciences (Physiological), International Union of (Section of Pharmacology) : First International Pharmacological Meeting, 29
Sciences (Social) : The Literature of the (Peter R. Lewis), *review*, 729
Scientific Activities at Halley Bay : Recent—International Geophysical Co-operation, 1959 (M. J. Blackwell), 982
Scientific Age : The Spiritual Crisis of the (G. D. Yarnold), *review* by R. Brightman, 818
Scientific Information, Institute for (Philadelphia) : *Index Chemicus*, No. 1, 993

Scientific Institutions and Scientists in Latin America (Unesco Centre for Scientific Co-operation in Latin America), Vol. 4, Argentina, 29
Scientific Instrument Manufacturers' Association : Election of Officers for 1960-61, 742
Scientific Mission in Washington (United Kingdom) : Appointment of Dr. H. T. Hookway as director, 24
Scientific Periodical Publications : Cost of (Capt. I. R. Maxwell), 1052
Scientific Personnel : Shortages of, in European Countries in Process of Development, 565
Scientific Publications Council : Discussion on the Influence of Editors, 120
Scientific Radio Union (International) : Thirteenth General Assembly, 902
Scientific Research : Satellites and (Desmond King-Hele), *review* by Sir Harold Spencer Jones, 268
Scientific Research in East Africa, 206
Scientific Research in the United States : Control of, *review* by R. Brightman, 181
Scientific Research into Road Safety (European Productivity Agency of the Organization for European Economic Co-operation Discussion on), 116
Scientific Research and Development—a Comparative Study (S. Dedijer), 458
Scientific Research (Agricultural and), Overseas, 556
Scientific Results of the Danish Deep-Sea Expedition round the World, 1950-52 : Galathea Report— (edited by Dr. Anton Bruun, Capt. Sv. Greve and Prof R. Spärck), *review* by Dr. N. B. Marshall, 443
Scientific Translations : Israel Programme for, 832
Scientific Unions, International Council of : Year Book for 1960, 198
Scientific Work of J S. Haldane (1860-1936), (Prof. J. B. S. Haldane), 102
Scientific and Engineering Personnel : Direction and Supervision of (Northampton College of Advanced Technology, London, Advanced Course on), 905
Scientific and Industrial Research : Co-operation and, 89
Scientific and Industrial Research, Council of (Indian) : Bibliography of Indian Scientific and Technical Publications, 199
Scientific and Industrial Research, Council of (Indian), (Chemical Research Committee) : Symposium on Redox Processes, 650
Scientific and Industrial Research, Department of : Report of the Research Council for 1959, 89
  Report of the Council for 1959, 118
  Conference on Ergonomics in Industry, 117
  The National Physical Laboratory—Open Days (H. G. Short), 454
  Grant of £5,000 to the Department of Physics in the University of Leeds, 465
  The National Engineering Laboratory, 1960—Open Days (R. I. Lithgow), 899
  Report of the National Chemical Laboratory for 1959, 902
  Symposium on Flow Measurement in Closed Conduits, at the National Engineering Laboratory, 905
  Open Days at the National Chemical Laboratory, 994
  Building Research Station Digest 133, Domestic Heating and Thermal Insulation, 999
  Road Research Laboratory, Technical Paper No. 49, Report on Road Accidents during Christmas 1959, 1000
  Report of the Warren Spring Laboratory (1959), 1082
  Building Research Station, Factory Building Studies No. 6, Noise in Factories (A. G. Aldersey-Williams), 1085
Scientific and Industrial Research Organization (Australian Commonwealth) : Establishment of a new Sugar Research Laboratory, 372
  Appointment of Dr. H. H. Hatt as leader of research in the Sugar Research Laboratory, 372
  List of Publications to December 31, 1959, 466
  Appointment of Dr. S. D. Hamann as chief of the Division of Physical Chemistry, 901
  Retirement of S. A. Clarke as chief of the Division of Forest Products, 901
  Grant of £6,000 from the Broken Hill Proprietary Company, to support tinplate research, 904
Scientific and Industrial Research, Department of (New Zealand) : Retirement of R. C. Hayes as superintendent of the Seismological Observatory, Wellington, 24
  Appointment of Dr. F. F. Evison as superintendent of the Seismological Observatory, Wellington, 830
Scientific and Technical Books : Recent, Supp. vi, July 30 ; Supp. iv, August 27 ; Supp. vi, September 24
Scientific and Technical Books and Dictionaries (Japanese) : A Collection of, presented to the Science Museum Library, London, on behalf of the Prime Minister of Japan, Nobusuke Kishi, 201
Scientific and Technical Publications (Indian) : Bibliography of (Council of Scientific and Industrial Research, New Delhi), 199
Scientific and Technical Reports : Indexes for (ASLIB Survey on), 372
Scientist and Technologist in Administration, 353
Scientists in Scotland, 1600-1950 : The Output of (R. H. S. Robertson), 372
Scientists (Scientific Institutions and), in Latin America (Unesco Centre for Scientific Co-operation in Latin America), Vol. 4, Argentina, 29
Scope for Expanding Pulp and Board Industries in Britain (J. J. MacGregor), 32
Scotland—the Northern Highlands (Dr. J. Phemister), (Handbook of Regional Geology), third edition, 831
Scotland : The Output of Scientists in, 1600-1950 (R. H. S. Robertson), 372
Scott, Dr. A. : Behaviour of Radioactive Griseofulvin in Skin, 705
Scott, C. G., and Rowell, D. A. : Gas-Solid Chromatographic Separation of Hydrocarbons of High Molecular Weight, 143
Scott, H. M., and others : Growth of Sulphide Films on Steel, 588
Scott, Dr. J. S. : Appointed to a senior lectureship in obstetrics and gynaecology in the University of Liverpool, 117
Scott, Dr. Patricia P (Greaves, Dr. J. P., and). Urinary Amino-Acid Pattern of Cats on Diets of varying Protein Content, 242
Scott, Dr. Wendell G., and Evans, Dr. Titus (edited by) : Genetics, Radiobiology and Radiology Proceedings, Mid-Western Conference, *review* by Dr. Lorna J. Lilly, 97
Scott, W. H., and others : Management in Britain—a General Characterization, 537
Scottish Field Studies Association : Annual Report for 1959, 200
Screw Sense of the α-Helix in Poly-β-benzyl-L-aspartate (E. M. Bradbury, A. R. Downie, Dr. A. Elliott and W. E. Hanby), 321
Scriven, L. E., and Sternling, C. V. : The Marangoni Effects, 186
Scrutton, Hugh : At the sixty-sixth Annual Conference of the Museums Association (Purchase of Art Objects for Museums), 657
Sea : The Earth beneath the (Prof. Francis P. Shepard), *review* by Dr. G. E. R. Deacon, 629
Sea (Barents) : Echo Sounding Experiments in the (L. D. Richardson, D. H. Cushing, F. R. Harden Jones, R. J. H. Beverton and R. W. Blacker), 855
Sea (Central North) : A Quantitative Investigation of the Echinoderm Fauna of the (Dr. Erik Ursin), (Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 24), *review* by Dr. A. J. Southward, 360
Sea (Irish) : Pleistocene History of the (G. F. Mitchell), 842
Sea (Norwegian) : Investigations on the Quantitative and Qualitative Distribution of Zooplankton in the Southern Part of the (V. K. Hansen), (Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 23), *review* by Dr. A. J. Southward, 360
Sea-Trout marked in Devonshire : Recapture in the River Tweed of a (A. Swain, I. R. H. Allan and M. J. Bulleid), 877
Sea-Water : Alleged Occurrence of the Perchlorate Ion in (R. Greenhalgh and Dr. J. P. Riley), 1107
Sea Water (Surface), off the California Coast (1959-60) : Fall-out Caesium in, by Gamma-Ray Measurements (Dr. Theodore R. Folsom, Dr. G. J. Mohanrao and Perrin Winchell), 480
Seals : Age Determination of (H R. Hewer), 959
Search for Oil in Britain, 1078
Season : Conditioning *Ostrea edulis* L. from Limfjord for Reproduction out of (I. A. Aboul-Ela), (Meddelelser frå Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 25), *review* by Dr. A J. Southward, 360
Second Mechanism of Inhibition at the Crayfish Neuromuscular Junction (Dr. Josef Dudel and Prof. Stephen W. Kuffler), 247
Second Transition Group : Ferromagnetic and Antiferromagnetic Behaviour in the (Dr. B. R Coles and D. Griffiths), 226
Second Virial Coefficient of Methane at Low Temperature (G. Thomaes and R. Van Steenwinkel), 229
Secondary Modern Schools : Science Teaching in (Science Masters' Association Survey on), 206
Secondary Selection in Pure Lines of Rice (T. K. Van), 169
Secretion (Dorsal Skin), of *Xenopus laevis* : Serotonin, a Melanocyte-stimulating Component in the (Dr. F. C. G. van de Veerdonk), 948
Sections (Ultra-thin) : A Vacuolar System in Cells of *Agrobacterium tumefaciens* as shown by Electron Microscopy of (Miguel Rubio-Huertos and Paul R Desjardins), 1043
Sections (Ultra-thin), of Vitrinite from a High-volatile Bituminous Coal : Absorption of Ultra-violet and Visible Light by (Sabri Ergun, J. T. McCartney and R. E. Walline), 1014
Security (National) : More Effective Organization and Administration of Materials Research and Development for (United States National Academy of Sciences—National Research Council, Publication No. 718), 470
Sediment Cores from the Eastern Atlantic Ocean : Magnetization of (M J. Keen), 220
Sedimentation Characteristics of the β-Chain Haemoglobin (Haemoglobin 'Bart's'), (Dr. R. A. Kekwick and Dr. H. Lehmann), 158
Seed, Dr. J : Appointed by the Royal Society to a Foulerton Gift Research Fellowship at the Department of Radiotherapeutics, University of Cambridge, 291
Seed of Rice : Viability and Germination Inhibitor of the (Prof. S. M. Sircar and Manjula Biswas), 620
Seed Coats (Legume) : Inhibition of Nodule Bacteria by an Antibiotic from (J A. Thompson), 619
Seeded Varieties (Seedless and), of *Vitis vinifera* : Toxicity of Gibberellin to (Dr. Robert J. Weaver), 1135
Seedless and Seeded Varieties of *Vitis vinifera* : Toxicity of Gibberellin to (Dr Robert J Weaver), 1135
Seedling (Wheat) : Plant Hormone Activity—Stilboestrol applied to the (Dr. J. J. C. Hinton and Dr. T. Moran), 258
Seeds (*Ricinus communis*) : Anti-Pneumococcus Type XIV Activity of Precipitins from (Lieut.-Col. G. W. G Bird), 415
Seegal, Beatrice C., and others : Use of Ferritin-conjugated Antibody to Localize Antigen by Electron Microscopy, 1094
Seel, D. C. : Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Zoology), 742
Segrè, Emilio, and Schiff, Leonard I. (edited by, in association with Gerhart Friedlander and Walter E. Meyerhof) : Annual Review of Nuclear Science, Vol. 9, *review* by Dr. E. B, Paul, 182
Seifert, Prof. Howard S. (edited by) : Space Technology, *review*, 884
Seiji, Dr. M., and others : Melanin Granules and Mitochondria, 392
Seismic Body Waves : Oscillatory Character of Amplitude Curves for (Dr. J. Vanek and J. Stelzner), 491
Seismological Observatory, Wellington, New Zealand : Retirement of R. C. Hayes as superintendent, 24
  Appointment of Dr. F. F. Evison as superintendent, 830
Seismology in New Zealand, 830
Seitz, Frederick, and Turnbull, David (edited by) : Solid State Physics—Advances in Research and Applications, Vols. 7, 8, 9 and 10, *review* by Dr. R. O Davies, 886
Seizure Threshold (Electro-shock), of Metacorticoid Hypertensive Rats (Dr. P. M. Sturtevant), 874
Selachii : Modification of the Neurocranium in *Zygaena malleus* and the Nature of the Optic Stalk in (Dr. A. R. Hamdy), 257
Selby Fellowship for 1960 awarded to Dr. W. Deachars, 464
Selection of Executives (T. H. Hawkins), 31
Selection (Secondary), in Pure Lines of Rice (T. K. Van), 169
Selective Cytochemical Demonstration of Arginine Groups in Nucleoprotein in the Cell Nucleus (Dr. E. A. Barnard and Dr. L. G. E. Bell), 508
Selective Solvents (Two Highly), for Gas-Liquid Chromatography Analysis of C_6-C_8 Hydrocarbons (Dr. A van der Wiel), 142
Selenium : Non-destructive Analysis of, by Neutron Activation followed by Gamma-Ray Spectrometry (Dr. Minoru Okada), 594
Self : The Divided—a Study of Sanity and Madness (Dr. R. D. Laing), *review* by Dr. Clifford Allen, 1062
Self-Diffusion of Alkali Metal Ions in Analcite : Energies of Activation for (Prof. R. M. Barrer and L. V. C. Rees), 768

Self-Fertilization in the Calyptraeidae : Protandry and (Dr. H. V. Wyatt), 520
Self-Incompatible Cocoa : Selfing of (D. R. Glendinning), 170
Self-Regulation in Living Systems : Ottawa Symposia on, 3, Tremor, 297
Selfing of Self-Incompatible Cocoa (D. R. Glendinning), 170
Selmeczi, F. V., and others : Damage to Liver induced by DL-Methionine-Ethylester, 421
Semiconducteurs : Les (Prof. P. Aigrain et F. Englert), *review* by Dr. J. R. Tillman, 1058
Semiconducteurs Électroniques : Les (Dr. E. Spenke), traduit par L. Godefroy, *review* by Dr. J. R. Tillman, 1058
Semiconductor Devices : The Properties, Physics and Design of (John N. Shive), *review* by Dr. J. R. Tillman, 1058
Semiconductor Physics (Czechoslovak Academy of Science International Conference on), 29
  A Source-Book of, *review* by Prof. G. F. J. Garlick, 885
Semiconductors (Dr. R. A. Smith), *review* by Prof. G. F. J. Garlick, 885
  Progress in (edited by Dr. Alan F. Gibson, Prof. R. E. Burgess and Dr. F. A. Kroger), Vol. 4, *review* by Dr. J. R. Tillman, 185
Semiconductors and Transistors, *review* by Dr. J. R. Tillman, 1058
Semi-Insulator : Gallium Arsenide as a (J. W. Allen), 403
Senegal : Haptoglobin Types in 398 Blood Donors from Dakar, (Dr. J. Moullec, Dr. J. M. Fine and J. Linhard), 517
Senftle, Dr. Frank E., and others : Comparison of the Chemical Composition and Magnetic Properties of Tektites and Glasses formed by Fusion of Terrestrial Rocks, 1089
Sense (Screw), of the α-Helix in Poly-β-benzyl-L-aspartate (E. M. Bradbury, A. R. Downie, Dr. A. Elliott and W. E. Hanby), 321
Sensitive and Resistant L1210 Mouse Leukaemia Cells : Effect of 6-Mercaptopurine on the Net *in vitro* Gas Production of (Dr. H. J. Woodliff), 156
Sensitivity (Electrical), of the Ampullae of Lorenzini (Dr. R. W. Murray), 957
Sensitivity (Tuberculin) : Production of (Prof. Hubert Bloch and Albert A. Nordin), 434
Sensitivity (X-Ray), of *Serratia marcescens* : Effect of Glycerine on the (Dr. D. L. Dewey), 1008
Sensitization (Anaphylactic), of Isolated Tissues *in vitro*: Influence of the Ionic Strength of the Medium on the (R. Binaghi, M. Liacopoulos-Briot, Dr. B. N. Halpern and P. Liacopoulos), 697
Sensory Innervation of the Anal Canal (R. P. Gould), 337
Separation (Electrophoretic), of certain *in vitro* and *in vivo* Reactions of Rabbit Anti-Mouse Erythrocyte Serum (Chang-Ling Lee, Tamon Takahashi and Israel Davidsohn), 157
Separation (Gas-Solid Chromatographic), of Hydrocarbons of High Molecular Weight (C. G. Scott and D. A. Rowell), 143
Separation (Microanalytical), of Steroids by Gas Chromatography (C. C. Sweeley and Dr. E. C. Horning), 144
Sequence (Amino-Acid), of Human Insulin (Dr. D. S. H. W. Nicol and Dr. L. F. Smith), 483
Sequence (Amino-Acid), about the Reactive Serine of a Proteolytic Enzyme from *Bacillus subtilis* (Dr. F. Sanger and D. C. Shaw), 872
Sera from Pregnant Women : Immuno-electrophoretic Demonstration of Precipitating Components in (Dr. Jan Hirschfeld and Dr. Ulf Soderberg), 332
Sera (Normal Human) : Immuno-Electrophoretic Differentiation of Haptoglobins from another Group-Specific Inheritable System in (Dr. Jan Hirschfeld), 126
Sereda, P. J. : Effect of Temperature on the Expansion on Setting of Gypsum Plaster, 929
Serengeti National Park (Sir Landsborough Thomson), 174
D-Serine (Free), in the Earthworm : Occurrence of (Dr. H. Rosenberg and Prof. A. H. Ennor), 617
Serine (Acetyl-) Peptides : Structures of some, from Acetyl-chymotrypsin (Leo Benoiton, Prof. H. N. Rydon, R. A. Oosterbaan, M. E. Van Adrichem and Prof. J. A. Cohen), 596
Serine (Reactive), of a Proteolytic Enzyme from *Bacillus subtilis* : Amino-Acid Sequence about the (Dr. F. Sanger and D. C. Shaw), 872
Serotonin, a Melanocyte-stimulating Component in the Dorsal Skin Secretion of *Xenopus laevis* (Dr. F. C. G. van de Veerdonk), 948
Serratia marcescens : Delayed Recovery of Airborne, after Short-Time Exposure to Ultra-violet Irradiation (Dr. R. L. Dimmick), 251
  Effect of Glycerine on the X-Ray Sensitivity of (Dr. D. L. Dewey), 1008
Serratia marcescens (*Chromobacterium prodigiosum*) : Association of Pigment with the Cell Envelope of (Mira Purkayastha and Prof. R. P. Williams), 349
Serum of Pregnant Women : Inhibition of Glucuronosyl Transferase by Progestational Agents from (Dr. David Yi-Yung Hsia, Robert M. Dowben, Ralph Shaw and Aaron Grossman), 693
Serum Albumin Concentration in Analbuminaemia and its Immunological Significance (Dr. J. H. Humphrey), 304
Serum Factors Gm^a, Gm^b, Gm^x and Gm-like: Effect of Heat on the (Prof. Arthur G. Steinberg and Rachael Stauffer), 791
Serum Iron and Total Iron-binding Capacity in certain Mammals (Prof. Jose Planas and Sancio de Castro), 1126
Serum Protein (An Abnormal), in Experimental Poisoning by Cadmium and other Metals (D. J. Lawford), 946
Serum (Blood), and Urine of Cattle : Occurrence of Keto-Acids in, in comparison with Man, Horse, Sheep and Dog (Dr. C. J. G. van der Horst), 146
Serum (Human) : Isolation of Material with Proactivator Activity from (H. B. W. Greig and Elsie M. Cornelius), 1125
Serum (Rabbit Anti-Mouse Erythrocyte) : Electrophoretic Separation of certain *in vitro* and *in vivo* Reactions of (Chang-Ling Lee, Tamon Takahashi and Israel Davidsohn), 157
Serum (Rat) Acid Phosphatase : Total and *l* (+) Tartaric Acid Inhibited (Dr. Z. Laron and B. Epstein Halberstadt), 67
Service (The Public), in New States—a Study in some Trained Manpower Problems (Kenneth Younger), 971
Setting of Gypsum Plaster : Effect of Temperature on the Expansion on (P. J. Sereda), 929
Severyanka (Submarine) : Oceanographic and Fisheries Research by the (V. P. Zaitzev), 559
Sewage Works (Water and) : Problems of Radioactivity at (Manchester College of Science and Technology Course of Lectures on), 743
Sewers : Control of Rats in (Dr. W. E. Bentley), 288
Sex Ratio of Ammocoetes (M. W. Hardisty), *erratum*, 29
Sgarzi, S., and others : An Antibiotic Complex derived from a *Streptomyces* and Active against Gram-positive Bacteria, 1029
Shape of the Human Red Cells : Adenosine Triphosphate and Maintenance of (Makoto Nakao, Toshiko Nakao and Saburo Yamazoe), 945
Shape Factors (Particle), in the Sieve Range : A Method for the Routine Measurement of (Dr. Colin C. Harris), 401 ; (D. Howitt), 403
Shaposhnikov, V. V., and others : A New Species of Green Sulphur Bacteria, 167
Sharan, Dr. R. K. : Occurrence and Function of the Provisional Embryonic Cuticle of a Lepidopteran, 1040
Sharnoff, Dr. J. George, and Scardino, Dr. Vito : Platelet-Count Differences in Blood of the Rabbit Right and Left Heart Ventricles, 334
Sharp, Dr. L. K. : Story of Chemical Industry in Basle, *review*, 540
Shaw, Dr. B., and others : Effect of Wheat Gluten on the Peristaltic Reflex, 516
Shaw, D. C. (Sanger, Dr. F., and) : Amino-Acid Sequence about the Reactive Serine of a Proteolytic Enzyme from *Bacillus subtilis*, 872
Shaw, Ralph, and others : Inhibition of Glucuronosyl Transferase by Progestational Agents from Serum of Pregnant Women, 693
Shaylor, H. R. : Appointed Staff Fellow in nuclear physics in the Department of Physics in the University of Birmingham, 465
Shear (Simple) : A Simple Method of Investigating the Creep of Metals under (Prof. E. N. da C. Andrade), 494
Sheep : Use of Diodone in Renal Studies in (B. J. Potter), 698
Sheep infected experimentally with the Virus of Tick-borne Encephalitis : Virus and Antibodies in the Lymph and Blood of (Doubravka Málková), 716
Sheep and Dog (Man, Horse,) : Occurrence of Keto-Acids in Blood Serum and Urine of Cattle in comparison with (Dr. C. J. G. van der Horst), 146
Shell Research Centre : Low-Temperature Fuel Cell, 994
Shemilt, Prof. L. W. (Dullien, F. A. L., and) : Equations for Determining Diffusion Coefficients in Liquid Systems by the Diaphragm-Cell Technique, 767
Shepard, Prof. Francis P. : The Earth beneath the Sea, *review* by Dr. G. E. R. Deacon, 629
Shepherd, Dr. M. : Appointed reader in psychiatry at the University of London Institute of Psychiatry, 117
Sheppard, Herbert, and Zimmerman, Joseph H. : A Suggested Effect on Levels of Catecholamine in Brain produced by Small Doses of Reserpine, 1035
Sheppard, Prof. P. A. : Energy for the Atmosphere, *review*, 974
Sheth, Prof. U. K., and others : Diuretic Activity of 2-Amino-4-meta-chloroanilino-1,3,5,triazine (*R-37*), 1034
Shettles, Dr. Landrum B. : *X* and *Y* Spermatozoa, 254
Shifrine, Moshe, and Biberstein, Prof. Ernst L. : A Growth Factor for *Haemophilus* Species secreted by a Pseudomonad, 623
Shikimic Acids (Quinic and) : Excretion of Catechol after Ingestion of (Dr. A. N. Booth, D. J. Robbins, M. S. Masri and F. DeEds), 691
Shilnikov, V. I., and others : Work of the Antarctic Expeditions of the Academy of Sciences of the U.S.S.R., 287
Shirlaw, D. W. Gilchrist (Willimott, Dr. S. G., and) : *C* Horizon of the Soil Profile, 966
Shive, John N. : The Properties, Physics and Design of Semiconductor Devices, *review* by Dr. J. R. Tillman, 1058
Shooter, Dr. K. V. (Crathorn, Dr. A. R., and) : Uptake of Thymidine and Synthesis of Deoxyribonucleic Acid in Mouse Ascites Cells, 614
Shore Crab, *Carcinus maenas* (L.) : Albinism in an American Population o the (Anthony J. Provenzano, jun.), 521
Shorley, Patricia G., and others : Synthesis and Biological Properties of L-Arginyl-L-Prolyl-L-Prolyl-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenylalanyl-L-Arginine, an Octapeptide related to Bradykinin, 773
Short, B. F., and others : Abnormal Crimping in Merino and Polwarth Wools, 960
Short, H. G. : The National Physical Laboratory—Open Days, 454
Short-Time Exposure to Ultra-violet Irradiation : Delayed Recovery of Airborne *Serratia marcescens* after (Dr. R. L. Dimmick), 251
Shortages of Scientific Personnel in European Countries in Process of Development, 565
Shotton, F. E. : Appointed director of Terrington and Kirton Experimental Husbandry Farms, King's Lynn, 905
Shrinkage Temperature of Collagen : Hydroxyproline and the (B. J. Rigby and Dr. J. D. Spikes), 150
Shternfeld, Ari : Soviet Space Science (translated by the United States Air Force), *review*, 884
Shuter, W. L. H., and others : A New Limit to the Galactic Magnetic Field set by Measurements of the Zeeman Splitting of the Hydrogen Line, 1088
Shuttleworth, A. C. : Appointed reader in veterinary surgery in the University of Liverpool, 117
Sialoadenectomy and the Distribution of Thyrotrophin labelled with Iodine-131 (Prof. Arthur W. Wase and Dr. Yu Sheng Louise Feng), 778
Sickling Phenomenon in Deer (E. Undritz, K. Betke and Dr. H. Lehmann), 333
Sierra Leone River : Plankton of the Estuary and Offshore Waters of the (V. Bainbridge), 557
Sieve Range : A Method for the Routine Measurement of Particle Shape Factors in the (Dr. Colin C. Harris), 401 ; (D. Howitt), 403
Signals from Satellite *Echo I* : Reflexion of, 901
Signals (Satellite) : Ionospheric Information from (Dr. G. H. Munro), 1017
Signals (Time) : The International Co-ordination of, and Standard Frequency Transmissions (Dr. L. Essen), 452
Significance of the Difference between Two Means when the Population Variances may be Unequal (John B. de V. Weir), 438
Significance of the Type of Host Plant Crop in Successful Biological Control of Insect Pests (D. C. Lloyd), 430
Significance (Immunological) : Serum-Albumin Concentration in Analbuminaemia and its (Dr. J. H. Humphrey), 304
Significance (Taxonomic), of Spermathecal Structure in some Species of *Tribolium* (Gordon Surtees), 1138
Silberrad, Dr. O. J. : *Obituary* by J. S. Grew, 553
Silicate (Lead) Glass : Gamma Irradiation of (R. S. Barker, D. A. Richardson, E. A. G. McConkey and R. Rimmer), 135

Silicon : Isotopic Analysis of, by Solid-Source Mass Spectrometry using Negative Ions (Dr. D. C. Newton, J. Sanders and A. C. Tyrrell), 683
Silicon bearing 17 per cent Chromium, 8 per cent Nickel and 1 per cent Niobium Steel : A New Phase in a (M. J. O'Hara, D. Wilkinson and R. T. Allsop), 407
Silicon–Boron System (Prof. Cyrill Brosset and Bengt Magnusson), 54
Silicon (Gold–) Alloys : Non-crystalline Structure in Solidified (W. Klement, jun., R. H. Willens and Prof. Pol Duwez), 869
Silicon (An Iron–) Carbide (J. G. Humphreys and Prof. Walter S. Owen), 589
Silkworm, *Bombyx mori* : Function of the Corpus Allatum in 'Dauer-pupa' of the (Dr. Masatoshi Kobayashi), 346
  Nutritive Values of Carbohydrates for the (Dr. Toshio Ito), 527
Silkworm Raising on Artificial Food (Toshifumi Fukuda, Mitsumasa Suto and Yoshikichi Higuchi), 669
Silver : Non-destructive Analysis of Microgram Quantities of, by Radioactivation (Dr. Minoru Okada), 57
AgSCN $P(n\text{-}C_4H_9)_3$: Structure of (Dr. A. Turco, C. Panattoni and E. Frasson), 762
Silver Cup : The Enkomi (Dr. G. F. Claringbull and A. A. Moss), 1051 ; (Dr. Harold J. Plenderleith), 1052
Silverman, Dr. Robert : Appointed assistant professor of mathematics in the University of Pittsburgh, 905
Simaika, Dr. Youssef : Problems of the Arid Zones (Alternative Uses of Limited Water Supplies—United Arabic Republic–Egyptian Region), 296
Simmons, Dr. S. W., and others : DDT—the Insecticide DDT and its Significance (edited by Paul Muller), Vol. 2, Human and Veterinary Medicine (edited by Dr. S. W. Simmons), *review* by Prof. D. S. Bertram, 271
Simms, E. M., and Blake, J. N. : At the Nineteenth Meeting of the Research Panel of the British Gelatine and Glue Research Association (The Swelling of Gelatine Films), 998
Simon, Brian : Studies in the History of Education, 1780-1870, *review* by Dr. James L. Henderson, 357
Simons, Dr. J. P., and Yarwood, A. J. : Photochemical Formation and Stability of the CF_3 Radical, 316
Simony, P. S. : Awarded an Overseas Scholarship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Simple Azo-Dye Method for Histochemical Demonstration of Acid Phosphatase (Dr. Tibor Barka), 248
Simple Compounds of Uranium, Thorium, Plutonium, Neptunium : Crystal Chemistry of (E. S. Makarov), translated from the Russian by E. B. Uvarov, *review* by Dr. L. E. J. Roberts, 728
Simple Method of Investigating the Creep of Metals under Simple Shear (Prof. E. N. da C. Andrade), 494
Simple Shear : A Simple Method of Investigating the Creep of Metals under (Prof. E. N. da C. Andrade), 494
Simpson, M. V. : Cytoplasmic Particles and their Role in Protein Synthesis (Mitochondria of both Rat Liver and Calf Heart to study the Incorporation of Amino-Acids into Cytochrome *c*), 645
Simpson, Dr. O., and others : Gallium Arsenide for γ-Ray Spectroscopy, 405
Simpson, Prof. S. : Fossils for the Naturalist, *review*, 271
Simuliidae (Immature) : Attachment of, to other Arthropods (Dr. D. J. Lewis, E. T. Reid, R. W. Crosskey and J. B. Davies), 618
Simultaneous Measurement of Adsorption and Electrodekinetic Parameters at Metal Surfaces (A. M. Peers), 503 ; (Dr. E. A. Blomgren and Dr. J. O'M. Bockris), 504
Sinclair, Dr. H. M. : *Obituary* of Sir Robert McCarrison, 195
Singapore Botanic Gardens, 1000
Singer, Prof. Charles : *Obituary* by Dr. E. Ashworth Underwood, 827
Single Contour : Perceptual Anomalies associated with a (J. P. Wilson), 137
Single Crystal (Aluminium) : Borrmann Effect observed in an (Koichi Nakajima and Prof. Shigeyasu Koda), 53
Sinha, Dr. A. : Isolation of a δ-Lactone Compound from the Leaves of *Clitoria marina* Linn., 149
Siphonaceous Green Algae : Xylan of (Yoshihiko Iriki, Takao Suzuki, Kazutosi Nisizawa and Tomoo Miwa), 82
Sircar, Prof. S. M., and Biswas, Manjula : Viability and Germination Inhibitor of the Seed of Rice, 620
Sirotnak, Francis M., and others : Transformation of Resistance to 8-Azaguanine in *Diplococcus pneumoniae*, 800
Site and Nature of Adenovirus Nucleic Acid (Dr. M. A. Epstein and Dr. S. J. Holt), 1050
Sites (Breeding), of Non-Cichlid Fishes in Lake Victoria (Dr. Philip S. Corbet), 616
Six, F., and others : Ionospheric Modification of the Radio Emission from Jupiter, 568
Sixty Years of Progress in English Education (Prof. H. C. Dent), 848
Size of Aggregate : Dependence of Cement-Aggregate Bond-Strength on (K. M. Alexander and J. Wardlaw), 230
Size of Isolated Cells : Measuring the (Dr. Samuel S. Epstein and Jacqueline B. Weiss), 461
Size of Pupil : Effect of, on Visual Acuity (Dr. F. W. Campbell and Dr. A. H. Gregory), 1121
Sjenitzer, F. (Klinkenberg, A., and) : 'Eddy' Diffusion in Chromatography, 1023
Sjogren, Torsten (Hallgren, Bertil, and) : A Clinical and Genetico-Statistical Study of Schizophrenia and Low-Grade Mental Deficiency in a Large Swedish Rural Population, 298
Skin : Behaviour of Radioactive Griseofulvin in (Dr. A. Scott), 705
  Eosinophil Leucocyte-attracting Effect of Histamine in (Dr. R. K. Archer), 155
Skin (Mammalian) : Phosphate Esters produced by, from 2-Deoxy-D-glucose (Dr. S. A. Brooks, Dr. J. C. Lawrence and Dr. C. R. Ricketts), 1028
Skin (Precancerous Mouse) : Mast Cells and 5-Hydroxytryptamine in (Dr. R. E. Coupland and Dr. J. P. Riley), 1128
Skin Secretion (Dorsal), of *Xenopus laevis* : Serotonin, a Melanocyte-stimulating Component in the (Dr. P. C. G. van de Veerdonk), 948
Skin (Nose and) : Bacterial Population of the (H. Williams Smith and W. E. Crabb), 287
Skinner, Dr. N. J., and others : Equatorial Spread-*F* and *F*-Layer Heights, 1086
Skoglund, Dr. Sten : Hind-Limb Reflexes in the Kitten—Velocity of Conduction and Spinal Transmission of Proprioceptive Hind-Limb Reflexes, 132 ; Properties of the Two Neuron Arc, 134
Skull (Piltdown) : Artificial Thickening of Bone and the (Prof. Ashley Montagu), 174 ; (Dr. Kenneth P. Oakley), 174
Sky : The Night, in August, 289 ; in September, 650 ; in October, 1079
Skylark Rocket Sodium Experiment : Upper-Atmosphere Wind Studies by (Dr. G. V. Groves), 1001
Slater, C. H., and others : A New Limit to the Galactic Magnetic Field set by Measurements of the Zeeman Splitting of the Hydrogen Line, 1088
Slater, Prof. E. C. (Laser, Dr. H., and) : Effect of Heavy Water on Respiratory-chain Enzymes, 1115
Slater, Dr. J. D. H., and others : Staining for Iodine in Chromatograms of Human Plasma—an Artefact due to Thiourea or Thiouracils, 691 ; *erratum*, 1079
Slater, Colonel L. : At the second Annual Conference of the British Computer Society (Installation of Data-processing Schemes for the Payment of the Military), 656
Slater, Dr. L. J. : Confluent Hypergeometric Functions, *review* by Prof. W. N. Bailey, 93
Slater, Sir William : Appointed chairman of the governing body of the Glasshouse Crops Research Institute, 1079
Slatyer, Dr. R. O., and Taylor, Prof. S. A. : Terminology in Plant- and Soil-Water Relations, 922
Slawson, William F., and Austin, Carl F. : Anomalous Leads from a Selected Geological Environment in West-Central New Mexico, 400
Sleep (Hexobarbitone-induced), in Mice : Effect of Hydration on (Dr. N. K. Bhide), 1030
Slip (*Ko*) and Viscous (*Bo*) Flow Coefficients of Permeable Solids : Measurement of (J. G. Biram), 865
Slopek, S., and others : Anti-neoplastic Activity of Tetrahydro-1,3-oxazine Derivatives, 426
Sluckin, Dr. W. : Appointed lecturer in psychology at the University of Leicester, 743
Small, J. R. : Appointed lecturer in accounting and business methods at the University of Edinburgh, 465
Small Bodies : Dispersal in Space of (Dr. D. O. Wolfenbarger), 1078
Small Doses of Reserpine : A Suggested Effect on Levels of Catecholamine in Brain produced by (F. Barbara Orlans and Dr. Bernard B. Brodie), 1034 ; (Herbert Sheppard and Joseph H. Zimmerman), 1035
Small Experiments : Analysis of (P. Sprent), 437
Small Pacific Island : Continuity in a, *review* by Sir Harry Luke, 816
Small-Scale Turbulent Diffusion in the Atmosphere (Dr. L. A. Clarenburg and C. E. Speans v. d. Tang), 586
Smillie, Dr. Robert : Alkaline C-1 Fructose-1,6-diphosphatase—Evidence for its Participation in Photosynthesis, 1024
Smit, Dr. J., and Wijn, Dr. H. P. J. : Ferrites, *review* by Dr. G. E. Bacon, 974
Smith, Prof. A. G. : Elected first holder of the Hives chair of thermodynamics in the University of Nottingham, 743
Smith, Prof. A. G., and others : Ionospheric Modification of the Radio Emission from Jupiter, 568
Smith, Dr. Audrey U. : Freezing and Drying of Biological Materials, 748
Smith, B. S. : Health Physics Instrumentation, *review*, 9
  U.K. Atomic Energy Research Establishment—Wantage Research Laboratory, 292
Smith, Dr. C. L. : Appointed reader in zoology in the University of Liverpool, 117
Smith, Prof. Carter R. : Effect of Autumn Applications of Potassium Gibberellate on Fruit Production of the Strawberry, 620
Smith, C. T., and others : The Making of the Broads, *review* by Miles Burkitt, 636
Smith, D. E. (May, B. R., and) : Final Months and Descent of Satellite *Sputnik* 3, 456
  The Sudden Discontinuity in the Orbital Period of *Sputnik* 4 Satellite, 866
Smith, Deane K. : Bibliography on Molecular and Crystal Structure Models (United States National Bureau of Standards, Monograph No. 14), 903
Smith, E. (Jeffery, R. A., and) : Work-Hardening and Ductility of Rhenium and their relation to the Behaviours of other Metals having a Hexagonal Structure, 52
Smith, E. B. (compiled by) : Safety in Mines Research Establishment Bibliography, 1960, second edition, *review* by Prof. S. G. Ward, 1063
Smith, Dr. E. Lester : Vitamin B_{12}, *review* by Prof. John Yudkin, 889
Smith, Dr. F. G. : Grant of £11,230 for Space Research (for the measurement of cosmic radio noise by receivers mounted on rockets and satellites), 744
Smith, G. K., and Burns, Prof. B. Delisle : A Biological Interval Analyser, 512
Smith, H. Williams, and Crabb, W. E. : Bacterial Population of the Nose and Skin, 288
Smith, Dr. J. A. B. : The National Institute for Research in Dairying, 909
Smith, K. R. E. : Nutzenergie aus Atomkernen, *review*, 979
Smith, Dr. L. F. (Nicol, Dr. D. S. H. W., and) : Amino-Acid Sequence of Human Insulin, 483
Smith, Dr. M. J. H. (Marks, Dr. V., and) : Anti-Inflammatory Activity of Salicylate, 610
Smith, Dr. R. A. : Semiconductors, *review* by Prof. G. F. J. Garlick, 885
Smith, Ray F. (edited by Edward A. Steinhaus and) : Annual Review of Entomology, Vol. 5, *review* by Prof. V. B. Wigglesworth, 542
Smith, R. J. Ord : Automatic Programming in the U.S.S.R., *review*, 92
Smith, Prof. W. : Title of professor emeritus of bacteriology in the University of London conferred on, 466
Smith-Rose, Dr. R. L. : Principles and Practice of Television Engineering, *review*, 358
  Appointed chairman of the General Post Office Frequency Advisory Committee, 466
  Communications and Electronics Dictionaries, *review*, 1059
Smithsonian Institution, Washington : Langley Medal awarded posthumously to Dr. Robert H. Goddard, 20[illegible]
  Appointment of James C. Bradley as assistant secretary (management), 743
Smolker, Robert E. (Hackel, Prof. Emanuel, and) : Effect of Ribonuclease on Erythrocyte Antigens, 1036
Smooth Muscle (Nerve—) Transmission : Autonomic (G. Burnstock and Mollie E. Holman), 951

Smythe, L. E. (Florence, T. M., and) : Use of Azo Dyestuffs for the Polarographic Determination of the Lanthanides, 771
Smythies, John R. (edited by Carl C. Pfeiffer and) : International Review of Neurobiology, Vol. I, *review* by Dr. D. H. Brinton, 447
Snail *Paludina vivipara* Lin. : *Diplodiscus* Species Parasitic in the (M. R. Honer), 431
Sneath, Dr. P. H. A. : Microbial Systematics, 191
Sneed, Prof. M. Cannon, and Brasted, Prof. Robert C. (edited by) : Comprehensive Inorganic Chemistry, Vol. 7, The Elements and Compounds of Group IVA (Harold P. Klug and Prof. Robert C. Brasted), *review* by Dr. K. W. Bagnall, 185
Snider, C. S., and others : A Comparison of Atomic Beam Frequency Standards, 681
Snows (Antarctic) : Isotopic Composition and Temperature of Formation of (Prof. E. Picciotto, X. de Maere and Dr. I. Friedman), 857
Soal, Dr. S. G. : Experimental Evidence for Extra-Sensory Perception, 171
Sobolev, Prof. V. V. : Moving Envelopes of Stars (translated by Sergei Gaposchkin), *review* by Prof. W. H. McCrea, 538
Sobotka, Harry, and Stewart, C. P. (edited by) : Advances in Clinical Chemistry, Vol. 2, *review* by Dr. R. Consden, 890
Social Change in Tikopia (Prof. Raymond Firth), *review* by Sir Harry Luke, 816
Social Development through the Family and Home : Report of the Conference on, 567
Social Science : Medicine as a, *review* by Prof. E. Maurice Backett, 633
Social Sciences : The Literature of the (Peter R. Lewis), *review*, 729
Social Structure : Religion and, *review* by Michael Argyle, 96
Società Italiana di Fisica : International Summer Course on Solid State Physics, 201
Société de Chimie Physique : Annual Meeting (Structure, Synthesis and Function of Deoxyribonucleic Acid), 1079
Société Française d'Histochimie : First International Congress of Histochemistry and Cytochemistry, 29
Société Française de Métallurgie : Meeting on the Heat Treatment of Metals and Alloys, 559
Society : Interactions of Science and Technology with, 1
Society and Health : Culture, (Division of Anthropology of the New York Academy of Sciences and the Research Institute for the Study of Man Conference on), 658
Sociological Studies at the University of Sheffield, 463
Soderberg, Dr. Ulf (Hirschfeld, Dr. Jan, and) : Immuno-electrophoretic Demonstration of Precipitating Components in Sera from Pregnant Women, 332
Sodermann, R. A., and Frisco, L. F. (edited by) : Digest of Literature on Dielectrics, Vol. 22, 1958 (United States National Academy of Sciences—National Research Council, Publication No. 713), *review* by S. Weintroub, 728
Sodium : Critical Energy Barriers in the Excretion of (Prof. E. J. Conway), 394
Sodium Butyrate : Reduction of the Intestinal Absorption of Glucose, Methionine and, by the Cation Trimethylhexadecylammonium (Dr. J. A. Nissim), 308
Sodium Chloride : Change of the Chlorine—Sodium Ratio in the Atmosphere with Altitude and Distance from the Source of and the Distribution of Atmospheric Nitrate over the United States (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Sodium Experiment (Skylark Rocket) : Upper-Atmosphere Wind Studies by (Dr. G. V. Groves), 1001
N Sodium Hydroxide : Ammonia released on Treating Soils with, as a Possible Means of Predicting the Nitrogen-supplying Power of Soils (A. H. Cornfield), 260
Sodium Hydroxide in Water : Interaction of Picric Acid with (Takehiro Abe), 234
Sodium Molecules (Lithium and) : Excited Electronic States of (Dr. R. F. Barrow, N. Travis and C. V. Wright), 141
Sodium and Potassium in Mitochondrial Membrane Fractions (Dr. Frank Ulrich), 949
Softening Chitin for Histology (Dr. D. B. Carlisle), 1132
Soil : Herbicides and the (British Weed Control Council Symposium on), 376
Relative Availability of some Strontium-90 Compounds in (Dr. R. L. Uhler and Dr. F. P. Hungate), 252
Soil (Relic-) on Limestone in South Wales (D. F. Ball), 497
Soil Engineering : Laboratory Testing in (T. N. W. Akroyd), *review* by Dr. H. L. Penman, 891
Soil Profile : *C* Horizon of the (Dr. S. G. Willimott and D. W. Gilchrist Shirlaw), 966
Soil-Water Relations (Plant- and) : Terminology in (Dr. R. O. Slatyer and Prof. S. A. Taylor), 922
Soils : Ammonia released on Treating Soils with *N* Sodium Hydroxide as a Possible Means of Predicting the Nitrogen-supplying Power of (A. H. Cornfield), 260
The Geochemistry of Rare and Dispersed Chemical Elements in (A. P. Vinogradov), second edition, (translated from the Russian), *review* by A. H. Debnam, 629
Minor Elements in, *review* by A. H. Debnam, 629
Soils (British) : Potassium-supplying Power of some (Dr. P. W. Arnold), 436
Soils (Swedish) : Content of Caesium-137 and (Zirconium + Niobium)-95 in (Kerstin Low and K. Edvarson), 736
Soils (Treating) with *N* Sodium Hydroxide : Ammonia released on, as a Possible Means of Predicting the Nitrogen-supplying Power of Soils (A. H. Cornfield), 260
Soils (Wet and Dry) : Potash in, *review* by Dr. P. W. Arnold, 976
Soils, Plants and Bones : Radioactivity of (Sir Ernest Marsden), 192
Sokal, Dr. R. R. : Microbial Systematics, 191
Solar Atmosphere : Temperatures reached in Electrical Discharges in the (Dr. C. E. R. Bruce), 865
Solar Flare of June 1, 1960 (Prof. M. A. Ellison, Susan M. P. McKenna and J. H. Reid), 926
Solar System : The Exploration of the (Felix Godwin), *review* by D. G. King-Hele, 811
Origin of the (Dr. M. M. Woolfson), 47 ; (M. H. Briggs), 1102
Solid—Solid Interactions on Active Adsorbents (Dr. Philip Anthony and Prof. Harry Zeitlin), 936
Solid-Source Mass Spectrometry using Negative Ions : Isotopic Analysis of Silicon by (Dr. D. C. Newton, J. Sanders and A. C. Tyrrell), 683
Solid State Physics (Società Italiana di Fisica International Summer Course on), 201
Solid State Physics, *review* by Dr. R. O. Davies, 886
Solid State Physics—Advances in Research and Applications (edited by Frederick Seitz and David Turnbull), Vols. 7, 8, 9 and 10, *review* by Dr. R. O. Davies, 886 ; Supplement 2, Paramagnetic Resonance in Solids (William Low), *review* by Dr. R. O. Davies, 886
Covalent Super-Exchange in (Prof. W. S. Fyfe and Prof. J. Verhoogen), 1108
Solid (Gas-) Chromatographic Separation of Hydrocarbons of High Molecular Weight (C. G. Scott and D. A. Rowell), 143
Solidified Gold—Silicon Alloys : Non-crystalline Structure in (W. Klement, Jun., R. H. Willens and Prof. Pol Duwez), 869
Solids : Paramagnetic Resonance in (William Low), (Solid State Physics—Advances in Research and Applications, Supplement 2), *review* by Dr. R. O. Davies, 886
The Strength of (Prof. A. H. Cottrell), 659
Solids (Permeable) : Measurement of Slip (*Ko*) and Viscous (*Bo*) Flow Coefficients of (J. G. Birum), 865
Solomon, Dr. A. K., and others : Effect of Anti-Diuretic Hormone and Calcium on the Equivalent Pore Radius of Kidney Slices from *Necturus*, 699
Solomon, Dr. A. K. (Schultz, Dr. Stanley G., and) : A Bacterial Mutant with Impaired Potassium Transport, 802
Solonenko, V. P., and Florensov, N. A. : Tectonics of the Gobi Mountains, 373
Solubility Data : Analyses of, to estimate Small Amounts of Chain Fracture during the Cross-linking of Rubber (L. Mullins and D. T. Turner), 145
Soluble Bacterial Antigens : Antibody Responses of the Domestic Fowl to Two (Dr. G. Gowland), 624
Soluble Matrix Antifouling Compositions : Mode of Action of (A. Partington), 1105
Solutes : Plants in relation to Water and (Plant Physiology, edited by F. C. Steward, Vol. 2), *review* by Prof. Walter Stiles, 869
Solutions : Expression of Concentrations of (E. H. Leach), 350
Solutions of Hyaluronic Acid : Exclusion of Inulin from (Dr. A. G. Ogston and C. F. Phelps), 1024
Solutions (Aqueous) : Effects of *p*H and the Nature of the Primary Species in the Radiolysis of (J. T. Allan and Dr. G. Scholes), 218
A New Method for the Differential Precipitation of Nucleic Acids from (William G. Aldridge), 323
Solutions (Aqueous Electrolyte) : Ultrasonic Velocities in (Dr. C. G. Balachandran), 136
Solutions (Ferrous) : Radiolytic Oxidation of, with Standardized Internal Sources of Phosphorus-32 (Dr. M. Pesach and J. Steyn), 58
Solutions (Highly Enriched Oxygen-18 Water), containing Hydrogen Peroxide-16,16 : Radiolysis of (Dr. Michael Anbar, Shmuel Guttmann and Prof. Gabriel Stein), 57
Solutions (Urea—Lithium Bromide) : Viscosity of Concentrated (Dr. Irving I. Geschwind), 324
Solvey, Dr. E. J. : Research and Development in Industry (Presidential Address to the Society of Chemical Industry), 830
Solvent Systems (Mixed) : Activity of Bovine Pancreatic Ribonuclease *A* in (Dorothy Findlay, Dr. A. P. Mathias and Dr. B. R. Rabin), 601
Solvents (Two Highly Selective), for Gas-Liquid Chromatography Analysis of C_5–C_6 Hydrocarbons (Dr. A. van der Wiel), 142
Somatic Cell Nuclei : Absorbance of Feulgen-stained (Dr. Simon Iversen), 86
Somers, Dr. E. : Fungitoxicity of Metal Ions, 427
Sondheimer, Prof. E. H. : Appointed to the chair of mathematics in Westfield College, London, 363 ; work of, 363
Soper, Dr. J. M. : Les Modèles du Noyau, *review*, 979
Sørensen, Prof. N. A. : The Chemistry of Natural Products (Structural Patterns of Polyacetylenic Compounds isolated from the Plant Family Compositae), 1080
Šorm, Prof. F. : The Chemistry of Natural Products (Terpenic Compounds with Medium-sized Rings), 1080
Sorokin, Helen P., and Thimann, Prof. Kenneth V. : Plastids of the *Avena* Coleoptile 1038
Sorsby, Prof. Arnold, and Harding, Ronald : Protective Effect of Cysteine against Retinal Degeneration induced by Iodate and by Iodoacetate, 608
Sound Transmission : Introduction to the Theory of, with Application to the Ocean (Prof. C. B. Officer), *review* by Dr. A. B. Wood, 539
Sound and Television : Science Broadcasting in (A. B. Oldfield Davies), 850
Sound-producing Fish : Electrophysiological Observations on a (A. Packard), 63
Sounding Experiments (Echo), in the Barents Sea (I. D. Richardson, D. H. Cushing, F. R. Harden Jones, R. J. H. Beverton and R. W. Blacker), 855
Source of Food for Black-Fly Larvae : Bacteria as a (F. J. H. Fredeen), 963
Source of Sodium Chloride : Change of the Chlorine—Sodium Ratio in the Atmosphere with Altitude and Distance from the, and the Distribution of Atmospheric Nitrate over the United States (Dr. Henry M. Papée and Dr. Alberto Montefinale), 1103
Source-Book of Semiconductor Physics, *review* by Prof. G. F. J. Garlick, 885
Souter, L. S. : Awarded a Travel Award for Women Engineers by the Caroline Haslett Memorial Trust, 116
South Africa : Polychaete Fauna of (Prof. J. H. Day), Part 5, 199
South African Animal Life—Results of the Lund University Expedition in 1950-1951, Vol. 6 (edited by Bertil Hanström, Per Brinck and Gustav Rudebeck), *review* by H. Oldroyd, 1063
South African Bantu : The Rh Factor C in (Dr. A. Zoutendyk and Dr. H. Teodorczuk), 790
South African Broadcasting Corporation : Van Riebeeck Lectures, Africa's Place in the Emergence of Civilisation (Prof. Raymond A. Dart), *review* by M. C. Burkitt, 891
South African Museum : *Annals* of the Vol. 45, Part 3, 199
South African University Students : Daily Food Consumption by (Sonia E. Walker), 381
South America : Cosmic Radiation Studies in, 648
South Atlantic : Pelagic Polychaetes of the (N. Tebble), 289
Potassium—Argon Ages of some Rocks from the (John A. Miller), 1019

South Australia Museum : Annual Report for 1958-59, 287
South Indian People : Potassium Tolerance Tests in (Dr. G. Henrotte, G. Krishnamurthi and G. Ranganathan), 328
South Pole : Observations of 'Whistlers' and 'Chorus' at the (Dr. L. H. Martin), 1018
South Wales : Relic-Soil on Limestone in (D. P. Ball), 497
Southern Atmospheric Cyclones and the Whale Feeding Grounds in the Antarctic (Dr. C. W. Beklemishev), 530
Southern Rhodesia : Environment and Culture in (Roger Summers), 993
Southgate, Dr. B. A. : The Metropolitan Water Board, 468
Southward, Dr. A. J. : Marine Biological Reports from Denmark, *review*, 360
Soviet Science in English Catalogue, 1960 (Program for Science Translations, Jerusalem), 832
Soviet Space Science (Ari Shternfeld), translated by the United States Air Force, *review*, 884
Soviet Union : Atomic Energy in the (Arnold Kramish), *review* by Dr. S. C. Curran, 630
Sowby, Dr. F. D., and Taylor, Dr. D. M. : Removal of Internally Deposited Americium by Chelating Agents, 612
Sows : Experiments on the Nutrition of (Dr. G. A. Lodge), 115
Space : Dispersal in, of Small Bodies (Dr. D. O. Wolfenbarger), 1078
Space around the Earth : Geomagnetic Storms and the (Prof. Sydney Chapman), 824
Space (Vector), and its Applications in Crystal-Structure Investigation (Prof. Martin J. Buerger), *review* by Dr. J. W. Jeffery, 975
Space Flight : Proposals for, *review* by D. G. King-Hele, 811
Space Research, *review* by Sir Harold Spencer Jones, 268
  Resources for Atomic Energy and, 1055
Space Research in Britain : Grants for, 744
Space Science : Soviet (Ari Shternfeld), translated by the United States Air Force, *review*, 884
Space Technology (edited by Prof. Howard S. Seifert), *review*, 884
Space Telecommunications : Radio Frequency Control in (Edward Wenk, jun.), 373
Space Travel : Biology of (Institute of Biology Symposium on), 29
  Designing for, *review*, 884
Space, Time and Gravitation : The Theory of (V. Fock), translated from the Russian by N. Kemmer, *review* by Dr. D. W. Sciama, 4
Spacing (Interlayer), in Carbons of Different Graphitic Perfection : Dependence on Temperature of the (E. G. Steward, B. P. Cook and E. A. Kellett), 1015
Spain, David M. : Culture, Society and Health (Study of Coronary Artery Disease), 659
Spärck, Prof. R., and others (edited by) : Galathea Report—Scientific Results of the Danish Deep-Sea Expedition round the World, 1950-52, *review* by Dr. N. B. Marshall, 443
Spaul, Prof. E. A. : Retirement from the chair of zoology in the University of Leeds, 197 ; work of, 197
Speake, G. D. : Appointed deputy chief of research at Marconi's Research and Development Laboratories, 290
Speakman, Prof. J. B (Wolfram, Dr. L. J., and) : Reactivity of the Disulphide Bond in Wool, 595
Special Assistance for Effluent Liaison (British Leather Manufacturers' Research Association), 992
Species : Darwin's Notebooks on Transmutation of (edited by Sir Gavin de Beer), Part 2, 26 ; Part 3, 649 (British Museum (Natural History)).
Species of *Tribolium* : Taxonomic Significance of Spermathecal Structure in some (Gordon Surtees), 1138
Species (Five), of Birds : Variability in Levels of Blood Uric Acid in (Jack W. Hudson and Charles R. Taylor), 788
Species (A New), of Green Sulphur Bacteria (V. V. Shaposhnikov, E. N. Kondratieva and V. D. Federov), 167
Species (Primary), in the Radiolysis of Aqueous Solutions : Effects of *p*H and the Nature of the (J. T. Allan and Dr. G. Scholes), 218
Species (Two), of Elateridae : Pathogenicity of *Metarrhizium anisopliae* (Metch.) Sor. and *Beauveria bassiana* (Bals.) Vuill. to (Dr. R. D. Tinline and R. Y. Zacharuk), 794
Species Level : Evolution above the (Prof. Bernhard Rensch), *review* by C. S. Elton, 446
Specific Inhibitors of the Adrenal Cortex (Prof. J. H. U. Brown), 985
Specificity of Polyglycosidases : Steric Factors affecting the (F. W. Parrish and A. S. Perlin), 1110
'Speckle' (Banana Fruit-spot) caused by *Deightoniella torulosa* (Syd.) Ell. (Dr. D S. Meredith), 961
Spector, W. G. : Anti-Fertility Action of a Monoamine Oxidase Inhibitor, 514
Spectra (Carbon Dioxide Mass) : High-Energy Oxygen Ions in (R. M. S. Hall), 683
Spectra (Electronic Absorption), and Chemical Reactivity with Mercaptalbumin : An Ortho Effect influencing Fungitoxicity, (Dr. H. P. Burchfield and Eleanor E. Storrs), 593
Spectra (Infra-Red), of Amino-Acids and related Substances in Water (Prof. Frank S. Parker and Prof Donald M. Kirschenbaum), 386
Spectra (Ultra-violet Absorption), of the Diazines (Prof. K Keith Innes, James A Merritt, Wayne C. Tincher and Shelby G. Tilford), 500
Spectra (Ultra-Violet Absorption), of the Molecules H_2O, HDO and D_2O (Dr. Jack Barrett and Dr A. L. Mansell), 138 ; (R M. Golding), 139
Spectra (Ultra-violet Absorption), of Proteins in Deuterium Oxide (Dr. Shiro Takashima), 597
Spectral Analysis (Direct Infra-Red), of the Cucumber Mosaic Virus Infection Process (Prof. G. W. Cochran, G. W. Welkie and J. L. Chidester), 1049
Spectral Reflectivity of Ore Minerals (I. Gray and Dr. A. P. Millman), 282
Spectrometric Investigation (Mass), of the Vaporization of Sulphides and the Dissociation Energy of Se (R. Colin, Prof. P. Goldfinger and M. Jeunehomme), 408
Spectrometry (Gamma-Ray) : Non-destructive Analysis of Selenium by Neutron Activation followed by (Dr. Minoru Okada), 594
Spectrometry (Solid-Source Mass), using Negative Ions : Isotopic Analysis of Silicon by (Dr. D. C. Newton, J. Sanders and A. C. Tyrrell), 683
Spectrophotometric Determination (Atomic Absorption), of Molybdenum and Strontium (D. J. David), 1109
Spectroscopy : New Frontiers in Optics and (Pittsburgh Conference and the Optical Society of America Symposium on), 289
Spectroscopy (Applied) : Analytical Chemistry and (Twelfth Pittsburgh Conference on), 289
Spectroscopy (γ-Ray) : Gallium Arsenide for (W. R. Harding, C. Hilsum, M. E. Moncaster, D. C. Northrop and Dr O. Simpson), 405
Spectroscopy (Proton Magnetic Resonance) : Structure Determination with the Help of (Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives), (C. F. Blakely, Dr. R. F. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662
Specular Reflexions : Effect of, on the Radiation Flux from a Heated Tube (Sir K. S. Krishnan), 135
Speed of the Superconducting-Normal Transition in Tin Films (D. J. Oliver, M J. Rayner and E. H. Rhoderick), 492
Spence, Dr. R. : Appointed deputy director of the Atomic Energy Research Establishment, 556
Spencer, Dr. B., and others : Effect of Trypan Blue on Rat Embryos, 605
Spencer, Dr. M., and Worthington, Dr. C. R. : A Hypothesis of Contraction in Striated Muscle, 388
Spenke, Dr. E. : Les Semiconducteurs Électroniques (traduit par L. Godefroy), *review* by Dr. J. R. Tillman, 1058
Spensley, Dr. P. C. : Appointed acting director of the Tropical Products Institute, 117
Spermathecal Structure in some Species of *Tribolium* : Taxonomic Significance of (Gordon Surtees), 1138
Spermatozoa : X and Y (Rt. Hon. Lord Rothschild), 253 ; (Dr. Landrum B. Shettles), 254 ; (Prof. David W Bishop), 255
Spermatozoa (Bull) : Effect of Acridine Orange on Living (C. van Duijn, jun.), 1006
Sphaerocarpos (Liverwort) : Maternal Inheritance and Interspecific Hybrids of the (Dr. William T. Doyle), 429
Spheres (Hard) : Packing of Mixtures of (Prof. Paul C. Mangelsdorf, jun., and Elmer L. Washington), 930
Spikes, Dr. J. D. (Rigby, B. J., and) . Hydroxyproline and the Shrinkage Temperature of Collagen, 150
Spilopsyllus cuniculi Dale (Rabbit Flea) : Breeding of the—Requirement of a 'Factor' from a Pregnant Rabbit for Ovarian Maturation (A. R. Mead-Briggs and A. J. B. Rudge), 1136
Spin Resonance Techniques : Diamagnetic Moment of Gaseous Plasmas measured by (T. C. Marshall, R. A. Kawcyn and Prof. L. Goldstein), 584
Spinal Transmission of Proprioceptive Hind-Limb Reflexes : Velocity of Conduction and (Hind-Limb Reflexes in the Kitten), (Dr. Sten Skoglund), 132
Spinel (Olivine–) Transition on Nickel Orthosilicate (Dr. A. E. Ringwood), 1019
Spiritual Crisis of the Scientific Age (G. D. Yarnold), *review* by R. Brightman, 818
Splachnum ampullaceum (L.) Hedw. : Intracellular Configuration and Dedifferentiation in (Prof. Kraft E. von Maltzahn and Mary M. MacNutt), 344
Spleen : A Polyploidizing Principle in the (L. Bouvier, Prof. R. Rigler and W. Rosenkranz), 965
Spleen Cells (Homologous Adult), injected into New-born Mice : Fate of (A. J. S. Davies and Sheila M. A. Doak), 610
Splitting (Zeeman), of the Hydrogen Line : A New Limit to the Galactic Magnetic Field set by Measurements of the (Dr. R. D. Davies, C. H. Slater, W. L. H. Shuter and P. A. T. Wild), 1088
Spontaneous Fission of Californium-252 : Rare Modes in the (Prof. E. W. Titterton and T. A. Brinkley), 228
Spontaneous Osteogenic Sarcoma : A Transplantable, observed in the Muscle Tissue of an Albino Mouse (R. G. Herne, M. Gregoire and G. Rona), 1129
Spooner, Prof E. T. C. : Appointed dean of the London School of Hygiene and Tropical Medicine, 466
Sporadic E and the Earth's Magnetic Field : Longitude Effect in Temperate Zone (L H. Heisler and Dr. J. D. Whitehead), 676
Spotswood, T. M., and others : Mode of Formation of 3,4-Benzopyrene in Human Environment, 663
Spotting Ketosteroids, *review* by Prof. G. A. D. Haslewood, 183
Spread *F* Echoes at Low Latitudes : Possibility of Detecting Ionospheric Drifts from the Occurrence of (R. W. Knecht), 927
Spread-*F* and *F*-Layer Heights : Equatorial (Dr. A. J. Lyon, Dr. N. J. Skinner and Prof. R. W. Wright), 1086
Sprent, P. : Analysis of Small Experiments, 437
Spurny, Dr. K. (Kubie, Dr G., and) : Radioactive Labelling of Membrane Filters for the Assay of Air-borne Material, 930
Sputnik 3 Satellite : Final Months and Descent of (B. R. May and D. E. Smith), 456
Sputnik 4 Satellite : The Sudden Discontinuity in the Orbital Period of (B. R. May and D. E. Smith), 966
Sputnik 5 Satellite, 830
Squalene : Biosynthesis of, by the Annelid *Lumbricus terrestris* (Joyce M. Wootton and Lemuel D. Wright), 1027
Srivastava, Dr. P. N. : Bacterial Effect and Radiophosphorus Assimilation in Organic and Inorganic Forms in Salmon, 83
St. Mary's Hospital Medical School, London : Appointment of Dr. Richard Creese to the readership in physiology, 743
Stability of the CF_2 Radical : Photochemical Formation and (Dr. J. P. Simons and A. J. Yarwood), 316
Stability of Epidote Minerals (Prof. W. S. Fyfe), 497
Stability and Control of Flight, *review*, 444
Stabilization of Austenite by Hydrogen (E. G. Ramachandran and C. Dasarathy), 684
Stabilization by Manganous Ions of Ribosomes from Embryonic Plant Tissue (Dr J. W. Lyttleton), 1026
Stack-Forsyth, Dr. E. F. : Appointed lecturer in electrical engineering at the University of Birmingham, 465
Stages (Initial), of Oxidation of Coal (S. K. Chakrabartty, B. K. Mazumdar and A. Lahiri), 502
Stainforth, Dr. R M. : The American Oligocene, 678
Staining for Iodine in Chromatograms of Human Plasma—an Artefact due to Thiourea or Thiouracils (A. Dimitriadou, Prof. T. Russell Fraser, Dr. J. D. H. Slater and P. C. R. Turner), 691 ; *erratum*, 1079
Stains (Ageing Blood-) : Use of Reflectance Measurements in assessing the Colour Changes of (Dr. D. Patterson), 688

Stains (Dried Blood-), on Fabrics : Absorption-Elution Grouping of (S. S. Kind), 789
Stamburgo, M., and others : Synergistic Action of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia, *erratum*, 559
Stamp, Dr. J. T. : Tuberculosis in Animals (Comparative Pathology), 996
Stamp, Prof. L. Dudley : Our Developing World, *review* by M. K. Milne, 816
Standard Frequency Transmissions : The International Co-ordination of Time Signals and (Dr. L. Essen), 452
Standardized Internal Sources of Phosphorus-32 : Radiolytic Oxidation of Ferrous Solutions with (Dr. M. Pelsach and J. Steyn), 58
Standards, United States National Bureau of : Monograph No. 14, Bibliography on Molecular and Crystal Structure Models (Deane K. Smith), 903
  Monograph No. 10, The Helium-4 Scale of Temperature (F. C. Brickwedde, H. van Dijk, M. Durieux, J. R. Clement and J. K. Logan), 1077
Standards (Frequency) : A Comparison of Atomic Beam (R. E. Beehler, R. C. Mockler and C. S. Snider), 681
Standing Waves (Electromagnetic), and Ball Lightning (Dr. Lewi Tonks), 1013
Staphylococcal Diseases : Antibiotic Therapy and (edited by Dr. Henry Welch and Prof. Maxwell Finland), *review* by Prof. R. Knox, 637
Staples, Dr Richard C., and Burchfield, Dr. H. P. : Incorporation of Acetate into Protein by Obligately Parasitic and Saprophytic Fungi, 1040
Star-Projector : Operation of a (Science Museum, London), 117
Starch Biosynthesis : Mechanism of (Dr. Marta A. Rongine de Fekete, Dr. Luis F. Leloir and Dr. Carlos E. Cardini), 918
Starch-like Polysaccharide of *Streptococcus pyogenes* (Dr. H. Baum and Dr. N. Crowley), 413
Starch-Gel Electrophoresis of Wheat Proteins (Dr. G. A. H. Elton and J. A. D. Ewart), 600
Stars : Moving Envelopes of (Prof. V. V. Sobolev), translated by Sergei Gaposchkin, *review* by Prof. W. H. McCrea, 538
State : The Child, the Parent and the (Dr. James Bryant Conant), *review* by Brian Holmes, 635
State Government : Science and—a Study of the Scientific Activities of State Government Agencies in Six States (Dr. Frederic N. Cleaveland), *review* by R. Brightman, 181
States (New) : The Public Service in—a Study in some Trained Manpower Problems (Kenneth Younger), 971
Statesman of Science : Francis Bacon, the First (J. G. Crowther), *review* by Prof. B. Farrington, 817
Statically Indeterminate Frameworks : A Historical Note on the Reciprocal Theorem and Theory of (T. M. Charlton), 231
Statics and the Engineer (Sir Alfred Pugsley), 844
Statistical Mechanics (with special reference to Irreversibility), (Institute of Physics and the Physical Society Conference on), 1079
Stauffer, Rachel (Steinberg, Prof. Arthur G., and) : Effect of Heat on the Serum Factors Gm^a, Gm^b, Gm^x and Gm-like, 791
Steam Engine to Satellite : Science as History—the Story of Man's Technological Progress from (Heinz Gartmann), translated from the German by Alan G. Readett, *review* by J. L. Stollery, 8
Steel : Growth of Sulphide Films on (R. B. Campbell, L. Gronberg and H. M. Scott), 588
Steel (Mild) : Correlation of the Alternating Stresses required to Initiate and Propagate a Fatigue Crack in (N. E. Frost), 233
Steel (Niobium) (1 per cent) : A New Phase in a Silicon bearing 17 per cent Chromium, 8 per cent Nickel and (M. J. O'Hara, D. Wilkinson and R. T. Allsop), 407
Steel Castings Research Association (British) : Open Days (Dr. A. H. Sully), 657
  Seventh Annual Report, 658
Steele, L. P. (Bannon, J. K., and) : Average Water Vapour Content of the Air, 748
Steels : Precipitation Processes in—Report of a Conference held in the University of Sheffield, 1958, *review* by Prof. F. C. Thompson, 9
Steim, Joseph M. (Hanig, Martin, and) : Physical Incompleteness of Influenza Virus propagated in De-embryonated Eggs, 40
Stein, Prof. Gabriel, and others : Radiolysis of Highly Enriched Oxygen-18 Water Solutions containing Hydrogen Peroxide-16,16, 57
Stein, Dr. Joseph A., and others : Reversibility of an Inherited Metabolic Block (Inborn Error of Metabolism), 515
Steinberg, Prof. Arthur G., and Stauffer, Rachel : Effect of Heat on the Serum Factors Gm^a, Gm^b, Gm^x and Gm-like, 791
Steinhaus, Edward A., and Smith, Ray F. (edited by) : Annual Review of Entomology, Vol. 5, *review* by Prof. V. B. Wigglesworth, 542
Stellar Motions (Dr. R. v. d. R. Woolley), 841
Stelzner, J. (Vanek, Dr. J., and) : Oscillatory Character of Amplitude Curves for Seismic Body Waves, 491
Stephen, Dr. Karin : The Wish to Fall Ill—a Study of Psychoanalysis and Medicine, *review* by Dr. Clifford Allen, 978
Stephenson, Dr. J. L. : Freezing and Drying of Biological Materials, 749
Stepwise Ablation and Heat Transfer in Cold-Cathode Arcs (Dr. A. von Engel and Dr. K. W. Arnold), 1101
Stereographic Projection : Use of, in Structural Geology (Dr. F. C. Phillips), second edition, *review* by John Sutton, 729
Steric Factors affecting the Specificity of Polyglycosidases (F. W. Parrish and A. S. Perlin), 1110
Sterilization of Pharmaceutical Products : Use of Gamma-Radiation Sources for the (Report of the Association of the British Pharmaceutical Industry), 903
Stern, Dr. Curt : Mechanisms of Meiotic Non-disjunction in Man, 805
Stern, P. A. (Oppenheim, A. K., and) : Combustion and Propulsion—High Mach Number Air-breathing Engines (Applicability of Detonation Wave Studies to Hypersonic Combustion), 21
Sternling, C. V. (Scriven, L. E., and) : The Marangoni Effects, 186
Steroid Chemistry : Recent Advances in (Kingston Technical College Postgraduate Course on), 905
Steroid 11β-ol Dehydrogenase in Human Placenta (Dr. P. A. Osinski), 777
Steroids : Microanalytical Separation of, by Gas Chromatography (C. C. Sweeley and Dr. E. C. Horning), 144
Stevenson, D. E. (Hall, L. W., and) : Effects of Ataractic Drugs on the Blood-Pressure and Heart-Rate of Dogs, 696
Steward, E. G., and others : Dependence on Temperature of the Interlayer Spacing in Carbons of Different Graphitic Perfection, 1015
Steward, F. C. : Plant Physiology, Vol. 2, Plants in relation to Water and Solutes, *review* by Prof. Walter Stiles, 889
Stewardson, Prof. E. A. : Grant of £13,006 for Space Research (for investigations of solar and stellar soft X-Ray emissions), 744
Stewart, C. M., and Higgins, H. G. : Carbohydrates of *Ecklonia radiata*, 511
Stewart, C. P. (edited by Harry Sobotka, and) : Advances in Clinical Chemistry, Vol. 2, *review* by Dr. R. Consden, 890
Stewart, Doreen L. (Brown, F., and) : Infective Ribonucleic Acid from the Viruses of Talfan and Teschen Diseases, 714
Stewart, John S. S. : Mechanisms of Meiotic Non-disjunction in Man, 804
Steyn, J. (Peisach, Dr. M., and) : Radiolytic Oxidation of Ferrous Solutions with Standardized Internal Sources of Phosphorus-32, 58
Stilboestrol applied to the Wheat Seedling : Plant Hormone Activity—(Dr. J. J. C. Hinton and Dr. T. Moran), 258
Stiles, Prof. Walter : Aspects of Plant Nutrition, *review*, 815
  A New Treatise on Plant Physiology, *review*, 889
Stimulated Optical Radiation in Ruby (Dr. T. H. Maiman), 493
Stimulus (Physiological) : Summative Action of Acetylcholine with, on the Generator Potential in the Lateral Eye of the Horseshoe Crab (R. Kikuchi, K. Naito and S. Minagawa), 1118
Stobo, I. J. F. : Awarded a Wellcome Fellowship by the Animal Health Trust, 904
Stochastic Path Integrals : A Remark on (Prof. M. S. Bartlett), 968
Stockholm Cyclotron : Modernization of the, 381
Stoll, Prof. A. : The Chemistry of Natural Products (Impact of Studies of Natural Products on Chemical Industry), 1080
Stollery, J. L. : History of Engineering Invention, *review*, 8
Stommel, Dr. Henry : The Gulf Stream—a Physical and Dynamical Description, *review* by Dr. G. E. R. Deacon, 183
Stone, N. W. B., and others : Pure Rotational Absorption of Ozone in the Region 125-500 Microns, 765
Stone Age in Northern Africa (Dr. C. B. M. McBurney), *review* by M. C. Burkitt, 1062
Storms (Geomagnetic), and the Space around the Earth (Prof. Sydney Chapman), 824
Storrs, Eleanor E. (Burchfield, Dr. H. P., and) : An Ortho Effect influencing Fungitoxicity, Electronic Absorption Spectra, and Chemical Reactivity with Mercaptalbumin, 593
Story of Chemical Industry in Basle (published by Ciba Limited on the occasion of its 75th Anniversary), *review* by Dr. L. K. Sharp, 540
Strachey, C. : At the second Annual Conference of the British Computer Society (A Common Computer Language), 655
Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture : Production of Lysergic Acid Derivatives by a (F. Arcamone, C. Bonino, Prof. E. B. Chain, A. Ferretti, P. Pennella, A. Tonolo and Lidia Vero), 238
Strain Differences in Acetylcholine Concentration in the Brain of the Rat (Edward L. Bennett, James Crossland, David Krech and Mark R. Rosenzweig), 787
Straining (Tensile) : Behaviour of Paper during (A. E. Ranger and L. F. Hopkins), 1097
Strains of Enteric Bacilli : Effect of the Peritoneal Fluid of the Guinea Pig on (Prof. R. J. Roantree and L. R. Collis), 1045
Strange, R. E. : Glucosamine Values of Muramic Acid and other Amino-Sugars by the Elson and Morgan Method, 38
Straus, Herbert L. : Awarded a United States fellowship by the Ramsay Memorial Fellowship Trustees, 832
Strawberry : Effect of Autumn Applications of Potassium Gibberellate on Fruit Production of the (Prof. Carter R. Smith), 620
Streak (Virus-) Disease of Tomatoes (B. H. MacNeill and Hikmet Ismen), 903
Stream : The Gulf—a Physical and Dynamical Description (Dr. Henry Stommel), *review* by Dr. G. E. R. Deacon, 183
Streaming in Cytoplasm dissociated from the Giant Amoeba, *Chaos chaos* (Prof. R. D. Allen, J. W. Cooledge and P. J. Hall), 896
Street, Sir Kenneth : The Chemistry of Natural Products, 1081
Strength of Solids (Prof. A. H. Cottrell), 659
Strength (Bond-) (Cement-Aggregate) : Dependence of, on Size of Aggregate (K. M. Alexander and J. Wardlaw), 230
Strength (Ionic), of the Medium : Influence of the, on the Anaphylactic Sensitization of Isolated Tissues *in vitro* (R. Binaghi, M. Liacopoulos-Briot, Dr. B. N. Halpern and P. Liacopoulos), 697
Strengths of Acid-etched Glass Rods (B. A. Proctor), 492
Streptococci (Nephritogenic) : Immunological Relationships between the Rat Glomerulus and (A. S. Markowitz, S. Howard Armstrong, Jun., and Daniel S. Kushner), 1095
Streptococcus pyogenes : Starch-like Polysaccharide of (Dr. H. Baum and Dr. N. Crowley), 413
Streptomyces : An Antibiotic Complex derived from a, and Active against Gram-positive Bacteria (B. Sgarzi, A. M. Lugli and G. Gioiitti), 1029
Streptomycin : Absence of Carbon Monoxide-sensitive Respiration in a Streptomycin-dependent Mutant of *Escherichia coli* grown in Limited Amount of (Hanna Engelberg and Dr. M. Artman), 801
Streptomycin-dependent Mutant of *Escherichia coli* grown in Limited Amount of Streptomycin : Absence of Carbon Monoxide-sensitive Respiration in a (Hanna Engelberg and Dr. M. Artman), 801
Streptomycin-resistant Mutants of *Bacillus subtilis* : Appearance of New Deficient Characters in (Masamichi Kohiyama and Yonosuke Ikeda), 168
Stress (Yield), exerted on a Body Immersed in a Bingham Fluid (G. Boardman and Dr. R. L. Whitmore), 50
Stress-Dependent Magnetization in some Quartz-Dolerites (Dr. D. W. Powell), 225
Stress Studies (Psychomotor), with Sub-normal Psychopathic Subjects : Preliminary (Dr. J. E. Tong, I. C. Murphy and F. R. Adams), 172
Stresses (Alternating), required to Initiate and Propagate a Fatigue Crack in Mild Steel : Correlation of the (N. E. Frost), 233
Stretch, R. G. A. : Appointed lecturer in psychology at the Queen's University, Belfast, 465
Striated Muscle : A Hypothesis of Contraction in (Dr. M. Spencer and Dr. C. R. Worthington), 388
Striga : Insects attacking (D. V. Murthy), 959
Stringer, Ivor S. (Schnurmann, Dr. Robert, and) : Initiation of Chemical Reactions by Mechanical Forces, 587
Strmiska, Dr. Jaroslav, and Vacek, Dr. Antonin : Effect of Electronarcosis on Oxygen Consumption and Carbon Dioxide Output, 151

Strontium : Atomic Absorption Spectrophotometric Determination of Molybdenum and (D. J. David), 1109
Strontium (Radioactive and Natural), in Human Bone (J. W. Arden, F. J. Bryant, E. H. Henderson, G. D. Lloyd and A. G. Morton), 994
Strontium-89 and Strontium-90 : The Deposition of, on Agricultural Land and their Entry into Milk after the Reactor Accident at Windscale in October 1957 (United Kingdom Atomic Energy Authority and the Agricultural Research Council joint Report on), 1077
Strontium-90 Compounds in Soil : Relative Availability of some (Dr. R. L. Uhler and Dr. P. P. Hungate), 252
Structural Geology : The Use of Stereographic Projection in (Dr. F. C. Phillips), second edition, *review* by John Sutton, 729
Structure of β-Acylacrylic Acids (Prof. Nils Hellstrom), 146, *erratum*, 650
Structure of the 1:1-Adducts of Cupric β-Diketone Chelates with Heterocyclic Bases (Dr. D. P. Graddon and E. C. Watton), 1021
Structure of the Antibiotics *PA1148-1* and *PA1148-3* (D. C. Hobbs and W. D. Celmer), 598
Structure of $AgSCN.P(n\text{-}C_4H_9)_3$ (Dr. A. Turco, C. Panattoni and E. Frasson), 772
Structure of the Trinuclear Basic Acetates (Dr. L. E. Orgel), 504
Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy (Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives), (C. P. Blakely, Dr R. J. Gillespie, L. Roubinek, Dr. A. Wassermann and R. F. M. White), 662
Structure (Crystal), of 9:10-Dimethyl-1:2-benzanthracene (Dr D. Sayre and Dr P. H. Friedlander), 139
Structure (Crystal) Determination : Modern Methods of (Manchester College of Science and Technology Summer School in), 201
Structure (Crystal-) Investigation : Vector Space and its Application in (Prof. Martin J. Buerger), *review* by Dr. J. W. Jeffery, 975
Structure (Crystal) Models : Bibliography on Molecular and (Deane K. Smith), (United States National Bureau of Standards, Monograph No. 14), 903
Structure (Domain or Turbostratic), of Clays (L. A. G. Aylmore and Dr. J. P. Quirk), 1046
Structure (Hexagonal) : Work-Hardening and Ductility of Rhenium and their relation to the Behaviours of other Metals having a (R. A. Jeffery and E. Smith), 52
Structure (Laminated), of Bones from some Marine Mammals (Dr. R. M. Laws), 338
Structure (Molecular) : The Determination of (P. J. Wheatley), *review* by Dr. J. W. Cook, 812
Structure (Non-Crystalline), in Solidified Gold—Silicon Alloys (W. Klement, jun., R. H. Willens and Prof. Pol Duwez), 869
Structure (Nuclear) : International Conference on, 290
Structure (Social) : Religion and, *review* by Michael Argyle, 96
Structure (Spermathecal), in some Species of *Tribolium* : Taxonomic Significance of (Gordon Surtees), 1138
Structure and Function : Biological (International Union of Biochemistry and the International Union of Biological Sciences Symposium on), 905
Structure, Synthesis and Function of Deoxyribonucleic Acid (Société de Chimie Physique Meeting on), 1079
Structure and Systematic Position of the Australian Brown Alga, *Notheia anomala* (M. Nizamuddin and Dr H. B. S. Womersley), 673
Structures : Valence-Bond—a New Proposal (Dr. J. W. Linnett), 859
Structures of some Acetyl-serine Peptides from Acetyl-chymotrypsin (Leo Benoiton, Prof. H. N. Rydon, R. A. Oosterbaan, M. E. Van Adrichem and Prof. J. A. Cohen), 596
Structures (Auroral) : Theory of (E. R. Harrison), 383
Structures (Coral), and Classification, *review* by Dr. H. Dighton Thomas, 95
Structures (Crystal), of the High-Pressure Forms of Ice—Ice III (Prof. W. Barclay Kamb and Sankar K. Datta), 140
Structures (Layer) : Dislocations in (V. A. Phillips and P. Cannon), 313
Stubblefield, Dr. C. J. : Nomenclature of the Keuper Series, 869
Students entering Training Colleges : Recruits to Teaching—a Study of the Attainments, Qualifications and Attitudes of (F. W. Land), 750
Students (University) : Daily Food Consumption by South African (Sonia E. Walker), 381
Studentship (Mackinnon Research) awarded by the Royal Society to Dr. D. T. Edmonds, 291
Studentship and Scholarship Awards for 1960 (Royal Commission for the Exhibition of 1851), 116
Studentships (Research), for postgraduate training in Ecology (Nature Conservancy Awards for 1960), 742
Studies : Earthworm Population—a Comparison of Sampling Methods (F. Raw), 257
Studies in the History of Education, 1780-1870 (Brian Simon), *review* by Dr. James L. Henderson, 357
Studies in Marine Physics, *review* by Dr. G. E. R. Deacon, 183
Studies (Case) : Research in, 659
  Research Necessary for the Preparation and Use of (South London Committee of the British Institute of Management Conference on), 660
Studies (Cosmic Radiation), in South America, 648
Studies (Immunoelectrophoretic), on Purified Human Growth Hormone (Dr. Jan Hirschfeld, Carl-Axel Gemzell and Leif Wide), 64
Studies (Psychomotor Stress), with Subnormal Psychopathic Subjects : Preliminary (Dr. J. E. Tong, I. C. Murphy and F. R. Adams), 172
Studies (Renal), in Sheep : Use of Diodone in (B. J. Potter), 698
Studies (Sociological), at the University of Sheffield, 463
Studies (Upper-Atmosphere Wind), by *Skylark* Rocket Sodium Experiment (Dr. G. V. Groves), 1001
Study : Scientific Research and Development—a Comparative (S. Dedijer), 458
Study sponsored by the Nuffield Foundation : Principles for British Agricultural Policy—a (edited by H. T. Williams), *review* by Sir John Russell, 721
Study of the Attainments, Qualifications and Attitudes of Students entering Training Colleges : Recruits to Teaching—a (F. W. Land), 750
Study of Development and Growth, Society for the : Seventeenth Symposium—Cell, Organism and Milieu (edited by Prof. Dorothea Rudnick), *review* by Dr. E. N. Willmer, 450
Study of Eighteenth-Century Science : The Transits of Venus—a (Prof. Harry Woolf), *review* by Dr. David S. Evans, 636
Study of the Epidermal Cell in an Insect : The Control of Growth and Form—a (Prof. V. B. Wigglesworth), *review* by Prof. R. Dennell, 631
Study of Man, Research Institute for the (Division of Anthropology of the New York Academy of Sciences and the) : Conference on Culture, Society and Health, 658
Study of Non-Linear Problems, *review* by K. Krickeberg, 727
Study of Psychoanalysis and Medicine : The Wish to Fall Ill—a (Dr Karin Stephen), *review* by Dr Clifford Allen, 978
Study of Sanity and Madness : The Divided Self—a (Dr. R. D. Laing), *review* by Dr. Clifford Allen, 1062
Study in some Trained Manpower Problems : The Public Service in New States—a (Kenneth Younger), 971
Study (A Clinical and Genetico-Statistical), of Schizophrenia and Low-Grade Mental Deficiency in a Large Swedish Rural Population (Bertil Hallgren and Torsten Sjogren), 298
Study (A New), of the British Odonata, *review* by Dr D. E. Kimmins, 631
Study (Potentiometric), of Priming Paints for Metal (Dr. N. R. Bharucha), 756
Studying Tumour Blood Supply using Lissamine Green : A Rapid Method for (L. N. Owen), 795
Sturtevant, Dr F. M. : Electro-shock Seizure Threshold of Metacorticoid Hypertensive Rats, 874
Subjects (Normal and Leukaemic) : Zinc Content of Erythrocytes and Leucocytes of Blood of (E. Dennes, R. Tupper and Prof. A. Wormall), 302
Submarine *Severyanka* : Oceanographic and Fisheries Research by the (V. P. Zaitsev), 559
Submarine Geology, *review* by Dr. G. E. R. Deacon, 629
Submarine Oil Drilling (M. K. Kalinko), 903
Submerged Culture : Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in (F. Arcamone, C. Bonino, Prof. E. B. Chain, A. Ferretti, P. Pennella, A. Tonolo and Lidia Vero), 238
Subnormal Psychopathic Subjects : Preliminary Psychomotor Stress Studies with (Dr. J. E. Tong, I. C. Murphy and F. R. Adams), 172
Substance from Erythocytes of Blood Group A (J. Koscielak and K. Zakrzewska), 516
Substance (Pharmacologically Active) : An Unidentified, extracted from Cerebral Hemispheres (P. F. L. Andrews, Shirley A. P. Price and Dr. G. B. West), 420
Substances in Water : Infra-Red Spectra of Amino-Acids and related (Prof. Frank S. Parker and Prof. Donald M. Kirschenbaum), 386
Sub-Units of Tobacco Mosaic Virus Protein : A Difference between the (Dr H. G. Aach), 75
Successful Biological Control of Insect Pests : Significance of the Type of Host Plant Crop in (D. C. Lloyd), 430
Succinate Oxidation in Uncoupled Rat Liver Mitochondria : A High-Energy Phosphate Requirement for (Dr. Giovanni Felice Azzone and Dr. Lars Ernster), 65
Sucrose : Biosynthesis of, by Preparations from Potatoes stored in the Cold and at Room Temperature (Dr. Sigmund Schwimmer and Edward S. Rorem), 1113
Sucrose in the Rat's Ventricle : Effect of Nitrate Ion on the Distribution of (S. T. Takata, C. G. Alexander and Prof. G. A. Feigen), 419
Suction Traps (Insect) : Vent-Axia, 559
Sudden Discontinuity in the Orbital Period of *Sputnik* 4 Satellite (B. R. May and D. E. Smith), 866
Sugar Analysis, International Commission for Uniform Methods of—Report of the Proceedings of the Twelfth Session, Washington, D.C., 1958, *review* by Prof. E. L. Hirst, 9
Sugar Refining Co. (Colonial) : The David North Plant Research Centre (K. T. Glasson), 745
Sugar Research Laboratory to be established by the Australian Commonwealth Scientific and Industrial Research Organization, 372
Sugar Technology : Principles of (edited by Pieter Honig), Vol. 2, Crystallization, *review* by H. C. S. de Whalley, 979
Sugars : Ferricyanide Reduction Method for Reducing (Dr. Richard I. Mateles), 241
Sugars (Amino-) : Glucosamine Values of Muramic Acid and other, by the Elson and Morgan Method (R. E. Strange), 38
Suggested Effect on Levels of Catecholamine in Brain produced by Small Doses of Reserpine (F. Barbara Orlans and Dr. Bernard B. Brodie), 1034 ; (Herbert Sheppard and Joseph H. Zimmerman), 1035
Sugino, N., and others : Effect of Anti-Diuretic Hormone and Calcium on the Equivalent Pore Radius of Kidney Slices from *Necturus*, 699
Suicide, a Neglected Problem, 207
Sully, Dr. A. H. : The British Steel Castings Research Association—Open Days, 657
Sulphide Films on Steel : Growth of (R. B. Campbell, L. Grunberg and H. M. Scott), 588
Sulphide Phase in some Iron Meteorites (Dr. H. J. Axon), 406
Sulphides : Mass Spectrometric Investigation of the Vaporization of, and the Dissociation Energy of S_2 (R. Colin, Prof. P. Goldfinger and M. Jeunehomme), 408
S_2 : Mass Spectrometric Investigation of the Vaporization of Sulphides and the Dissociation Energy of (R. Colin, Prof. P. Goldfinger and M. Jeunehomme), 408
Sulphur (Tetra-substituted) : Optically Active Forms of a Derivative of (M. Baresh), 591
Sulphur Bacteria (Green) : A New Species of (V. V. Shaposhnikov, E. N. Kondratieva and V. D. Federov), 167
Summative Action of Acetylcholine with Physiological Stimulus on the Generator Potential in the Lateral Eye of the Horseshoe Crab (R. Kikuchi, K. Naito and S. Minagawa), 1118
Summer Course (International), on Solid State Physics (Società Italiana di Fisica), 201
Summer School in Modern Methods of Crystal Structure Determination (Manchester College of Science and Technology), 201
Summer School (Non-residential), on Numerical Analysis (Delegacy for Extra-Mural Studies, University of Oxford), 374
Summers, Roger : Environment and Culture in Southern Rhodesia, 993
Superconducting-Normal Transition in Tin Films : Speed of the (D. J. Oliver, M. J. Rayner and E. H. Rhoderick), 492
Super-Exchange (Covalent), in Solid State Physics (Prof. W. S. Fyfe and Prof. J. Verhoogen), 1108

Supervision (Direction and), of Scientific and Engineering Personnel (Northampton College of Advanced Technology, London, Advanced Course on), 905
Support for Under-developed Countries, 971
Suppression of Cytoplasmic Division in *Amoeba proteus* (Dr. Edmund Guttes and Sophie Guttes), 520
Surface Contamination formed in Demountable Vacuum Systems : Direct Observation of (D. E. Bradley), 227
Surface Density of Charge : Effect of, on the Physical Swelling of Lithium Montmorillonite (Dr J. P. Quirk and B. K. G. Theng), 967
Surface Sea Water off the California Coast (1959-60) : Fall-out Caesium in, by Gamma-Ray Measurements (Dr. Theodore R. Folsom, Dr. G. J. Mohanrao and Perrin Winchell), 480
Surface-active Agents : Treatment of *Leishmania donovani* Infections with (Dr. J. D. Fulton), 1129
Surface-active Compounds : Action of some, on the Gastro-intestinal Mucosa (Dr. J. A. Nissim), 305
Surfaces (Metal) : Simultaneous Measurement of Adsorption and Electrode-kinetic Parameters at (A. M. Peers), 503 ; (Dr. E. A. Blomgren and Dr. J. O'M. Bockris), 504
Surgeons of England, Royal College of : New Laboratory Building, 118
Surgeons of England, Royal College of, and others : First British Congress on the History of Medicine and Pharmacy, 374
Surtees, Gordon : Taxonomic Significance of Spermathecal Structure in some Species of *Tribolium*, 1138
Survival of Woody Plants at Extremely Low Temperatures (Johnson Parker), 1133 ; (Dr. Akira Sakai), 1134
Sustained Action of Injected Chelating Agents (Dr. A. Lindenbaum and Dr. J. Schubert), 575
Sutcliffe, D. W. : Osmotic Regulation in the Larvae of some Euryhaline Diptera, 331
Sutherland, Dr. I. O. : Appointed lecturer in organic chemistry at the University of Bristol, 465
Sutherland, Prof. Robert L. : Engineering Systems Analysis, *review* by Prof. J. Greig, 359
Suto, Mitsumasa, and others : Silkworm Raising on Artificial Food, 669
Sutton, Sir Graham (edited by) : The World Around Us, *review* by G. R. Noakes, 975
Sutton, John : The Use of Stereographic Projection in Structural Geology, *review*, 729
Suzuki, Keoshi, and Iwama, Yukiko : Recovery in the Presence of Chloramphenicol of *Escherichia coli* B (H) Irradiated with Ultra-violet Light, 347
Suzuki, Takeo, and others : Xylan of Siphonaceous Green Algae, 82
Svestka, Z., and others : Measurement of Magnetic Fields in Chromospheric Flares, 224
Swain, A., and others : Recapture in the River Tweed of a Sea-Trout marked in Devonshire, 877
Swamps (Papyrus) : Experimental Breeding of *Anopheles gambiae* Giles in (L. K. H. Goma), 1137
Swan, Dr. P. : Distorted Wave Approximation for Scattering Phase-Shifts, 585
Swedish Academy of Engineering Sciences (Royal), and the Swedish Association of Technical Physicists : Fifth International Instruments and Measurements Conference and Exhibition, 374
Swedish Association of Technical Physicists (Royal Swedish Academy of Engineering Sciences and the) : Fifth International Instruments and Measurements Conference and Exhibition, 374
Swedish National Committee for Physics : Tenth General Physics Conference, 557
Swedish Rural Population : A Clinical and Genetico-Statistical Study of Schizophrenia and Low-Grade Mental Deficiency in a Large (Bertil Hallgren and Torsten Sjogren), 298
Swedish Soils : Content of Caesium-137 and (Zirconium+Niobium)-95 in (Kerstin Löw and K. Edvarson), 736
Swedish Supplement to Elsevier's Dictionary of Electronics and Waveguides (W. E. Clason), *review* by Dr. R. L. Smith-Rose, 1059
Sweeley, C. C., and Horning, Dr. E. C. : Microanalytical Separation of Steroids by Gas Chromatography, 144
Swelling (Macroscopic), of Vermiculite Crystals in Water (G. F. Walker), 312
Swelling (Physical), of Lithium Montmorillonite : Effect of Surface Density of Charge on the (Dr. J. P. Quirk and B. K. G. Theng), 967
Swift, D. R. : An Improved Feed for Experimental Fish, 1133
Swinbank, Dr. P. : Appointed a lecturer in physics in the University of Birmingham, 465
Swinburne Medal of the Plastics Institute awarded to Prof. G. Gee, 740
Swinnerton, Prof. H. H. : Fossils, *review* by Prof. S. Simpson, 271
Swinton, Dr. W. E. : Presidential Address at the sixty-sixth Annual Conference of the Museums Association, 657
Sykes, G. : Elected president of the Society for Applied Bacteriology, 904
Sykes, J. (Dagley, Dr. S., and) : Cytoplasmic Particles and their Role in Protein Synthesis (One Effect of Chloramphenicol on Micro-organisms is to inhibit Protein Synthesis), 644
Symbolic Logic and its Applications : Introduction to (Rudolf Carnap), translated by William H. Meyer and John Wilkinson, *review* by F. I. G. Rawlins, 729
Symes, R J. : Évacuation et Récupération de la Chaleur des Réacteurs Nucléaires, *review*, 636
Symmetrical ? : Are the Laws of Nature (Prof. O. R. Frisch), 638
Symmetrical Fourfold Helical Fracture in Titanium Oxide (J. S. Jackson), 1104
Symons, Dr. M. C. R. : Appointed to the new chair of physical chemistry in the University of Leicester, 743
Synergetic Action of 2(*o*-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia (Dr. E. Fischer, J. L. J. Szabó and M. Stamburgo), *erratum*, 559
Synergism of Bivalent Metal Ions in Transphosphorylation (Dr. John M. Lowenstein), 570
Syntheses of Glucose, Cellobiose and other Saccharides by *Acetobacter acetigenum* in a Lactate-buffered Glycerol Medium (Dr. C. P. Jackson and K. Ramamurti), 942
Synthesis of Adenosine Diphosphate by the Oxidation of Quinol Phosphates : Oxidative Phosphorylation— (Dr. V. M. Clark, D. W. Hutchinson and Sir Alexander Todd), 59
Synthesis of Cyclic Ethers : A New Method for the (L. F. Schmoyer and L. C. Case), 592
Synthesis of Deoxyribonucleic Acid in Mouse Ascites Cells : Uptake of Thymidine and (Dr. A. R. Crathorn and Dr. K. V. Shooter), 614
Synthesis of Diphosphopyridine Nucleotide in Irradiated Rats (Dr. D. K. Myers), 1124
Synthesis (Enzymatic), of Formylglutamic Acid by a Plant Protein (Ernest H. Byers, jun., and T. J. Bond), 416
Synthesis (Homogeneous), of Isotactic Polystyrene using *n*-Butyllithium Initiator (Dr. R. J. Kern), 410
Synthesis (Laboratory) : Aluminium Interlayers in Clay Minerals, Montmorillonite and Vermiculite— (B. L. Sawhney), 261
Synthesis (Microbial), of Protein in relation to the Biogenesis of Nucleic Acids with *Azotobacter vinelandii* as the Test Organism (Maharani Chakravorty), 239
Synthesis (Optimal Protein), by Ascites Tumour Cells *in vitro* (Dr. M. J. Fraser), 1114
Synthesis (Protein) : Cytoplasmic Particles and their Role in (Colloid and Biophysics Committee of the Faraday Society Informal Discussion on), 643
Synthesis (Pterin), in the Amphibian Neural Crest Cell (Tadeo Hama and Masataka Obika), 326
Synthesis and Biological Properties of L-Arginyl-L-Prolyl-L-Prolyl-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenylalanyl-L-Arginine, an Octapeptide related to Bradykinin (E. D. Nicolaides, H. A. DeWald, Patricia G. Shorley and Dr. H. O. J. Collier), 773
Synthesis and Function of Deoxyribonucleic Acid : Structure, (Société de Chimie Physique Meeting on), 1079
Syrian Hamster : Occurrence of a Brown Mutation in the (Roy Robinson), 170
System : The Silicon–Boron (Prof. Cyrill Brosset and Bengt Magnusson), 54
System (Cambrian) : Age of the (Prof. C. F. Davidson), 1020
System (The Decimal), in Britain, 30
System (Metric) : Decimal Coinage and the—Should Britain Change ? (A joint Report of Committees appointed by the British Association for the Advancement of Science and the Association of British Chambers of Commerce), 30
System (Neurosecretory Hypothalamic) : Antigonadotropic Function of the Pineal Gland and the Oxytocin of the (Prof. S.-M. Milcou and S. Pavel), 950
System (Pituitary Portal), in Elasmobranchs : Presence of a (Patrick Meurling), 336
System (Reticulo-Endothelial) : Depressing Activity of Meprobamate on the (Prof. A. Del Vecchio and L. Bolis), 513
  Effect of some Aromatic Hydroxy Compounds on the Phagocytic Activity of the (Prof. T. Nicol, C. Druce and C. C. Ware), 422
  Effect of Three Compounds related to Diethylstilboestrol on the Phagocytic Activity of the (Prof. T. Nicol, G. Brownlee, C. Druce and C. C. Ware), 1032
System (Solar) : The Exploration of the (Felix Godwin), *review* by D. G. King-Hele, 811
  Origin of the (Dr. M. M. Woolfson), 47 ; (M. H. Briggs), 1102
System (A Vacuolar), in Cells of *Agrobacterium tumefaciens* as shown by Electron Microscopy of Ultra-thin Sections (Miguel Rubio-Huertos and Paul R. Desjardins), 1043
Systema Helminthum (Prof. Satyu Yamaguti), Vol. 2, The Cestodes of Vertebrates, *review* by Dr. Ben Dawes, 723
Systematic Position of the Australian Brown Alga, *Notheia anomala* : Structure and (M. Nizamuddin and Dr. H. B. S. Womersley), 673
Systematics (Microbial) : Discussion on, 190
Systems : Aspheric Imaging (Dr. C. R. Burch), 854
Systems (Interference), in Virus-infected Plants : Possible Occurrence of (A. D. Thomson), 761
Systems (Liquid) : Equations for Determining Diffusion Coefficients in, by the Diaphragm-Cell Technique (F. A. L. Dullien and Prof. L. W. Shemilt), 767
Systems (Mixed Solvent) : Activity of Bovine Pancreatic Ribonuclease A in (Dorothy Findlay, Dr. A. P. Mathias and Dr. B. R. Rabin), 601
Systems (Non-Static) : Astrophysics of, *review* by Prof. W. H. McCrea, 538
Systems (Pastoral), in relation to World Food Supplies (Dr. William Davies), 849
Systems (Plant Growth) : Ethionine and (R. L. Lowther and W. G. Boll), 832
Systems Analysis : Engineering (Prof. Robert L. Sutherland), *review* by Prof. J. Greig, 359
Systems (Demountable Vacuum) : Direct Observation of Surface Contamination formed in (D. E. Bradley), 227
Systems (Living) : Self-Regulation in (Ottawa Symposium on), 3, Tremor, 297
Szabó, J. L. J., and others : Synergetic Action of 2(*o*-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia, *erratum*, 559
Szaley, K., and others : Damage to Liver induced by DL-Methionine-Ethylester, 421
Székely, Dr. J., and others : Role of Mucoid Substances of the Aorta in the Deposition of Lipids, 152

TABLES of Constants and Numerical Data, Vol. 11, Selected Constants—Optical Rotatory Power, 4, Alkaloids (Prof. J.-P. Mathieu and Prof. M.-M. Janot), *review* by Dr. J. Walker, 7
Tabor, Dr. (Golding, E. W., and) : Problems of the Arid Zones (Local Energy Sources), 295
Tait, Dr. P. J. T. : General fellowship renewed by the Ramsay Memorial Fellowship Trustees, 832
Takahashi, Tamon, and others : Electrophoretic Separation of certain *in vitro* and *in vivo* Reactions of Rabbit Anti-Mouse Erythrocyte Serum, 157
Takashima, Dr. Shiro : Ultra-violet Absorption Spectra of Proteins in Deuterium Oxide, 597
Taketa, S. T., and others . Effect of Nitrate Ion on the Distribution of Sucrose in the Rat's Ventricle, 419
Talfan and Teschen Diseases : Infective Ribonucleic Acid from the Viruses of (F. Brown and Doreen L. Stewart), 714
Tanaka, Katuhide, and Nakajo, Prof. Seichi : Oxytocin in the Neurohypophysis of the Laying Hen, 245

Tang, C. E. Spaans-v d (Clarenburg, Dr. L. A., and) : Small-Scale Turbulent Diffusion in the Atmosphere, 586
Tannages : Types of (The Chemistry and Technology of Leather, edited by Fred O'Flaherty, William T. Roddy and Robert M Lollar, Vol. 2), *review* by Prof A. G. Ward, 724
Tanner, Dr. J. A : Self-Regulation in Living Systems (Tremor—Measuring the Impedance of the Wrist and Finger Extremities when subjected to Sinusoidal or Stochastic Vibrations), 298
Tantalum and Niobium (Dr. G L. Miller), *review* by Prof. A. G. Quarrell, 725
Tartaric Acid (Total and *l*(+)), Inhibited Rat Serum Acid Phosphatase (Dr. Z. Laron and B. Epstein Halberstadt), 67
Tartronic Acid Inhibition of Aerobic Glycolysis in Yoshida Ascites Hepatoma by (Dr. L. Fiume), 792
Tashkent : Botanical Garden in (F. N. Rusanov), 902
Taste Preference in the Monkey : Effects of Medial Temporal Lesions on (Dr. L. Weiskrantz), 879
'Tasters' and 'Non-Tasters' of 6-*n*-Propylthiouracil : Differential Reactivity of Saliva from (Frances Griffin and Prof Roland Fischer), 417
Tata, Dr. J. R. : Transiodination of Proteins during Enzymic De-iodination of Thyroxine, 1025
Taxonomic Significance of Spermathecal Structure in some Species of *Tribolium* (Gordon Surtees), 1138
Taylor, Dr. A C : Freezing and Drying of Biological Materials, 749
Taylor, Dr. Angela E. R. Awarded a Wellcome Research Fellowship, to enable her to undertake research on the metabolic requirements of helminths, using radioactive tracers, in the Department of Biology at Queen Elizabeth College, London, 201
Taylor, Charles R. (Hudson, Jack W., and) : Variability in Levels of Blood Uric Acid in Five Species of Birds, 788
Taylor, Dr. D. M (Sowby, Dr F. D., and) . Removal of Internally Deposited Americium by Chelating Agents, 612
Taylor, E. Windle . Metropolitan Water Board—Thirty-eighth Report on the Results of the Bacteriological, Chemical and Biological Examination of the London Waters for the Years 1957-1958, 468
Taylor, Dr. James : Chemistry is Not Enough (Presidential Address to Section B (Chemistry) of the British Association for the Advancement of Science), 841
Taylor, Dr. J. D., and others : New Inhibitor of Monoamine Oxidase, 941
Taylor, M. D. : Awarded a CJB Scholarship, 650
Taylor, R. B : Awarded a Wellcome Fellowship by the Animal Health Trust, 904
Taylor, Dr. Richard M., and Winbury, Martin M. . A Potent New Benzothiadiazine Diuretic, 603
Taylor, Prof S. A. (Slatyer, Dr. R. O., and) : Terminology in Plant- and Soil- Water Relations, 922
Taylor, Dr. S. R., and others : Major Element Relationships in Tektites, 680
Taylor, Dr. T. G , and Hertelendy, F. · Parallel Distribution of Calcium and Citric Acid in the Oviduct of the Hen, 244
Teachers Bill : Commonwealth (Second reading in the House of Commons), 441
Teachers for Health Education : Training of (United Nations, World Health Organization, Technical Report Series No 193), 648
Teaching · Recruits to—a Study of the Attainments, Qualifications and Attitudes of Students entering Training Colleges (F. W. Land), 750
Teaching (Laboratory-) of Languages (Arthur D. Little, Inc., Industrial Bulletin No 373), 568
Teaching (Science), in Secondary Modern Schools (Science Masters' Association Survey on), 206
Teale, Dr F. W. J. Appointed a lecturer in biochemistry at the University of Birmingham, 117
Tebble, N : Pelagic Polychaetes of the South Atlantic, 289
Technical Books . Recent Scientific and, Supp vi, July 30 ; Supp iv, August 27 , Supp. vi, September 24
Technical Books and Dictionaries (Japanese Scientific and) . A collection of, presented to the Science Museum Library, London, on behalf of the Prime Minister of Japan, Nobusuke Kishi, 201
Technical College (Kingston) : Postgraduate Course on Recent Advances in Steroid Chemistry, 905
Technical Physicists, Swedish Association of (Royal Swedish Academy of Engineering Sciences and the) Fifth International Instruments and Measurements Conference and Exhibition, 374
Technical Possibilities of a Thames Flood Barrier, 294
Technical Reports (Scientific and) : Indexes for (ASLIB Survey on), 372
Technical Publications (Indian Scientific and) : Bibliography of (Council of Scientific and Industrial Research, New Delhi), 199
Technical and Vocational Education in the U S.A.—a Bibliographical Survey prepared by the United States Office of Education (Unesco, Educational Studies and Documents No. 36), 741
Technique (Diaphragm-Cell) . Equations for Determining Diffusion Coefficients in Liquid Systems by the (F. A. L. Dullien and Prof. L. W. Shemilt), 767
Technique (A New), for Following Rapid Rates of Crystallization (J. H. Magill), 770
Technique (The Ouchterlony), using Antigen or Antiserum labelled with Iodine-131 (Joan M. Rhodes), 793
Techniques (Computer) : Application of, to Nuclear Physics Instruments (G. G. Scarrott), 854
Techniques (Spin Resonance) : Diamagnetic Moment of Gaseous Plasmas measured by (T. C. Marshall, R. A. Kawcyn and Prof L. Goldstein), 584
Technological Awards, National Council for . Report for 1959-1960, 286
Technological Progress (Man's), from Steam Engine to Satellite : Science as History—the Story of (Heinz Gartmann), translated from the German by Alan G. Readett, *review* by J L. Stollery, 8
Technologist in Administration : Scientist and, 353
Technology : High-Pressure, *review* by Dr K. E. Bett, 541
  Interactions of Science and, with Society, 1
  Management and, 537
  Rubber, *review* by Dr. W. F. Watson, 359
  Space (edited by Prof Howard S. Seifert), *review*, 884
Technology, Illinois Institute of : International Symposium on Photoelasticity, 650
Technology, Massachusetts Institute of : Seminar Lectures on the Physiological Role of Fast Transfer Reactions, 904
Technology of Leather : The Chemistry and (edited by Fred O'Flaherty, William T. Roddy and Robert M. Lollar), Vol. 2, Types of Tannages, *review* by Prof A. G. Ward, 724
Technology of Plastics Processing (Association for the Advancement of the Knowledge of Materials, the Royal Institute of Engineers, the Royal Netherlands Chemical Federation and the International Union of Pure and Applied Chemistry International Congress on the), 559
Technology (Advanced), Northampton College of (London) : Advanced Course on Direction and Supervision of Scientific and Engineering Personnel, 905
Technology (Chemical), at Edinburgh, 555
Technology (Food Science and) : International Congress of, 905
Technology (Nuclear Reactor) : Analytical Chemistry in (Oak Ridge National Laboratory Conference on), 994
Technology (Plastics) : Training Grants for (Plastics Institute), 28
Technology (Rubber) : Introduction to (edited by Maurice Morton), *review* by Dr. W. F. Watson, 359
Technology (Science and), in Africa South of the Sahara, 198
Technology (Science and), Manchester College of : Summer School in Modern Methods of Crystal Structure Determination, 201
  Course of lectures on Problems of Radioactivity at Water and Sewage Works, 743
Technology (Science and) : National Lending Library for, 992
Technology (Science and), Royal College of (Glasgow) : Annual Report (1958-59), 115
Technology (Sugar) : Principles of (edited by Pieter Honig), Vol. 2, Crystallization, *review* by H. C. S. de Whalley, 979
Tectonics of the Gobi Mountains (V P Solonenko and N A. Florensov), 373
Teeth of Primates : The Jaws and (W. Warwick James), *review* by Sir Wilfrid Le Gros Clark, 891
Tektites : Major Element Relationships in (R. D. Cherry, Dr. S. R. Taylor and Maureen Sachs), 680
  Origin of (Prof. H. C. Urey), 855
Tektites and Glasses formed by Fusion of Terrestrial Rocks . Comparison of the Chemical Composition and Magnetic Properties of (Dr. Irving Friedman, Dr. Arthur Thorpe and Dr. Frank E. Senftle), 1089
Tektites, and Petrogenesis : Average Composition of Granites, the Genesis of (Prof E. H. Timothy Whitten), 867
Telecommunication Dictionary (Elsevier's), in Six Languages—English/American, French, Spanish, Italian, German, Dutch (compiled and arranged on an English alphabetical base by A. Visser), *review* by Dr. R L. Smith-Rose, 1059
Telecommunications (Space) : Radio Frequency Control in (Edward Wenk, Jun.), 373
Television : Science Broadcasting in Sound and (A B. Oldfield Davies), 850
Television Engineering (S. W. Amos and D C Birkinshaw), Vol. 1, Fundamentals, Camera Tubes, Television Optics, Electron Optics (written in collaboration with J. L. Bliss) ; Vol 2, Video-Frequency Amplification ; Vol 3, Wave-form Generation ; Vol. 4, General Circuit Techniques, *review* by Dr. R. L. Smith-Rose, 358
  Principles and Practice of, *review* by Dr. R. L. Smith-Rose, 358
Television Field Trials of 405-Line and 625-Line Systems in the UHF and VHF Bands, 1957-1958 (British Broadcasting Corporation), 288
'Telex' : Directory of Libraries in the United Kingdom with access to (Library Association), 558
Temperate Zone Sporadic *E* and the Earth's Magnetic Field : Longitude Effect in (L. H. Heisler and Dr. J D. Whitehead), 676
Temperature : Dependence on, of the Electrical Resistivity of Thermosetting Polymers (R. W. Warfield and M. C. Petree), 316
  Dependence on, of the Interlayer Spacing in Carbons of Different Graphitic Perfection (E. G. Steward, B P. Cook and E. A. Kellett), 1015
  Effect of, on the Expansion on Setting of Gypsum Plaster (P. J. Sereda), 929
  Effect of Variations in, on Meiosis in *Gagea reticulata* Schultes (Dr C. P. Malik), 805
  The Helium-4 Scale of (F. C. Brickwedde, H. van Dijk, M. Durieux, J. R. Clement and J. K. Logan), 1077
Temperature of Formation of Antarctic Snows : Isotopic Composition and (Prof. E Picciotto, X de Maere and Dr I. Friedman), 857
Temperature (Frost-point), and Wind : Airborne Measurements of Latitudinal Variation of (N. C. Helliwell), 993
Temperature (High-) Furnaces (A Gallenkamp and Co., Ltd., Catalogue No. 620), 1077
Temperature (High-) Resistance and Thermal Degradation of Polymers (Plastics and Polymer Group of the Society of Chemical Industry Symposium on), 466
Temperature (Low) . The Second Virial Coefficient of Methane at (G. Thomaes and R. Van Steenwinkel), 229
Temperature (Low-) Fuel Cell (Shell Research Centre), 994
Temperature (Room) : Biosynthesis of Sucrose by Preparations from Potatoes stored in the Cold and at (Dr. Sigmund Schwimmer and Edward S Rorem), 1113
Temperature (Shrinkage), of Collagen : Hydroxyproline and the (B. J. Rigby and Dr. J. D. Spikes), 150
Temperatures reached in Electrical Discharges in the Solar Atmosphere (Dr. C. E. R. Bruce), 865
Temperatures (Extremely Low) : Survival of Woody Plants at (Johnson Parker), 1133 , (Dr. Akira Sakai), 1134
Temperatures (High) : An Improvement in the Ductility of Beryllium at (A. Brown, F. Morrow and A. J. Martin), 494
Temperatures (Low) · Thermal Expansion at (Guy K. White), 927
Tempering of Martensite . Retained Austenite and the (S. Matas and Prof. R. P. Hehemann), 685
Temporal Lesions (Medial) : Effects of, on Taste Preference in the Monkey (Dr L Weiskrantz), 879
Tensile Straining : Behaviour of Paper during (A. E. Ranger and L. F. Hopkins), 1097
Tension of Vascular Muscle : Effect of the Cations of the Lyotropic Series on the (Prof. L. Laszt), 329
Teodorczuk, Dr. H (Zoutendyk, Dr. A., and) : The Rh Factor C in South African Bantu, 790
Terayama, Prof. H , and others · Distribution of Protein-bound Aminoazo Dyes in the Rat Liver Microsome, 943

Term Placental (Human,) 17β-Œstradiol Dehydrogenases : Histochemical Localization of—Implications for the Transhydrogenase Reaction (Dr. Donald A. Kellogg and Dr. George G. Glenner), 763
N-Terminal Amino-Acids of Bovine Antibody (Elizabeth M. Press and R. R. Porter), 59
Terminal Inflorescence in the Genus *Trifolium* : Axial Origin of the (Yvonne Aitken), 622
Terminology in Plant- and Soil- Water Relations (Dr. R. O. Slatyer and Prof. S. A. Taylor), 922
Terpene Hydrocarbons : Radiolysis of—Isomerization and Polymerization of α- and β-Pinene (T. H. Bates and Dr. T. Ffrancon Williams), 665
Terpenes : Microbiological Transformation of—Hydroxylation of α-Pinene (P. K. Bhattacharyya, B. R. Prema, B. D. Kulkarni and S. K. Pradhan), 609
Terrestrial Rocks : Comparison of the Chemical Composition and Magnetic Properties of Tektites and Glasses formed by Fusion of (Dr Irving Friedman, Dr. Arthur Thorpe and Dr. Frank E. Senftle), 1089
Terrington and Kirton Experimental Husbandry Farms, King's Lynn : Appointment of F. E. Shotton as director, 905
Territories . British Colonial, 906
Territories, 1959-1960 : The Colonial, 906
Terroune, Prof. E F. : Elected an honorary member of the American Institute of Nutrition, 374
Teschen Diseases (Talfan and) : Infective Ribonucleic Acid from the Viruses of (F. Brown and Doreen L. Stewart), 714
Test (The Anti-Globulin (Coombs)), in Laboratory Practice (Dr. I. Dunsford and Jean Grant), *review* by Dr. R Drummond, 357
Test Organism : Microbial Synthesis of Protein in relation to the Biogenesis of Nucleic Acids with *Azotobacter vinelandii* as the (Maharani Chakravorty), 239
Testicular Hyaluronidase : Effect of, on the Permeability of Human Arterial Tissue (Jørgen Matzke), 873
Testing (Laboratory), in Soil Engineering (T. N. W. Akroyd), *review* by Dr. H. L. Penman, 891
Testing (Non-Destructive), of Materials (British Council Course on), 1079
Testis Lipids in the Common Frog, *Rana temporaria* . Cyclical Changes in the Distribution of the (Dr B. Lofts and C. Boswell), 708
Tests (Potassium Tolerance), in South Indian People (Dr G. Henrotte, G Krishnamurthi and G. Ranganathan), 328
Tetanus : pH Changes during Muscle Twitch and (A. Distèche), 1119
  Vaccination against Whooping Cough, Diphtheria and (Research Defence Society, *Conquest* Pamphlet No. 11), 649
Tetra-substituted Sulphur : Optically Active Forms of a Derivative of (M. Baresh), 591
Tetrahydro-1,3-oxazine Derivatives : Anti-neoplastic Activity of (Prof. T. Urbański, D. Gürne, S. Slopek, H. Mordarska and M. Mordarski), 426
Tetrakis (Hydroxymethyl) Phosphonium Chloride Action of, on Wool (L. S. Bajpai, Prof. C. S. Whewell and J. M. Woodhouse), 602
Tetraploids (Colchicine-induced), of *Annona squamosa* L. : Unproductivity in the (Prof Ahmad Shamsul Islam), 343
Textile Encyclopedia : Man-Made (edited by J. J. Press), *review* by Prof. C. S. Whewell, 2
Textile Institute : Warner Memorial Medal awarded to Prof. C. S. Whewell, 201
Thames Flood Barrier : Technical Possibilities of a, 294
Theng, B. K. G. (Quirk, Dr. J. P., and) : Effect of Surface Density of Charge on the Physical Swelling of Lithium Montmorillonite, 967
Theorem (Reciprocal), and Theory of Statically Indeterminate Frameworks : A Historical Note on the (T. M. Charlton), 231
Theoretical Physics : Reference Book of, *review* by Prof. R. Eisenschitz, 445
Theories of Figures of Celestial Bodies (Wenceslas S. Jardetzky), *review* by Prof. L. S. Goddard, 890
Theory of Atomic Nuclei (Publication by the Physical Society of Japan of a volume of papers on), 743
Theory of Auroral Structures (E. R. Harrison), 383
Theory of Heredity : Chromosomes and the (Prof. C. D. Darlington), 892
Theory of High Explosives, *review* by Dr. W. L. Murray, 539
Theory of the Ionosphere : Recent Trends in the (J. A. Ratcliffe), 853
Theory of Optimal Games (Prof. Alan S. C. Ross), 968
Theory of Relativity (W. Pauli), translated from the German by G. Field, *review* by Dr. D. W. Sciama, 4
Theory of Sound Transmission with Application to the Ocean : Introduction to the (Prof. C. B. Officer), *review* by Dr A. B. Wood, 539
Theory of Space, Time and Gravitation (V. Fock), translated from the Russian by N. Kemmer, *review* by Dr. D. W. Sciama, 4
Theory of Statically Indeterminate Frameworks : A Historical Note on the Reciprocal Theorem and (T. M. Charlton), 231
Theory (Circuit) : General (Prof. Gordon Newstead), *review* by Prof. A. H. M. Arnold, 811
  General and Linear, *review* by Prof. A. H. M. Arnold, 811
Theory (Evolutionary), after Mendel, *review* by Dr. H Kalmus, 726
Theory (Evolutionary), and Christian Belief : The Conflict between (Dr. David Lack), 98
Theory (The Magneto-Ionic), and its Applications to the Ionosphere (J. A. Ratcliffe), *review* by Sir Harrie Massey, 810
Theory (Random) : Nonlinear Problems in (Prof. Norbert Wiener), *review* by K. Krickeberg, 727
Theory and Practice : Ferrimagnetism in, *review* by Dr. G. E. Bacon, 974
Therapy (Antibiotic), and Staphylococcal Diseases (edited by Dr. Henry Welch and Prof. Maxwell Finland), *review* by Prof. R. Knox, 637
Thermal Analysis (Differential), of some Transition Metal Ethylenediamine Tetraacetic Acid Chelates (Prof. Wesley W. Wendlandt and G. Robert Horton), 769
Thermal Conduction in Mica along the Planes of Cleavage (H. J. Goldsmid and A. E. Bowley), 864
Thermal Degradation of Polymers : High-Temperature Resistance and (Plastics and Polymer Group of the Society of Chemical Industry Symposium on), 466
Thermal Expansion at Low Temperatures (Guy K. White), 927
Thermal Insulation : Domestic Heating and (Building Research Station, Digest 133), 999
Thermal Neutrons : Localization by Autoradiography at -195° C. of Radioactive Areas in Rats exposed to a High Flux of—Importance of Phosphorus-32 in Consecutive Internal Irradiation (Jean Chanteur and Pierre Pellerin), 472
Thermochemistry in Molten Salts : 'Enthalpy Titrations' and (Prof. Joseph Jordan, Jurg Meier, Edward J. Billingham, jun., and James Pendergrast), 318
Thermosetting Polymers : Dependence on Temperature of the Electrical Resistivity of (R. W. Warfield and M. C. Petree), 316
Thickening (Artificial), of Bone and the Piltdown Skull (Prof. Ashley Montagu), 174 ; (Dr. Kenneth P. Oakley), 174
Thimann, Prof. Kenneth V. (Sorokin, Helen P., and) : Plastids of the *Avena* Coleoptile, 1038
Thin (Ultra-) Sections : A Vacuolar System in Cells of *Agrobacterium tumefaciens* as shown by Electron Microscopy of (Miguel Rubio-Huertos and Paul R. Desjardins), 1043
Thin (Ultra-) Sections of Vitrinite from a High-volatile Bituminous Coal : Absorption of Ultra-violet and Visible Light by (Sabri Ergun, J. T. McCartney and R. E. Walline), 1014
Thiouracils : Staining for Iodine in Chromatograms of Human Plasma—an Artefact due to Thiourea or (A. Dimitriadou, Prof. T. Russell Fraser, Dr. J. D. H. Slater and P. C. R. Turner), 691 ; *erratum*, 1079
Thiourea or Thiouracils : Staining for Iodine in Chromatograms of Human Plasma—an Artefact due to (A Dimitriadou, Prof. T. Russell Fraser, Dr. J. D. H. Slater and P C. R. Turner), 691 ; *erratum*, 1079
Thomaes, G., and Van Steenwinkel, R. : The Second Virial Coefficient of Methane at Low Temperature, 229
Thomas, D. Brynmor, and others : Pattern of Haemopoiesis in the Foetal Liver, 876
Thomas, Dr. H. Dighton : Coral Structures and Classification, *review*, 95
Thomas, Prof. J. A., and McNicol, Dr. R. W. E. : A Highly Directive Rotating Array for 16 Mc./s., 398
Thompson, Prof. F. C. : Precipitation Processes in Steels—Report of a Conference held in the University of Sheffield, 1958, *review*, 9
  Flat Rolled Products, *review*, 273
Thompson, Dr H. W. : The Chemistry of Natural Products (Physico-Chemical Methods of Studying Natural Products), 1080
Thompson, J. A. : Inhibition of Nodule Bacteria by an Antibiotic from Legume Seed Coats, 619
Thomson, A. D. : Possible Occurrence of Interference Systems in Virus-infected Plants, 761
Thomson, Dr. C. G. : Appointed lecturer in clinical chemistry at the University of Edinburgh, 465
Thomson, D. H., and others : Chemical Effects of Ionizing Radiations on Nucleic Acids and Nucleoproteins, 319
Thomson, Sir George : The Two Aspects of Science (Presidential Address to the British Association for the Advancement of Science), 837
Thomson, Sir Landsborough : The Serengeti National Park, 174
Thomson, T. R., and others : Formation of Fayalite in Roast Reduced Jaspilite, 683
Thorium, Plutonium, Neptunium (Uranium,) : Crystal Chemistry of Simple Compounds of (E. S. Makarov), translated from the Russian by E. B Uvarov, *review* by Dr. L. E. J. Roberts, 728
Thorium and Uranium in the Periodic Table : Positions of (Dr. A. E. Dwight), 505
'Thorotrast' in Tissue Sections : Combined Oil-immersion, Phase-contrast and Dark-ground Viewing of (Dr. E. W Baxter), 162
Thorpe, Dr. Arthur, and others : Comparison of the Chemical Composition and Magnetic Properties of Tektites and Glasses formed by Fusion of Terrestrial Rocks, 1089
Thorpe, Dr. W. V. : Title of professor of physiological chemistry in the University of Birmingham conferred on, 465
Thought (Monetary), and Monetary Policy in England (Prof. R. S. Sayers), 844
Thread-like Apparatus in the Petiole of *Mimosa pudica* : Behaviour of a (Dr. Hideo Toriyama), 709
Threshold (Electro-shock Seizure), of Metacorticoid Hypertensive Rats (Dr. F. M. Sturtevant), 874
Thrombokinase (Blood) · Chromatography of, on 'DEAE'-Cellulose (Dr. J H. Milstone), 1127
Thrombosis and Atherosclerosis : Connective Tissue,—Proceedings of a Conference held at Princeton, N J., 1958 (edited by Irvine H. Page), *review* by Dr. G. S. Boyd, 634
Thrush, Dr. B. A. : The Exploding Wire Phenomenon, *review*, 726
Thymectomized Mice : Recovery of Leukaemogenic Agent from Non-Leukaemic Tissues of (J. F. A. P. Miller), 703
Thymidine : Uptake of, and Synthesis of Deoxyribonucleic Acid in Mouse Ascites Cells (Dr. A. R Crathorn and Dr. K. V. Shooter), 614
Thymidine into Deoxyribonucleic Acid : Capacity of Extracts from Pre-starved *Escherichia coli* to Incorporate (Dr. Daniel Billen), 1044
Thymidine labelled with Tritium : Urinary Excretion of β-Amino-isobutyric Acid after Injection of (Dr. Georg B. Gerber, Gisela Gerber and Kurt I. Altman), 956
Thymus Nuclei (Calf) : Water-soluble, Non-fibrous Deoxyribonucleoprotein from (Dr. Richard S. Walsh), 943
Thymus Nucleoprotein : Labilization of Deoxyribonucleic Acid in, after Whole-body Irradiation (Dr. Ulrich Hagen), 1123
Thyrotrophin labelled with Iodine-131 : Sialoadenectomy and the Distribution of (Prof. Arthur W. Wase and Dr. Yu Sheng Louise Feng), 778
Thyroxine : Transiodination of Proteins during Enzymic De-iodination of (Dr. J. R. Tata), 1025
Tick-borne Encephalitis : Virus and Antibodies in the Lymph and Blood of Sheep infected experimentally with the Virus of (Doubravka Málková), 716
Tick-borne Encephalitis Virus-infected Chick Embryo Fibroblast Cells : An Interferon-like Substance released from (Dr. J Vilček), 73
Ticks : Accessory Glands of Gene's Organ in (Dr. B. Feldman-Muhsam and Y. Havivi), 964
Tidal Flooding in London : Protection against (N. B. Webber), 293
Tikopia : Social Change in (Prof. Raymond Firth), *review* by Sir Harry Luke, 816
Tilapia : Interspecific Hybrids of—*T. nigra* x *T. zillii* (P. J. Whitehead), 878
Tilford, Shelby G., and others : Ultra-violet Absorption Spectra of the Diazines, 500
Tilley, Prof. C. E. : Farewell Dinner given by, to mark the retirement of Dr. W. A. Wooster, 25
Tillman, Dr. J. R. Progress in Semiconductors, *review*, 185
  Semiconductors and Transistors, *review*, 1058

Timber : Combating the Decay of, *review* by Prof. F. W. Jane, 977
  Decay of, and its Prevention (K. St. G. Cartwright and W. P. K. Findlay), *review* by Prof. F. W. Jane, 977
Timber Development Association : Open Days at the Research Laboratories, Penn, 994
Time : An Introduction to the Physics of Mass, Length and (Prof. Norman Feather), *review* by G. R. Noakes, 183
  Mass, Length and, *review* by G. R. Noakes, 183
Time of Local Aurorae : Atmospherics on 20 kc./s. at the (Father E. Gherzi), 225
Time (Choice Reaction) : Time Uncertainty and (Paul Bertelson and Jean-Paul Boons), 531
Time (Short-) Exposure to Ultra-violet Irradiation : Delayed Recovery of Airborne *Serratia marcescens* after (Dr. R. L. Dimmick), 251
Time and Gravitation (Space,) : The Theory of (V. Fock), translated from the Russian by N. Kemmer, *review* by Dr. D. W. Sciama, 4
Time-Scale : A Revised Geological (Prof. Arthur Holmes), 27
Time Signals : The International Co-ordination of, and Standard Frequency Transmissions (Dr. L. Essen), 452
Time Uncertainty and Choice Reaction Time (Paul Bertelson and Jean-Paul Boons), 531
Timmis, G. M. : Title of reader in chemistry in the University of London (at the Institute of Cancer Research, Royal Cancer Hospital) conferred on, 904
Timoshenko, S. P. : Engineering Education in Russia, 537
Tin Films : Speed of the Superconducting-Normal Transition in (D. J. Oliver, M. J. Rayner and E. H. Rhoderick), 492
Tincher, Wayne C., and others : Ultra-violet Absorption Spectra of the Diazines, 500
Tinggaard, Karl Aage (illustrated by) : Birds in Colour (with descriptions by Bruce Campbell), *review* by B. J. G. Maitland, 273
Tinline, Dr. R. D., and Zacharuk, R. Y. : Pathogenicity of *Metarrhizium anisopliae* (Metch.) Sor. and *Beauveria bassiana* (Bals.) Vuill. to Two Species of Elateridae, 794
Tinplate in Australia : Research on, 904
Tintometer, Ltd : A Handbook of Colorimetric Chemical Analytical Methods, fifth edition, *review* by A. M. G. Macdonald, 3
Tiros I (Satellite) : Cloud Pictures from, 647
Tissue (Connective), Thrombosis and Atherosclerosis—Proceedings of a Conference held at Princeton, N.J., 1958 (edited by Irvine H. Page), *review* by Dr. G. S. Boyd, 634
Tissue (Embryonic Plant) : Stabilization by Manganous Ions of Ribosomes from (Dr. J. W. Lyttleton), 1026
Tissue (Human Aortic) : Presence of Neutral Carbohydrates in (Dr. Sv. Bertelsen), 411
Tissue (Human Arterial) : Effect of Testicular Hyaluronidase on the Permeability of (Jørgen Matzke), 873
Tissue (Muscle), of an Albino Mouse : A Transplantable Spontaneous Osteogenic Sarcoma observed in the (R. G. Harne, M. Gregoire and G. Rona), 1129
Tissue Culture (Insect) : Growth by Cell Division in (Dr. B. M. Jones and I. Cunningham), 1072
Tissue Cultures : Plant, *review* by A. Allsopp, 976
Tissue Sections : Combined Oil-Immersion, Phase-contrast and Dark-ground Viewing of 'Thorotrast' in (Dr. E. W. Baxter), 162
Tissues of *Helix* : Physiological Media for (C. K. Goddard), 68
Tissues (Isolated), *in vitro* : Influence of the Ionic Strength of the Medium on the Anaphylactic Sensitization of (R. Binaghi, M. Liacopoulos-Briot, Dr. B. N. Halpern and P. Liacopoulos), 697
Tissues (Mammalian) : The β-D-Fucosidase Activity of, and its relation to other Glycosidases (Dr. G. A. Levvy), 1027
Tissues (Non-Leukaemic), of Thymectomized Mice : Recovery of Leukaemogenic Agent from (J. F. A. P. Miller), 703
Tissus Végétaux : La Culture des (Prof. R. J. Gautheret), *review* by A. Allsopp, 976
Titanium : Five Co-ordinated, in $K_2Ti_2O_5$ (Dr. Sten Andersson and Dr. A. D. Wadsley), 499
  The Fusion Electrolysis of (Dr. W. J. Kroll), 994
Titanium Metals and Compounds : Analytical Chemistry of (Maurice Codell), *review* by Prof. A. G. Quarrell, 725
Titanium Oxide : A Symmetrical Fourfold Helical Fracture in (J. S. Jackson), 1104
Titrations' ('Enthalpy), and Thermochemistry in Molten Salts (Prof. Joseph Jordan, Jurg Meier, Edward J. Billingham, jun., and James Pendergrast), 318
Titterton, Prof. E. W., and Brinkley, T. A. : Rare Modes in the Spontaneous Fission of Californium-252, 228
Tivy, Dr. Joy : The Geography of the Garth Area—the Central Highlands in Miniature, 200
Toad *Xenopus laevis* : Expanded Ilio-Sacral Joint in the (Margaret Palmer), 797
Tobacco Mosaic Virus : Polyphenol Oxidase Activity of *Nicotiana glutinosa* Leaves infected with (Dr. Masataka Kikuchi and Akira Yamaguchi), 1048
Tobacco Mosaic Virus Protein : A Difference between the Sub-Units of (Dr. H. G. Aach), 75
Tobe, Dr. M. L., and others : Orienting Effects in Octahedral Aquation, 477
Tocher, K. : At the second Annual Conference of the British Computer Society (A Common Computer Language), 655
Todd, Sir Alexander : New Horizons in Chemistry, 819
  The Chemistry of Natural Products (Natural Product Chemistry—Retrospect and Prospect), 1080
  Honorary degree of Doctor of Laws of the University of Melbourne conferred on, 1081
Todd, Sir Alexander, and others : Oxidative Phosphorylation—Synthesis of Adenosine Diphosphate by the Oxidation of Quinol Phosphates, 59
Tolerance (Polyvalent Immunological), in Homologous Radiation Chimaeras (Alena Lengerová), 160
Tolerance Tests (Potassium), in South Indian People (Dr. G. Henrotte, G. Krishnamurthi and G. Ranganathan), 328
Tomatoes : Virus-Streak Disease of (B. H. MacNeill and Hikmet Ismen), 903
Tomnovec, F. M., and others : Fractionation of Nuclear Weapon Debris, 1100
Tong, Dr. J. E., and others : Preliminary Psychomotor Stress Studies with Subnormal Psychopathic Subjects, 172
Tongue, Harold : The Design and Construction of High Pressure Chemical Plant, second edition, *review* by Dr. K. E. Bett, 541
Tonks, Dr. Lewi : Electromagnetic Standing Waves and Ball Lightning, 1013
Tonolo, A., and others : Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture, 238
Tooth Enamel : Organic Matrix of (J. E. Eastoe), 411
Toovey, F. W. : Glasshouse Crops Research Institute—Open Day, 204
Topographical Anatomy of the Dog (Dr. O. Charnock Bradley), sixth edition revised by Prof. Tom Grahame, *review* by Prof. T. Nicol, 451
Toriyama, Dr. Hideo : Behaviour of a Thread-like Apparatus in the Petiole of *Mimosa pudica*, 709
Tóro, Prof. Imre, and others : Increase of Esterase Activity during Intracellular Digestion in a Histophagous Ciliate, 65
Total Iron-binding Capacity in certain Mammals : Serum Iron and (Prof. Jose Planas and Siunio de Castro), 1126
Total and *l*(+) Tartaric Acid Inhibited Rat Serum Acid Phosphatase (Dr. Z. Laron and B. Epstein Halberstadt), 67
Tóth, József, and others : Increase of Esterase Activity during Intracellular Digestion in a Histophagous Ciliate, 65
Tottenham, H. C. : Appointed to the readership in structural engineering at the University of Southampton, 290
Towards a Unified Cosmology (Prof. Reginald O. Kapp), *review* by Dr. C. W. Kilmister, 634
Toxic Chemicals in Agriculture and Food Storage : Use of (Request from the Research Study Group for evidence), 290
Toxicity of Gibberellin to Seedless and Seeded Varieties of *Vitis vinifera* (Dr. Robert J. Weaver), 1135
Toxicology : Handbook of, Vol. 3, Insecticides (William O. Negherbon), *review* by Prof. V. B. Wigglesworth, 544
Traces of Metals : Colorimetric Determination of (Prof. E. B. Sandell), third edition, *review* by A. M. G. Macdonald, 3
Trained Manpower Problems : The Public Service in New States—a Study in some (Kenneth Younger), 971
Training of Professional Radio and Electronics Engineers : Education and (British Institution of Radio Engineers Report on), 115
Training in Radiological Health and Safety (Prof. J. E. Roberts), 471
Training of Teachers for Health Education (United Nations, World Health Organization, Technical Report Series No. 193), 648
Training Colleges : Recruits to Teaching—a Study of the Attainments, Qualifications and Attitudes of Students entering (F. W. Land), 750
Training Facilities (Nuclear), at the Royal Naval College, Greenwich (Prof. J. Edwards, 545
Training Grants in Plastics Technology (Plastics Institute), 28
Trans-Atlantic Frequency Comparison between Caesium-controlled Oscillators : The 'GBR Experiment'—a (J. A. Pierce, G. M. R. Winkler and R. L. Corke), 914
Transfer (Heat), in Cold-Cathode Arcs : Stepwise Ablation and (Dr. A. von Engel and Dr. K. W. Arnold), 1101
Transfer (Linear Energy) : Effects of, on the Radiolysis of Water and Heavy Water (Dr. E. Collinson, Prof. F. S. Dainton and J. Kroh), 475
Transfer (Turbulent), in the Lower Atmosphere (Dr. C. H. B. Priestley), *review* by Prof. P. A. Sheppard, 974
Transfer Reactions (Fast) : Physiological Role of (Massachusetts Institute of Technology Seminar Lectures on), 904
Transferase (Glucoronosyl) : Inhibition of, by Progestational Agents from Serum of Pregnant Women (Dr. David Yi-Yung Hsia, Robert M. Dowben, Ralph Shaw and Aaron Grossman), 693
Transformable Bacteria : Fate of Transforming Deoxyribonucleate following Fixation by, 1 (Dr. Maurice S. Fox and Dr. Rollin D. Hotchkiss), 1002 , 2 (Dr. Maurice S. Fox), 1004
Transformation of Resistance to 8-Azaguanine in *Diplococcus pneumoniae* (Francis M. Sirotnak, Ramona B. Lunt and Dorris J. Hutchison), 800
Transformation (Microbiological), of Terpenes—Hydroxylation of α-Pinene (P. K. Bhattacharyya, B. R. Prema, B. D. Kulkarni and S. K. Pradhan), 689
Transforming Deoxyribonucleate : Fate of, following Fixation by Transformable Bacteria, 1 (Dr. Maurice S. Fox and Dr. Rollin D. Hotchkiss), 1002 ; 2 (Dr. Maurice S. Fox), 1004
Transhydrogenase Reaction : Histochemical Localization of Human, Term Placental 17β-Œstradiol Dehydrogenases—Implications for the (Dr. Donald A. Kellogg and Dr. George G. Glenner), 763
Transiodination of Proteins during Enzymic De-iodination of Thyroxine (Dr. J. R. Tata), 1025
Transistor (The Junction), and its Applications (edited by E. Wolfendale), *review* by Dr. J. R. Tillman, 1058
Transistors (A. C. Gillie), *review* by Dr. J. R. Tillman, 1058
  Semiconductors and, *review* by Dr. J. R. Tillman, 1058
Transition (Fibrinogen-Fibrin) : Some Aspects of the (K. Laki, Jules A. Gladner and J. E. Folk), 758
Transition (Olivine-Spinel), on Nickel Orthosilicate (Dr. A. E. Ringwood), 1019
Transition (Superconducting-Normal), in Tin Films : Speed of the (D. J. Oliver, M. J. Rayner and E. H. Rhoderick), 492
Transition Group (Second) : Ferromagnetic and Antiferromagnetic Behaviour in the (Dr. B. R. Coles and D. Griffiths), 226
Transition Metal Ethylenediamine Tetraacetic Acid Chelates : Differential Thermal Analysis of some (Prof. Wesley W. Wendlandt and G. Robert Horton), 769
Transits of Venus—a Study of Eighteenth-Century Science (Prof. Harry Woolf), *review* by Dr. David S. Evans, 636
Translations of Russian Biological Publications (American Institute of Biological Sciences), 558
Translations (Scientific) : Israel Programme for, 832
Translocation of Wild Animals as a Means of Game Control (Dr. A. M. Harthoorn, J. A. Lock and J. MacKeand), 518
Transmission : Autonomic Nerve-Smooth Muscle (G. Burnstock and Mollie E. Holman), 951
  Data (Benelux Section of the Institute of Radio Engineers, in co-operation with the Nederlands Radiogenootschap and the Group on Communications Systems of the Institute of Radio Engineers International Symposium on), 290
Transmission of Colicinogeny : Genetic Recombination in *Salmonella typhimurium* occurring during (Dr. Ozeki and Dr. Howarth), 649
Transmission of a Gall Disease of Cocoa (A. L. Wharton and A. A. Brunt), 80

Transmission (Sound) : Introduction to the Theory of, with Application to the Ocean (Prof. C. B. Officer), *review* by Dr. A. B. Wood, 539
Transmission (Spinal), of Proprioceptive Hind-Limb Reflexes : Velocity of Conduction and (Hind-Limb Reflexes in the Kitten), (Dr. Sten Skoglund), 132
Transmissions (Frequency) : The International Co-ordination of Time Signals and Standard (Dr. L. Essen), 452
Transmutation of Species : Darwin's Notebooks on (edited by Sir Gavin de Beer), Part 2, 26 ; Part 3, 649 (British Museum (Natural History)).
Transphosphorylation : Synergism of Bivalent Metal Ions in (Dr. John M. Lowenstein), 570
Transplantable Spontaneous Osteogenic Sarcoma observed in the Muscle Tissue of an Albino Mouse (R. G. Herne, M. Gregoire and G. Rona), 1129
Transplanted Bone Marrow Cells in Radiation Chimaeras : Identification of (P. Czerski, O. Rosiek and J. Sabliński), 955
Transport (Auxin) : A Method for the Detection of Inhibition of (B. E. S. Gunning), 428
Transport (Potassium) : A Bacterial Mutant with Impaired (Dr. Stanley G. Schultz and Dr. A. K. Solomon), 802
Traps : Vent-Axia Insect Suction, 559
Travel (Space) : Biology of (Institute of Biology Symposium on), 29
  Designing for, *review*, 884
Travel Awards for Women Engineers (Caroline Haslett Memorial Trust), 116
Travelling Fellowships in Medicine, 994
Travis, N., and others : Excited Electronic States of Lithium and Sodium Molecules, 141
Treasury, H.M. : Assistance from the United Kingdom for Overseas Development, 266
Treating Soils with N Sodium Hydroxide : Ammonia released on, as a Possible Means of Predicting the Nitrogen-supplying Power of Soils (A. H. Cornfield), 260
Treatise (A New), on Plant Physiology, *review* by Prof. Walter Stiles, 889
Treatment of Hypertension : Drugs for the (Manchester and District Section of the Royal Institute of Chemistry, and the Manchester Section and Fine Chemicals Group of the Society of Chemical Industry Symposium on), 743
Treatment of *Leishmania donovani* Infections with Surface-active Agents (Dr. J. D. Fulton), 1129
Treatment (Heat), of Metals and Alloys (Société Française de Métallurgie Meeting on), 559
Tremor (Ottawa Symposia on Self-Regulation in Living Systems, 3), 297
Trends in the Theory of the Ionosphere : Recent (J. A. Ratcliffe), 853
Trends (Population), among Hawks and Owls in Illinois (Richard R. Graber and Jack S. Golden), 999
Treshnikov, A. F. : Recent Progress in the Oceanography Studies in the Arctic, 287
Triassic Salt—Discoveries in the Cheshire–Shropshire Basin (Sir William Pugh), 278
Tribolium : Taxonomic Significance of Spermathecal Structure in some Species of (Gordon Surtees), 1138
Trifolium (Genus) : Axial Origin of the Terminal Inflorescence in the (Yvonne Aitken), 622
Trimethylhexadecylammonium (Cation) : Reduction of the Intestinal Absorption of Glucose, Methionine and Sodium Butyrate by the (Dr. J. A. Nissim), 308
Trinuclear Basic Acetates : Structure of the (Dr. L. E. Orgel), 504
Triphosphate (Adenosine), and Maintenance of Shape of the Human Red Cells (Makoto Nakao, Toshiko Nakao and Saburo Yamazoe), 945
Tristram, Dr. G. R. : At the Nineteenth Meeting of the Research Panel of the British Gelatine and Glue Research Association (A Preliminary Study of the Thermal Conversion of Acid-Soluble Calf-skin Collagen into Gelatin), 998
Tritium : Effect of Cocaine on the Disposition of Noradrenaline labelled with (Dr. L. G. Whitby, G. Hertting and Dr. J. Axelrod), 604
  Urinary Excretion of β-Amino-isobutyric Acid after Injection of Thymidine labelled with (Dr. Georg B. Gerber, Gisela Gerber and Kurt I. Altman), 956
Trocheris, Michel : Les Modèles du Noyau, *review* by Dr. J. M. Soper, 979
Tropical Agriculture, Imperial College of : To be merged into the University College of the West Indies, 374
Tropical Climates and Biology (Dr. G. S. Carter), 843
Tropical Products Institute : Appointment of Dr. P. C. Spensley as acting director, 117
Troup, G. W. : The Development of Pulp and Particle Board Industries and their Effect on Forest Management (The Evaluation of the Economists), 33
Trout (Sea-) Marked in Devonshire : Recapture in the River Tweed of a (A. Swain, I. R. H. Allan and M. J. Bulleid), 877
Trypan Blue : Effect of, on Rat Embryos (F. Beck, Dr. B. Spencer and Prof. J. S. Baxter), 605
D,L-Tryptophan-3-^{14}C in *Brassica oleracea* L. : Biogenesis of Ascorbigen, 3-Indolylacetonitrile and Indole-3-carboxylic Acid from (Dr. M. Kutáček, Dr. Z. Procházka and Dr. D. Grunberger), 61
Tsetse Fly (*Glossina*) : Free Amino-Acids of the (E. Bursell), 778
Tuan, Dr. T. F. : Appointed to a Research Fellowship in mathematical physics at the University of Birmingham, 465
Tube (Heated) : Effect of Specular Reflexions on the Radiation Flux from a (Sir K. S. Krishnan), 135
Tuberculin Sensitivity : Production of (Prof. Hubert Bloch and Albert A. Nordin), 434
Tuberculosis—Risk to Family Contacts, 1084
Tuberculosis in Animals (Zoological Society of London Symposium on), 996
Tuberculosis (Experimental) : Effect of *Candida albicans* on the Evolution of (Dr. E. Mankiewicz and Dr. M. Liivak), 250
Tuberculous Infection (Primary) : Effect of a, on the Resistance of Male and Female Mice to Ectromelia (Dr. A. W. Gledhill and Dr. R. J. W. Rees), 703
Tuck, James L. : A New Plasma Confinement Geometry, 863
Tucker, K. J., and others : Formation of Fayalite in Roast Reduced Jaspilite, 683
Tucker, M. J. : Echo-Sounding Experiments in the Barents Sea, 855
Tumey, S. B., and others : 5-Hydroxytryptamine in Cerebrospinal Fluid, 324
Tumour Blood Supply : A Rapid Method for studying, using Lissamine Green (L. N. Owen), 795
Tumour Cells (Ascites), *in vitro* : Optical Protein Synthesis by (Dr. M. J. Fraser), 1114
Tumour Formation : Polyoma Virus Mutant with a Reduction in (Dr. Leo Sachs and Dan Medina), 715
Tumour-destroying Virus : Isolation of a Non-pathogenic, from Mouse Ascites (Dr. J. G. Bennette), 72
Tumour-promoting Effect of Excessively Large Doses of Oral Griseofulvin on Tumours induced in Mice by Methylcholanthrene (Louis L. Barich, Takashi Nakai, Jan Schwarz and Donna Jean Barich), 335
Tumours : Chromosome Ploidy and Radiosensitivity of (László Révész and Ulla Norman), 861
Tumours induced in Mice by Methylcholanthrene : Tumour-promoting Effect of Excessively Large Doses of Oral Griseofulvin on (Louis L. Barich, Takashi Nakai, Jan Schwarz and Donna Jean Barich), 335
Tumours in *Rattus (Mastomys) natalensis* : Production of, by Polyoma Virus (Dr. Alan S. Rabson, William J. Branigan and Frances Y. Legallais), 423
Tumours (Human) : Polyploidy in (N. B. Atkin and Angela J. Ross), 579
Tumours (Mouse) : Localization of a Halogenated Porphyrin in (K. I. Altman and Prof. K. Salomon), 1124
Tunguska Meteorite : The (V. N. Rodionov and M. A. Tzikulin), 1077 ; (B. I. Vronsky), 1078 ; (E. L. Krynov), 1078
Tupper, R., and others : Zinc Content of Erythrocytes and Leucocytes of Blood of Normal and Leukaemic Subjects, 302
Turbostratic Structure of Clays : Domain or (L. A. G. Aylmore and Dr. J. P. Quirk), 1046
Turbulent Diffusion in the Atmosphere : Small-Scale (Dr. L. A. Clarenburg and C. E. Spaans-v. d. Tang), 586
Turbulent Transfer in the Lower Atmosphere (Dr. C. H. B. Priestley), *review* by Prof. P. A. Sheppard, 974
Turco, Dr. A., and others : Structure of $AgSCN.P(n\text{-}C_4H_9)_3$, 772
Turnbull, David (edited by Frederick Seitz and) : Solid State Physics—Advances in Research and Applications, Vols. 7, 8, 9 and 10, *review* by Dr. R. O. Davies, 886
Turnbull, Prof. H. W. : The Correspondence of Isaac Newton, Vol. 1, 1661-1675, *review* by Prof. L. Rosenfeld, 537
Turner, D. T. (Mullins, L., and) : Analysis of Solubility Data to estimate Small Amounts of Chain Fracture during the Cross-linking of Rubber, 145
Turner, Prof. E. E. : Title of professor emeritus of chemistry in the University of London conferred on, 466
Turner, P. C. R., and others : Staining for Iodine in Chromatograms of Human Plasma—an Artefact due to Thioureas or Thiouracils, 691, *erratum*, 1079
Turner, R. C., and others : Alpha Activity of certain Botanical Materials, 208
Tursky, Dr. T. : Effect of Potassium Cyanide Poisoning on the γ-Aminobutyric Acid-Level in the Brain, 322
Tweed (River) : Recapture in the, of a Sea-Trout marked in Devonshire (A. Swain, I. R. H. Allan and M. J. Bulleid), 877
Twentieth Century Darwinism : Genetics and (Cold Spring Harbor Symposia on Quantitative Biology, Vol. 24), *review* by Dr. H. Kalmus, 726
Twinning (Mimetic), in Urea–Ammonium Bromide (C. G. C. Catesby), 765
Twins (One-Egg), in the Mouse : Dichorial (Dr. A. J. Bateman), 339
Twitch (Muscle), and Tetanus : pH Changes during (A. Distèche), 1119
Two Aspects of Science (Sir George Thomson), 837
Two Heredities : The, *review* by Dr. J. D. Nisbet, 446
Two Means : Significance of the Difference between, when the Population Variances may be Unequal (John B. de V. Weir), 438
Two-Neuron Arc : Properties of the (Hind-Limb Reflexes in the Kitten), (Dr. Sten Skoglund), 134
Two R's of Plant Breeding, *review* by Dr. G. Haskell, 184
Two Types of Catalase-like Activity in Lactic Acid Bacteria (R. Whittenbury), 433 ; *erratum*, 466
Type of Host Plant Crop in Successful Biological Control of Insect Pests : Significance of the (D. C. Lloyd), 430
Types (Different), of Malnutrition : Influence of, on the ^{14}C-Lysine Metabolism in Young Rats (Prof. Kurt Schreier and Corinna Kazassis), 1117
Types (Two), of Catalase-like Activity in Lactic Acid Bacteria (R. Whittenbury), 433, *erratum*, 466
Tyrrell, A. C., and others : Isotopic Analysis of Silicon by Solid-Source Mass Spectrometry using Negative Ions, 683
Tzikulin, M. A. (Rodionov, V. N., and) : The Tunguska Meteorite, 1077

UBICHROMENOL in *Aspergillus fumigatus*, Fresenius : Ubiquinone (50) and (N. M. Packter and Dr. J. Glover), 413
Ubiquinone (50) and Ubichromenol in *Aspergillus fumigatus*, Fresenius (N. M. Packter and Dr. J. Glover), 413
UHF and VHF Bands : Television Field Trials of 405-Line and 625-Line Systems in the, 1957-1958 (British Broadcasting Corporation), 288
Uhler, Dr. R. L., and Hungate, Dr. F. P. : Relative Availability of some Strontium-90 Compounds in Soil, 252
Uhr, Jonathan W. : Development of Delayed-type Hypersensitivity in Guinea Pig Embryos, 957
Uhr, Jonathan W., and others : Delayed-type Hypersensitivity in Premature Neonatal Humans, 1130
Ujiie, Yukio, and others : High-Energy Bound Phosphate and Diabetes Mellitus, 702
Ulrich, Dr. Frank : Sodium and Potassium in Mitochondrial Membrane Fractions, 949
Ulrych, T. J., and others : Precision Intercomparisons of Lead Isotope Ratios—Broken Hill and Mount Isa, 754
Ultracentrifugation of Biological Macromolecules (Colloid and Biophysics Committee of the Faraday Society Discussion on), 905
Ultrasonic Velocities in Aqueous Electrolyte Solutions (Dr. C. G. Balachandran), 136
Ultra-sonic Velocity and Latent Heat of Vaporization : A Relation between (Prof. B. Ramachandra Rao and P. R. K. L. Padmini), 311
Ultra-thin Sections : A Vacuolar System in Cells of *Agrobacterium tumefaciens* as shown by Electron Microscopy of (Miguel Rubio-Huertos and Paul R. Desjardins), 1043

- Ultra-thin Sections of Vitrinite from a High-volatile Bituminous Coal . Absorption of Ultra-violet and Visible Light by (Sabri Ergun, J. T. McCartney and R. E. Walline), 1014
- Ultra-Violet Absorption Spectra of the Diazines (Prof. K. Keith Innes, James A. Merritt, Wayne C. Tincher and Shelby G Tilford), 500
- Ultra-Violet Absorption Spectra of the Molecules H_2O, HDO and D_2O (Dr. Jack Barrett and Dr. A. L. Mansell), 138 ; (R M. Golding), 139
- Ultra-Violet Absorption Spectra of Proteins in Deuterium Oxide (Dr. Shiro Takashima), 597
- Ultra-Violet Irradiation : Delayed Recovery of Airborne *Serratia marcescens* after Short-Time Exposure to (Dr R. L. Dimmick), 251
- Ultra-Violet Irradiation (Localized) : Influence of, on the Incorporation of Adenine-8-^{14}C and D,L-Methionine-^{35}S in *Acetabularia mediterranea* (Prof J. Brachet and Dr. M. J. Olszewska), 954
- Ultra-Violet Light : Potentiation of Hair-Growth by (B. E. Johnson), 159
  - Recovery in the Presence of Chloramphenicol of *Escherichia coli* B (H) Irradiated with (Kenshi Suzuki and Yukiko Iwama), 347
- Ultra-Violet and Visible Light : Absorption of, by Ultra-thin Sections of Vitrinite from a High-volatile Bituminous Coal (Sabri Ergun, J. T. McCartney and R E. Walline), 1014
- Uncertainty (Time), and Choice Reaction Time (Paul Bertelson and Jean-Paul Boons), 531
- Uncoupled Rat Liver Mitochondria : A High-Energy Phosphate Requirement for Succinate Oxidation in (Dr. Giovanni Felice Azzone and Dr Lars Ernster), 65
- Under-developed Countries . Support for, 971
- Under-developed Countries of the World, 266
- Understanding and Power, 809
- Underwood, Dr. E Ashworth : *Obituary* of Prof. Charles Singer, 827
- Undritz, E., and others : Sickling Phenomenon in Deer, 333
- Unequal : Significance of the Difference between Two Means when the Population Variances may be (John B de V. Weir), 438
- Unesco : Scientific Institutions and Scientists in Latin America, Vol 4, Argentina, 29
  - Symposium on Problems of the Arid Zones, 295
  - Fellowships for Research in the Use of Electronic Computers, 465
  - Educational Studies and Documents No. 36, Technical and Vocational Education in the U.S.A.—a Bibliographical Survey prepared by the United States Office of Education, 741
  - International Symposium on Cell Biology and Growth Inhibition, 836
- Unidentified Pharmacologically Active Substance extracted from Cerebral Hemispheres (P. F. L. Andrews, Shirley A. P. Price and Dr. G. B. West), 420
- Unification of Analytical Approaches to Engineering Problems, *review* by Prof J. Greig, 359
- Unified Cosmology Towards a (Prof. Reginald O. Kapp), *review* by Dr. C. W. Kilmister, 634
- Uniform Methods of Sugar Analysis, International Commission for : Report of the Proceedings of the Twelfth Session, Washington, D.C., 1958, *review* by Prof. E. L. Hirst, 9
- Union Carbide, Ltd. : Grant of £2,150 per annum (for three years in the first place) to the University of Southampton, to provide for a research fellowship and a research studentship in the Department of Chemistry, 743
- Uniqueness of Adenylic Acid in the Mediation of the Mutagenic Activity of Formaldehyde—Mechanism of Formaldehyde-induced Mutagenesis—the (Dr. Thomas Alderson), 485
- United Kingdom : Assistance from the, for Overseas Development (H.M. Treasury), 266
- United Kingdom Agricultural and Food Attaché in Argentina, 1075
- United Kingdom Atomic Energy Authority . *Zebra* (Zero Energy Breeder Reactor Assembly), 114
  - Report of the Committee on Training in Health and Safety to the Authority Committee on Health and Safety, 471
  - Sixth Annual Report (1959–60), 1082
  - Atom 1960—an Illustrated Summary of the Sixth Annual Report, 1084
  - Re-appointment of Lord Citrine, Sir James Chadwick and C. F. Kearton as part-time members, 743
  - Course for Trade Union Officials on the Industrial Uses of Radioisotopes, 905
  - *Hector*, a New Research Reactor, 992
- United Kingdom Atomic Energy Authority and the Agricultural Research Council : Joint Report on the Deposition of Strontium-89 and Strontium-90 on Agricultural Land and their Entry into Milk after the Reactor Accident at Windscale in October 1957, 1077
- United Kingdom Atomic Energy Research Establishment : Wantage Research Laboratory (B S Smith), 292
  - Appointment of Dr F A. Vick as director, 556
  - Appointment of Dr R Spence as deputy director, 556
  - Appointment of L. Grainger as assistant director, with special responsibilities for applied Research, 556
  - Radioactive and Natural Strontium in Human Bone (J. W. Arden, F J Bryant, E. H. Henderson, G. D Lloyd and A. G. Morton), 994
- United Kingdom Commonwealth Scholarship Commission : Scholarship Awards, 464
- United Kingdom Scientific Mission in Washington Appointment of Dr. H T. Hookway as director, 24
- United Nations (Food and Agriculture Organization) : Problems of the Arid Zones (Nomadism in relation to Grazing Resources—Nomadic Pastoralism), 296
  - Appointment of Dr. Marcel Autret as director of the Nutrition Division, 743
- United Nations (World Health Organization) · Technical Report Series No 192, Epidemiology of Cancer of the Lung, 115
  - Classification of Pharmaceutical Preparations—a Survey of Existing Legislation, 287
  - Public Health Papers No 3, Health Services in the U.S S R., 379
  - Technical Report Series No. 194, Local Health Service, 465
  - Official Records of the, No. 98, The Work of WHO, 1959—Annual Report of the Director-General to the World Health Assembly and to the United Nations, 468
  - Technical Report Series No. 193, Training of Teachers for Health Education, 648
  - Guide to Hygiene and Sanitation in Aviation, 911
- United States . Change of the Chlorine—Sodium Ratio in the Atmosphere with Altitude and Distance from the Source of Sodium Chloride, and the Distribution of Atmospheric Nitrate over the (Dr. Henry M. Papée and Dr Alberto Montefinale), 1103
  - Control of Scientific Research in the, *review* by R. Brightman, 181
  - Water Resources in the (Prof. W G V. Balchin), 562
- U.S.A. : Technical and Vocational Education in the—a Bibliographical Survey prepared by the United States Office of Education (Unesco, Educational Studies and Documents No. 36), 741
- United States Air Force Cambridge Research Center (Geophysics Research Directorate), with the co-operation of Lowell Technological Institute Research Foundation : Exploding Wires—Based on Conference on the Exploding Wire Phenomenon, 1959 (edited by William G. Chace and Howard K. Moore), *review* by Dr B. A. Thrush, 726
- United States Army (Mathematics Research Center) . Boundary Problems in Differential Equations—Proceedings of a Symposium held at the University of Wisconsin, 1959 (edited by Prof. Rudolph E. Langer), *review* by Prof E. T. Copson, 451
- United States Department of Agriculture : Supplements 9 and 10 to the Index-Catalogue of Medical and Veterinary Zoology, 559
- United States Department of Defense (Department of the Navy, Naval Research Advisory Committee) Basic Research in the Navy (Report prepared by Arthur D. Little, Inc.), 178
- United States Department of Health, Education and Welfare : Publication No. 739, Highlights of Research Progress in General Medical Sciences (1959), 200
  - Appointment of Dr. J H. Gerber as director of the Center for Aging Research, National Institutes of Health, 374
- United States Gas Chromatography Research Center (Barber-Colman Company, Houston), 289
- United States Information Service : Title of *Atoms for Peace Digest* changed to *Science Horizons*, 902
- United States Materials Research and Development for National Security, 470
- United States National Academy of Sciences : Election of Foreign Associates, 198
- United States National Academy of Sciences—National Research Council · Formation of a Committee on Chemical Control of Agricultural Pests and Conservation of America's Wild-Life, 114
  - The Biological Effects of Atomic Radiation, 380
  - Publication No. 718, More Effective Organization and Administration of Materials Research and Development for National Security, 470
  - Appointment of Prof Robert C. Elderfield as chairman of the Division of Chemistry and Chemical Technology, 647
  - Appointment of Dr. Edward P. Espenshade, jun., as chairman of the Division of Earth Sciences, 647
  - Appointment of Dr Emil W. Haury as chairman of the Division of Anthropology and Psychology, 647
  - Appointment of Prof. J Barkley Rosser as chairman of the Mathematics Division, 647
  - Publication No. 713, Digest of Literature on Dielectrics, Vol. 22, 1958 (edited by R A. Sodermann and L. F. Frisco), *review* by S. Weintroub, 728
  - Annual Report for 1958-59, 749
  - Nuclear Science Series, Report No. 29 (Publication No. 752) : Penetration of Charged Particles in Matter—Proceedings of an Informal Conference, Gatlinburg, Tennessee, 1958 (edited by A. Vehling), 1086
- United States National Academy of Sciences—National Research Council (International Union of Nutritional Sciences of the), and others : Fifth International Congress on Nutrition, 201
- United States National Bureau of Standards : Monograph No. 14, Bibliography on Molecular and Crystal Structure Models (Deane K. Smith), 903
  - Monograph No. 10, The Helium-4 Scale of Temperature (F. C. Brickwedde, H. van Dijk, M. Durieux, J R. Clement and J. K. Logan), 1077
- United States National Centre of Atmospheric Research : Appointment of Dr. Walter Orr Roberts as director, 200
- United States National Institutes of Health · Appointment of Dr. J. H. Gerber as director of the Center for Aging Research, 374
  - Tenth Annual Instrument Symposium and Research Equipment Exhibit, 559
- United States National Research Council—National Academy of Sciences : Formation of a Committee on Chemical Control of Agricultural Pests and Conservation of America's Wild-Life, 114
  - The Biological Effects of Atomic Radiation, 380
  - Publication No. 718, More Effective Organization and Administration of Materials Research and Development for National Security, 470
  - Appointment of Prof Robert C. Elderfield as chairman of the Division of Chemistry and Chemical Technology, 647
  - Appointment of Dr. Edward P. Espenshade, jun., as chairman of the Division of Earth Sciences, 647
  - Appointment of Dr. Emil W. Haury as chairman of the Division of Anthropology and Psychology, 647
  - Appointment of Prof. J. Barkley Rosser as chairman of the Mathematics Division, 647
  - Publication No. 713, Digest of Literature on Dielectrics, Vol. 22, 1958 (edited by R. A. Sodermann and L. F. Frisco), *review* by S. Weintroub, 728
  - Annual Report for 1958-59, 749
  - Nuclear Science Series, Report No 29 (Publication No. 752) · Penetration of Charged Particles in Matter—Proceedings of an Informal Conference, Gatlinburg, Tennessee, 1958 (edited by A Vehling), 1086
- United States National Research Council—National Academy of Sciences, (International Union of Nutritional Sciences of the), and others : Fifth International Congress on Nutrition, 201
- United States National Science Foundation : Grant of 500,000 dollars to the University Corporation on Atmospheric Research to assist in establishing the United States National Centre of Atmospheric Research, 200
  - Grants for Graduate Research Laboratories, 559
  - Financial support for the construction of the National Radio Astronomy Observatory at Green Bank, West Virginia, and the Kitt Peak National Observatory, Tucson, Arizona, 910

United States Office of Education (prepared by): Technical and Vocational Education in the U.S.A.—a Bibliographical Survey (Unesco, Educational Studies and Documents No. 36), 741
United States Record of Published Books, 116
United States Weather Bureau: World Weather Records, 1941-50, *review* by H. H. Lamb, 727
Universe: The Hollow (Prof Charles de Koninck), *review* by F. I. G. Rawlins, 890
Universities (British): Graduate Schools in (Prof. W. R. Niblett), 560
Universities (New Zealand) Report of the Committee on, 107
Universities Council for Adult Education: Report on the Year 1958-1959, 906
Universities Federation for Animal Welfare · Summer Congress, 374
University of Adelaide Appointment of Prof. R. N. Robertson as professor of botany, 740
  Appointment of Dr. H. B. S. Womersley as acting-head of the Department of Botany, 740
University of Birmingham: Appointment of Dr Stanley Mandelstam to the newly established chair of mathematical physics, 117, 197
  Appointment of Dr. R W. Whitworth and Dr. A. B. Robbins as lecturers in physics, 117
  Appointment of Dr. J. R. Majer as lecturer in chemistry, 117
  Appointment of Dr F. W. J. Teale and Dr. D. G. Walker as lecturers in biochemistry, 117
  Appointment of Dr. E. H. Creaser as lecturer in microbiology, 117
  Appointment of Dr. D. F. Gibbons as lecturer in physical metallurgy, 117
  Appointment of A. H. M. Hoare to a research fellowship in pure mathematics, 117
  Appointment of J. S. Lilley to a research fellowship in physics, 117
  Appointment of B Cockayne to a research fellowship in physical metallurgy, 117
  Appointment of E. N. Corlett as senior research fellow in the Department of Engineering Production, 117
  Appointment of Dr. L. E. Bush to the Bowman chair of physiology and to the directorship of the Department of Physiology, 465
  Title of professor of physiological chemistry conferred on Dr. W. V. Thorpe, 465
  Appointment of Dr. J. D. Dowell, Dr. P. Swinbank and C. P. van Zyl as lecturers in physics, 465
  Appointment of Dr. J. M. Webber as lecturer in chemistry, 465
  Appointment of K. Foster as lecturer in mechanical engineering, 465
  Appointment of Dr. G. W. Rose as lecturer in industrial metallurgy, 465
  Appointment of Dr V. J. Emery as lecturer in mathematical physics, 465
  Appointment of Dr. E. F. Stack-Forsyth as lecturer in electrical engineering, 465
  Appointment of R. N. Morris as lecturer in econometrics and social statistics, 465
  Appointment of Dr. T. F. Tuan to a research fellowship in mathematical physics, 465
  Appointment of Dr. N. Pessall and B. Cockayne to research fellowships in physical metallurgy, 465
  Appointment of D. J. White to be Kenward Memorial Fellow in engineering production, 465
  Appointment of H. R. Shaylor as Staff Fellow in nuclear physics, 465
  Grant of £26,000 to Prof. J. Sayers for Space Research (electron and ion-population studies of the upper atmosphere and interplanetary space), 744
University of Bristol: Appointment of Prof. T. K. Ewer to the newly established chair of animal husbandry, 465, 647
  Appointment of Dr. P. C. Caldwell as lecturer in biochemistry within the Department of Zoology, 465
  Appointment of A. J. B. Cruickshank as lecturer in physical chemistry, 465
  Appointment of Dr. I. O. Sutherland as lecturer in organic chemistry, 465
  Appointment of Dr. P. H. Fowler to a research fellowship in physics, 465
University of California: Appointment of Prof George N. Briggs as chairman of the Department of Nutrition in the College of Agriculture, 290
University of Cambridge: Appointment of Dr A. S. Parkes to the newly established Marshall chair of the physiology of reproduction, 113
  Grant of £250 from the Gulbenkian Foundation to the expedition to British Guiana, 558
  Election of C. St J Wilson to a Fellowship of Churchill College, 742
  Election of R. A Y. Jones, A. O. Gilchrist, C.'B. Cottrell and A. Howie to Junior Research Fellowships of Churchill College, 742
  Election of Prof. E. E. Saltpeter and Dr. J. D. Watson to Overseas Fellowships of Churchill College, 742
  Grants for Space Research—£1,694 to Dr. K. G. Budden (for research into the theory of propagation of radiations from artificial satellites); £2,678 to Prof. M Ryle (for the recording and the interpretation of Doppler and Faraday effects in the radiations from artificial satellites); and £11,230 to Dr. F. G. Smith (for the measurement of cosmic radio noise by receivers mounted on rockets and satellites), 744
University of Canberra: Appointment of Prof. L. G. H. Huxley as vice-chancellor, 290
University of Cape Town: Appointment of Dr. J. M. Winterbottom as director of the Percy Fitzpatrick Institute of African Ornithology, 201
University of Durham: Grant of £2,700-£3,400 over two years from the Gulbenkian Foundation to the Institute of Education, 558
University of Edinburgh: Appointment of Dr. J. P. Duguid as reader in bacteriology, 465
  Appointment of Dr. C. A. Beevers as reader in chemistry, 465
  Appointment of J. R. Small as lecturer in accounting and business methods, 465
  Appointment of Dr. C. G. Thomson as lecturer in clinical chemistry, 465
  Appointment of Dr. D. J. McAuliffe as lecturer in ophthalmology, 465
  Appointment of Dr. F. M. Martin as lecturer in public health and social medicine, 465
  Appointment of Dr. P. H. Calderbank to the chair of chemical technology, 555
University of Giessen (Justus Liebig): Roentgen Prize awarded to J. B Adams, 201
University of Leeds: Retirement of Prof. E. A. Spaul from the chair of zoology, 197
  Appointment of Dr. J. M Dodd to the chair of zoology, 197
  Appointment of Dr. F. Hepburn as lecturer in medical physics, 465
  Grant of £5,000 from the Department of Scientific and Industrial Research to the Department of Physics, 465
  Grant of £2,100 from the Cement and Concrete Association to the Department of Civil Engineering, 465
  Grant of 7,000 dollars from the Muscular Dystrophy Association of America to the Department of Biomolecular Structure, 465
University of Leicester: Appointment of Dr. S. G M. Lee to the new chair of psychology, 743, 901
  Appointment of Dr. M. C. R. Symons to the new chair of physical chemistry, 743
  Appointment of Dr. H. L. Kornberg to the new chair of biochemistry, 743, 1075
  Appointment of W. B. Birmingham as senior lecturer in economics, 743
  Appointment of Dr. J E. Brown, Dr. O. P D. Cutteridge, and Dr. R W. Maxwell as senior lecturers in engineering, 743
  Appointment of P. S Cohen as lecturer in sociology, 743
  Appointment of D. J Cockrell as lecturer in engineering, 743
  Appointment of Dr. W. Sluckin as lecturer in psychology, 743
  Grant of £13,006 to Prof. E. A. Stewardson for Space Research (for investigations of solar and stellar soft X-Ray emissions), 744
University of Liverpool: Appointment of R. L Plackett as reader in mathematical statistics, 117
  Appointment of A. C. Shuttleworth as reader in veterinary surgery, 117
  Appointment of Dr. C. L. Smith as reader in zoology, 117
  Appointment of Dr. A. S. Aldred to a senior lecturership in electric power engineering, 117
  Appointment of Dr. A. Bolton to a senior lecturership in civil engineering, 117
  Appointment of Dr. H. W. Douglas and Dr. T B. Grimley to senior lecturerships in inorganic and physical chemistry, 117
  Appointment of Dr V. H. Heywood to a senior lecturership in botany, 117
  Appointment of Dr. J. F. Norbury to a senior lecturership in fluid mechanics, 117
  Appointment of Dr. T. G. Richards to a senior lecturership in physiology, 117
  Appointment of Dr. I. C. Geddes to a senior lecturership in anaesthesia, 117
  Anpointment of Dr. J S. Scott to a senior lecturership in obstetrics and gynaecology, 117
University of London: Appointment of Dr. P. G. Saffman as reader in mathematics at King's College, 117
  Appointment of Dr. D. V. Ager as reader in geology at the Imperial College of Science and Technology, 117
  Appointment of Dr. M. Shepherd as reader in psychiatry at the Institute of Psychiatry, 117
  Title of professor of physics in the University (at University College) conferred on Dr. E. H. S Burhop, 201
  Grant of £3,800 from the Leverhulme Trust Fund to Queen Elizabeth College, to enable a sociological research programme to be started in the Department of Nutrition, 201
  Appointment of Dr. Paul Morpurgo as Leverhulme Research Fellow in the sociology of nutrition at Queen Elizabeth College, 201
  A Wellcome Research Fellowship awarded to Dr. Angela E. R. Taylor to enable her to undertake research on the metabolic requirements of helminths, using radioactive tracers, in the Department of Biology at Queen Elizabeth College, 201
  Grant of £56,000 from the London Research Foundation to Queen Elizabeth College, to further the research work of the Department of Nutrition, with special reference to its work on fertility control, 201
  Retirement of Prof W. Robson from the University chair of biochemistry at King's College, 286
  Appointment of Dr. H. Harris to the University chair of biochemistry at King's College, 286
  Westfield College—New Faculty of Science, 361
  Appointment of Prof E. H. Bellamy to the chair of physics at Westfield College, 361
  Appointment of Prof. W. Klyne to the chair of chemistry at Westfield College, 361
  Appointment of Prof. G. E. Fogg to the chair of botany at Westfield College, 362
  Appointment of Prof. J. E. Webb to the chair of zoology at Westfield College, 362
  Appointment of Prof. E. B. Sondheimer to the chair of mathematics at Westfield College, 363
  Foundation Oration at Goldsmiths' College, The Diffusion of Knowledge (Dr. Michael Grant), 371
  Appointment of A F. Huxley as Jodrell professor of physiology at University College, 371
  Seminar at University College on Colloid and Polymer Science, 378
  Appointment of Sir Willis Jackson to the chair of electrical engineering at the Imperial College of Science and Technology, 463
  Appointment of Dr. C. B. B. Downman to the Sophia Jex-Blake chair of physiology at the Royal Free Hospital School of Medicine, 466
  Appointment of Dr. I. Doniach to the chair of morbid anatomy at the London Hospital Medical School, 466
  Appointment of Dr. J. Hamilton to the second chair of physics at University College, 466, 555
  Appointment of A. J. Buller to the readership in physiology at King's College, 466
  Appointment of J. C. de Courcy Henderson to the readership in reinforced concrete structures at the Imperial College of Science and Technology, 466
  Title of professor of physics in the University (at the Imperial College of Science and Technology) conferred on Dr. H. Elliot, 466
  Title of professor of organic chemistry in the University (at Queen Mary College) conferred on Dr. W. J. Hickinbottom, 466

Title of professor emeritus in the University conferred on Prof. T. J. Bosworth (veterinary pathology), Prof. E S. Pearson (statistics), Prof. Dorothy S. Russell (morbid anatomy), Prof. W. Smith (bacteriology), and Prof E. E. Turner (chemistry), 466
Appointment of Prof E. T. C. Spooner as dean of the London School of Hygiene and Tropical Medicine, 466
Grant of £50 from the Gulbenkian Foundation to the Wye College Exploration Society's expedition to Morocco, 558
Appointment of Dr. Richard Creese to the readership in physiology at St. Mary's Hospital Medical School, 743
Appointment of Dr. L M. Jackman to the University readership in organic chemistry at the Imperial College of Science and Technology, 743
Grants to the Imperial College of Science and Technology for Space Research—£7,275 to Dr. H E Elliot (for satellite measurements of the primary cosmic-ray energy spectrum), and £1,500 to Dr. H. E. Elliot (for an investigation into cosmic-ray intensity variations at rocket altitudes); and £7,935 to Dr S. H Hall (for geomagnetic field measurements in the Earth's upper atmosphere), 744
Grants to Dr. R. L. F. Boyd, University College, London, for Space Research—£8,880 (for the development and use of photoelectric satellite tracking equipment, and £35,450 (for rocket research in the upper atmosphere of (1) atmospheric temperature, density and winds, (2) ionospheric temperature, density and composition, (3) short-wave-length solar radiation, and (4) stellar ultra-violet light), 744
Appointment of G. Belyavin to the University chair of bacteriology at University College Hospital Medical School, 904
Appointment of E. J. Ambrose to the University readership in physical chemistry at the Institute of Cancer Research, Royal Cancer Hospital, 904
Appointment of Dr. F. A. Holton to the University readership in veterinary biochemistry at the Royal Veterinary College, 904
Title of reader in chemistry (at the Institute of Cancer Research, Royal Cancer Hospital) conferred on G M Timmis, 904
Title of reader in mechanical engineering (at Queen Mary College) conferred on Dr. C. R. Webb, 904
University of London Institute of Psychiatry: Appointment of Dr. M. Shepherd as reader in psychiatry, 117
University of Manchester: Summer School in Modern Methods of Crystal Structure Determination, on behalf of the Department of Physics of the Manchester College of Science and Technology, 201
Course of lectures at the Manchester College of Science and Technology on Problems of Radioactivity at Water and Sewage Works, 743
Grants for Space Research—£15,277 to Dr. R C Jennison (for micrometeorite investigations from an Earth satellite), £15,020 to Dr. R. C Jennison (for low-frequency radio astronomy from an Earth satellite), and £2,500 to Prof. A C. B. Lovell (for the tracking of satellites and space probes), 744
University of Melbourne: Honorary degree of Doctor of Laws conferred on Sir Alexander Todd, 1081
University of Nottingham · Proceedings of the Sixth Easter School in Agricultural Science, 1959 (The Measurement of Grassland Productivity), (edited by Prof. J. D. Ivins), review by Dr. G. W. Cooke, 544
Election of Prof. A. G. Smith as first holder of the Hives chair of thermodynamics, 743
Proceedings of the Fifth Easter School in Agricultural Science, 1958 (Nutrition of the Legumes), (edited by Prof E. G. Hallsworth), *review* by Prof. Walter Stiles, 815
University of Oxford · Mullard Cryomagnetics Laboratory, 25
New Laboratory of the Department of Metallurgy, 105
Appointment of D. F W. Baden-Powell as lecturer in prehistoric archaeology, 117
Appointment of Dr M. J. Kearsley as lecturer in mathematics, 117
Appointment of Dr. H. R. Harré as lecturer in the philosophy of science, 117
Non-residential Summer School on Numerical Analysis, 374
Grant of £250 from the Gulbenkian Foundation towards the expedition to the Peruvian Andes, 558
Grant of £140 from the Gulbenkian Foundation to the Oxford Women's expedition to the Azores, 558
Grant of £100 from the Gulbenkian Foundation to the expedition to Cyrenaica, 558
Grant of £10,000 from the Gulbenkian Foundation to the Institute of Education, 558
Grant of £4,560 to Dr. J T Houghton for Space Research (for the development of photoconductive material for satellite measurements of infra-red radiation), 744
Appointment of Dr. Graham Higman to the Waynflete chair of pure mathematics, 830
University of Peshawar: Appointment of Dr. N E. Odell to the chair of geology, 905
University of Pittsburgh: Appointment of Dr. Theodore Holstein as professor of physics, 905
Appointment of Dr. Robert L. Wolke as associate professor of chemistry, 905
Appointment of Dr. David S. Feingold as assistant professor of bacteriology, 905
Appointment of Dr. Robert Silverman as assistant professor of mathematics, 905
University of Reading: Report for 1959 of the Museum of English Rural Life, 26
Report of the National Institute for Research in Dairying (1959), 909
University of St. Andrews Appointment of Dr J. A. Macdonald as professor of botany, 1075
University of Sheffield. Special Report No. 64, Precipitation Processes in Steels—Report of a Conference organized by the Department of Metallurgy, 1958, *review* by Prof. F. C. Thompson, 9
Appointment of R. K. Kelsall to the newly created chair of sociological studies, 463
Appointment of F. W. G. Warren as lecturer in applied mathematics, 466
Appointment of Dr. D N Jones and Dr. R. N. Dixon as lecturers in chemistry, 466
Appointment of Dr. J. M. West as lecturer in metallurgy, 466
University of Southampton: Contribution of £5,000 from the Ford Motor Co, Ltd, to the 1962 Centenary Appeal Fund, 290
Title of reader in history conferred on A T. Patterson, 290
Title of reader in mathematics conferred on Dr W H. Cockcroft, 290
Appointment of H. C. Tottenham to the readership in structural engineering, 290
Appointment of H. S. Allen as lecturer in civil engineering, 290
Appointment of C. H. B. Mee as assistant lecturer in physics, 290
Contribution of £17,500 to the Centenary Appeal Fund from the Westland Aircraft, Ltd, for a readership in helicopter engineering, 743
Grant of £2,150 per annum (for three years in the first place) from Union Carbide, Ltd., to provide for a research fellowship and a research studentship in the Department of Chemistry, 743
University of Sydney: New Chemical Laboratories in the (Prof. R. J. W. Le Fevre), 833
Degree of D Sc., *honoris causa*, conferred on Sir Robert Robinson, 1081
University of Wales: Appointment of Dr. S. P Hutton as professor of mechanical engineering in the University College of South Wales, Cardiff, 117, 555
Appointment of I G. Evans as lecturer in pure mathematics at University College, Swansea, 117
Appointment of Dr H. T. Miles as lecturer in physics at University College, Swansea, 117
Appointment of Dr. J. A. Schofield as lecturer in organic chemistry at University College, Swansea, 117
Appointment of Dr S K. Zaremba as senior lecturer in pure mathematics at University College, Swansea, 117
Appointment of Dr. D. R Davies to the newly created chair of applied mathematics in the University College of North Wales, Bangor, 197
Grant of £16,530 to Prof W. J G Beynon, University College of Wales, Aberystwyth, for Space Research (measurement of electron density/height profiles with rockets using the Doppler method and the pulse method), 744
University (Agricultural): India's First, 556
University College, London: Title of professor of physics in the University of London conferred on Dr. E. H. S Burhop, 201
Appointment of A. F. Huxley as Jodrell professor of physiology, 371
Seminar on Colloid and Polymer Science, 378
Appointment of Dr. J. Hamilton to the second chair of physics, 466, 555
Grants to Dr R. L. F. Boyd for Space Research—£8,880 (for the development and use of photoelectric satellite tracking equipment, and £35,450 (for rocket research in the upper atmosphere of (1) atmospheric temperature, density and winds, (2) ionospheric temperature, density and composition, (3) short-wave-length solar radiation, and (4) stellar ultra-violet light), 744
University College of North Wales, Bangor: Appointment of Dr D. R. Davies to the newly created chair of applied mathematics, 197
University College of South Wales and Monmouthshire, Cardiff: Appointment of Dr. S. P. Hutton as professor of mechanical engineering, 117, 555
University College, Swansea: Appointment of I G Evans as lecturer in pure mathematics, 117
Appointment of Dr H T. Miles as lecturer in physics, 117
Appointment of Dr. J. A. Schofield as lecturer in organic chemistry, 117
Appointment of Dr. S K Zaremba as senior lecturer in pure mathematics, 117
University College of Wales, Aberystwyth Grant of £16,530 to Prof. W J. G Beynon for Space Research (measurement of electron density/height profiles with rockets using the Doppler method and the pulse method), 744
University College of the West Indies: Imperial College of Tropical Agriculture to be merged into the, 374
University College Hospital Medical School: Appointment of G. Belyavin to the University of London chair of bacteriology, 904
University Corporation on Atmospheric Research. Grant of 500,000 dollars from the United States National Science Foundation, to assist in establishing the United States National Centre of Atmospheric Research, 200
University Education: The Place of Physiology in (Prof. J. A. B Gray), 719
University Education in Britain, 719
University Education in New Zealand (Prof. W. J. Chapman), 107
University Students (South African). Daily Food Consumption by (Sonia E. Walker), 381
Unproductivity in the Colchicine-induced Tetraploids of *Annona squamosa*. L. (Prof. Ahmad Shamsul Islam), 343
Upper Atmosphere Wind: Effect of, on the Rotation of Satellite 1958δ1 (Dr C R. Faulkner), 926
Upper-Atmosphere Wind Studies by *Skylark* Rocket Sodium Experiment (Dr G V Groves), 1001
Uptake of Heparin by Cells (Dr. G Csaba and Dr Eszter Kapa), 711
Uptake of Thymidine and Synthesis of Deoxyribonucleic Acid in Mouse Ascites Cells (Dr A. R. Crathorn and Dr K. V. Shooter), 614
Uranium in the Periodic Table. Positions of Thorium and (Dr. A. E. Dwight), 505
Uranium, Thorium, Plutonium, Neptunium: Crystal Chemistry of Simple Compounds of (E. S Makarov), translated from the Russian by E. B. Uvarov, *review* by Dr. L. E J Roberts, 728
Urbański, Prof T.: Elected a member of the Chemistry section of the Leopoldina Academy of Natural Sciences, 1079
Urbański, Prof. T., and others Antineoplastic Activity of Tetrahydro-1,3-oxazine Derivatives, 426
Urea—Ammonium Bromide: Mimetic Twinning in (C. G. C. Cateby), 765
Urea—Lithium Bromide Solutions: Viscosity of Concentrated (Dr. Irving I. Geschwind), 324
Uretz, Prof. Robert B. (Freifelder, Dr David, and): Dye-sensitized Photoreactivation of X-Ray Damage in Diploid Yeast, 953
Urey, Prof H. C.: Origin of Tektites, 855
Uri, Dr N. · Some Aspects of Autoxidation, 746
Physico-chemical, Biological and Applied Aspects of Autoxidation (Initiation Phase in the Aerobic Oxidation of Linoleic Acid and its Esters), 746
Uric Acid (Blood), in Five Species of Birds Variability in Levels of (Jack W Hudson and Charles R. Taylor), 788

Urinary Amino-Acid Pattern of Cats on Diets of varying Protein Content (Dr. J. P. Greaves and Dr. Patricia P. Scott), 242

Urinary Excretion of β-Amino-isobutyric Acid after Injection of Thymidine labelled with Tritium (Dr. Georg B. Gerber, Gisela Gerber and Kurt I. Altman), 956

Urinary Excretion of Œstrogens in Cases of Chronic Prostato-vesiculitis (Prof. Gunnar Nylander), 154

Urine of Cattle: Occurrence of Keto-Acids in Blood Serum and, in comparison with Man, Horse, Sheep and Dog (Dr. C. J. G. van der Horst), 146

Urine (Normal): The Plasma Proteins in (Dr. I. Berggård), 776

Ursin, Dr. Erik: A Quantitative Investigation of the Echinoderm Fauna of the Central North Sea (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 24), *review* by Dr. A. J. Southward, 360

Use of Azo Dyestuffs for the Polarographic Determination of the Lanthanides (T. M. Florence and L. E. Smythe), 771

Use of Case Studies: Research Necessary for the Preparation and (South London Committee of the British Institute of Management Conference on), 660

Use of Collagenase in the Characterization of Pseudocoelomic Membranes of *Ascaris lumbricoides* (Barbara Dawson), 798

Use of Dieldrin in the Control of *Glossina palpalis* (R-D) in Nigeria (J. B. Davies), 84

Use of Diodone in Renal Studies in Sheep (B. J. Potter), 698

Use of Electronic Computers: Research in the (Unesco Fellowships for), 465

Use of Ferritin-conjugated Antibody to Localize Antigen by Electron Microscopy (Richard A. Rifkind, Konrad C. Hsu, Councilman Morgan, Beatrice C. Seegal, Alice W. Knox and Harry M. Rose), 1094

Use of Gamma-Radiation Sources for the Sterilization of Pharmaceutical Products (Report of the Association of the British Pharmaceutical Industry), 903

Use of Measuring Instruments: Chemical Plant Instrumentation—some Notes on the (Association of British Chemical Manufacturers), 1079

Use of Reflectance Measurements in assessing the Colour Changes of Ageing Bloodstains (Dr. D. Patterson), 688

Use of Stereographic Projection in Structural Geology (Dr. F. C. Phillips), second edition, *review* by John Sutton, 729

Use of Toxic Chemicals in Agriculture and Food Storage (Request from the Research Study Group for evidence), 290

Uses (Industrial), of Radioisotopes (United Kingdom Atomic Energy Authority Course for Trade Union Officials), 905

U.S.S.R.: Automatic Programming in the, *review* by R. J. Ord Smith, 92
Health Services in the (United Nations, World Health Organization, Public Health Papers No. 3), 379
Nuclear Research in the, *review* by Dr. S. C. Curran, 630
Polar Research in the, 287
The Proterozoic in the, 742

U.S.S.R.—Great Britain Society and the Moscow Physiological Society: Joint Meeting to celebrate the centenary of the births of W. M. Bayliss and J. S. Haldane, 912

Utilization of Nitrogen and its Compounds by Plants—Symposia of the Society for Experimental Biology, No. 13 (edited by H. K. Porter), *review* by Prof. Walter Stiles, 815

Uvarov, Dr. B. P.: Problems of the Arid Zones (Development of Arid Lands and its Ecological Effect on the Insect Fauna), 295

VACCINATION against Whooping Cough, Diphtheria and Tetanus (Research Defence Society, *Conquest* Pamphlet No. 11), 649

Vacek, Dr. A.: Role of Initial Value of Metabolic Processes in Oxygen Consumption Changes in Rats during Irradiation, 76

Vacek, Dr. A. (Strmiska, Dr. Jaroslav, and): Effect of Electronarcosis on Oxygen Consumption and Carbon Dioxide Output, 151

Vacuolar System in Cells of *Agrobacterium tumefaciens* as shown by Electron Microscopy of Ultra-thin Sections (Miguel Rubio-Huertos and Paul R. Desjardins), 1043

Vacuoles: A Method for the Isolation of Plant Protoplasts and (Dr. E. C. Cocking), 962

Vacuum Systems (Demountable): Direct Observation of Surface Contamination formed in (D. E. Bradley), 227

Vacuums (Higher): Pump Fluids for (Kenneth Hickman), 405

Vainio, T., and others: Protection against Liver Injury due to Murine Hepatitis Virus, 507

Valence-Bond Structures—a New Proposal (Dr. J. W. Linnett), 859

Value (Historical): Preservation of Films of, 199

Value (Initial), of Metabolic Processes: Role of, in Oxygen Consumption Changes in Rats during Irradiation (Dr. A. Vacek), 76

Values (Glucosamine), of Muramic Acid and other Amino-Sugars by the Elson and Morgan Method (R. E. Strange), 38

Values (Nutritive), of Carbohydrates for the Silkworm, *Bombyx mori* (Dr. Toshio Ito), 527

Van, T. K.: Secondary Selection in Pure Lines of Rice, 169

Van Adrichem, M. E., and others: Structures of some Acetyl-serine Peptides from Acetyl-chymotrypsin, 596

van Dijk, H., and others: The Helium-4 Scale of Temperature, 1077

van Duijn, Jun., C.: Effect of Acridine Orange on Living Bull Spermatozoa, 1006

van Heyningen, Dr. Ruth (Pirie, Dr. Antoinette, and): Comparison between the Effects of Cystamine and of Anoxia on the Rate of Mitosis in Lens Epithelium, 947

van Mieghem, Prof. J.: Awarded the International Meteorological Organization Prize by the World Meteorological Organization, 740

van Mieghem, Prof. J. (edited by H. E. Landsberg and): Advances in Geophysics, Vols. 4 and 5, *review* by Dr. S. H. Hall, 1060

Van Riebeeck Lectures of the South African Broadcasting Corporation: Africa's Place in the Emergence of Civilization (Prof. Raymond A. Dart), *review* by M. C. Burkitt, 891

Van Steenwinkel, R. (Thomaes, G., and): The Second Virial Coefficient of Methane at Low Temperature, 229

van Vliet, W. F., and Schriemer, W. H.: Determination of Nonanol Residues in Potatoes, 235

Van Wyk, Prof. W. R., and de Wilde, Prof. J.: Problems of the Arid Zones (Microclimatology, physical and biological), 295

van Zyl, C. P.: Appointed a lecturer in physics at the University of Birmingham, 465

van de Veerdonk, Dr. F. C. G.: Serotonin, a Melanocyte-stimulating Component in the Dorsal Skin Secretion of *Xenopus laevis*, 948

Van der Hoeven, F. G., and others: Ocean Currents in McMurdo Sound, 867

van der Horst, Dr. C. J. G.: Occurrence of Keto-Acids in Blood Serum and Urine of Cattle in comparison with Man, Horse, Sheep and Dog, 146

van der Wiel, Dr. A.: Two Highly Selective Solvents for Gas-Liquid Chromatography Analysis of C_1–C_4 Hydrocarbons, 142

van der Zweep, Dr. W.: Herbicides and the Soil (Practical Use of Herbicides in relation to their Persistence in the Soil), 377

Vanek, Dr. J., and Stelzner, J.: Oscillatory Character of Amplitude Curves for Seismic Body Waves, 491

Vaporization: A Relation between Ultrasonic Velocity and Latent Heat of (Prof. B. Ramachandra Rao and P. R. K. L. Padmini), 311

Vaporization of Sulphides: Mass Spectrometric Investigation of the, and the Dissociation Energy of Se_2 (R. Colin, Prof. P. Goldfinger and M. Jeunehomme), 408

Vapour-Phase Polymerization of Methyl Acrylate: Generation of Aerosols by (R. Pearson and G. Langer), 235

Vapour (Water) Content of the Air: Average (J. K. Bannon and L. P. Steele), 748

Variability in Levels of Blood Uric Acid in Five Species of Birds (Jack W. Hudson and Charles R. Taylor), 788

Variances (Population) may be Unequal: Significance of the Difference between Two Means when the (John B. de V. Weir), 438

Variant (A Bleached), of *Euglena gracilis* showing a Doubling of the Content of Deoxyribonucleic Acid (Dr. George Brawerman, Carole A. Rebman and Prof. Erwin Chargaff), 1036

Variation (Continuous): Genetics of, *review* by Prof. Kenneth Mather, 813

Variation (Diurnal), of Cosmic Rays: Dependence on Latitude of the Amplitude of the (Arne Eld Sandström, Eric Dyring and Stig Lindgren), 1099

Variation (Latitudinal), of Frost-point Temperature and Wind: Airborne Measurements of (N. C. Helliwell), 993

Variations in Temperature: Effect of, on Meiosis in *Gagea reticulata* Schultes (Dr. C. P. Malik), 805

Varieties (Seedless and Seeded), of *Vitis vinifera*: Toxicity of Gibberellin to (Dr. Robert J. Weaver), 1135

Vascular Muscle: Effect of the Cations of the Lyotropic Series on the Tension of (Prof. L. Laszt), 329

Vasil, Dr. I. K.: Pollen Germination in some Gramineae—*Pennisetum typhoideum*, 1134

Vasoconstrictor Amines: Influence on the Effect of, by Pretreatment with Reserpine (H. C. Sabelli), 784

Vasotocin (Arginine): Evidence for the Identity of Natriferin, the Frog Water-Balance Principle and (Prof. Wilbur H. Sawyer), 1030

Vector Space and its Application in Crystal-Structure Investigation (Prof. Martin J. Buerger), *review* by Dr. J. W. Jeffery, 975

Végétaux (Tissus): La Culture des (Prof. R. J. Gautheret), *review* by A. Allsopp, 976

Vehling, A. (edited by): Penetration of Charged Particles in Matter—Proceedings of an Informal Conference, Gatlinburg, Tennessee, 1958 (United States National Academy of Sciences—National Research Council, Nuclear Science Series, Report No. 29), 1086

Velocities (Ultrasonic), in Aqueous Electrolyte Solutions (Dr. C. G. Balachandran), 136

Velocity of Conduction and Spinal Transmission of Proprioceptive Hind-Limb Reflexes (Hind-Limb Reflexes in the Kitten), (Dr. Sten Skoglund), 132

Velocity (Ultra-sonic), and Latent Heat of Vaporization: A Relation between (Prof. B. Ramachandra Rao and P. R. K. L. Padmini), 311

Venkata Ram, Dr. C. S.: Foliar Application of Nutrients and Rhizosphere Microflora of *Camellia sinensis*, 621

Venkataraman, Prof. K.: Elected a member of the Chemistry section of the Leopoldina Academy of Natural Sciences, 1079

Venom (*Bothrops jararaca*): Bradykinin-releasing Factor from (Dr. Olga B. Henriques, Mina Fichman and W. T. Beraldo), 414

Vent-Axia Insect Suction Traps, 559

Vertebrates: Classification of the Cestodes of, *review* by Dr. Ben Dawes, 723

Ventricle (Lateral), of the Rat: Hunger Reduction produced by Injecting Glucose into the (L. J. Herberg), 245

Ventricle (Rat's): Effect of Nitrate Ion on the Distribution of Sucrose in the (S. T. Taketa, C. G. Alexander and Prof. G. A. Feigen), 419

Ventricles (Heart): Platelet-Count Differences in Blood of the Rabbit Right and Left (Dr. J. George Sharnoff and Dr. Vito Scardino), 334

Venus: The Transits of—a Study of Eighteenth-Century Science (Prof. Harry Woolf), *review* by Dr. David S. Evans, 636

Verdier, Dr. E. T.: Science and Technology in Africa South of the Sahara, 198

Verhoogen, Prof. J. (Fyfe, Prof. W. S., and): Covalent Super-Exchange in Solid State Physics, 1108

Vermiculite (Clay Minerals, Montmorillonite and): Aluminium Interlayers in—Laboratory Synthesis (B. L. Sawhney), 261

Vermiculite Crystals in Water: Macroscopic Swelling of (G. F. Walker), 312

Vero, Lidia, and others: Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture, 238

Veronese, Vittorino: Problems of the Arid Zones, 295

Vertebrate Morphology: A Manual of Practical (J. T. Saunders and Dr. S. M. Manton), third edition, *review* by Dr. N. B. Marshall, 9

Very Low-Frequency Hiss observed at Byrd Station, Antarctica: Association between Aurorae and (Dr. L. H. Martin, Dr. R. A. Helliwell and K. R. Marks), 751

Veterinary College (Royal), London: Appointment of Jennifer Remfry as Junior Universities Federation for Animal Welfare (UFAW) Research Fellow, to assist Dr. Phyllis G. Croft in research relating to anaesthetics and relaxants, 743
Appointment of Dr. F. A. Holton to the University of London readership in veterinary biochemistry, 904

Veterinary Medicine : Human and (Dr W. J. Hayes, Jr., Dr. S W. Simmons and Dr. E. F. Knipling), (edited by Dr. S. W. Simmons), (DDT—the Insecticide DDT and its Significance, edited by Paul Müller, Vol. 2), *review* by Prof. D. S. Bertram, 271
Veterinary Science : Advances in (edited by C. A. Brandly and E L. Jungherr), Vol. 5, *review* by Prof. H Burrow, 448
Veterinary Zoology (Medical and) : Index-Catalogue of (United States Department of Agriculture), Supplements 9 and 10, 559
VHF Bands (UHF and) : Television Field Trials of 405-Line and 625-Line Systems in the, 1957-1958 (British Broadcasting Corporation), 288
Viability and Germination Inhibitor of the Seed of Rice (Prof. S M. Sircar and Manjula Biswas), 620
Vicia faba : Radiation Biology of, in relation to the General Problem (Dr. John Read), *review*, 8
Vick, Dr. F. A. : Appointed director of the Atomic Energy Research Establishment, 556
Victoria (Lake) : Breeding Sites of Non-Cichlid Fishes in (Dr. Philip S Corbet), 616
Viewing of 'Thorotrast' in Tissue Sections : Combined Oil-immersion, Phase-contrast and Dark-ground (Dr. E. W. Baxter), 162
Vilček, Dr. J. : An Interferon-like Substance released from Tick-borne Encephalitis Virus-infected Chick Embryo Fibroblast Cells, 73
Vines (Grape), in Europe and North America : Sap-Transmissible Viruses associated with Diseases of (C. H. Cadman, H. F. Dias and B. D. Harrison), 577
Vinograd, Dr. Jerome, and Hutchinson, William D. : Carbon-14-Labelled Hybrids of Haemoglobin, 216
Vinogradov, A. P. : The Geochemistry of Rare and Dispersed Chemical Elements in Soils, (translated from the Russian), second edition, *review* by A. H. Debnam, 629
Virág, Dr. S., and others : Role of Mucoid Substances of the Aorta in the Deposition of Lipids, 152
Virial Coefficient (The Second), of Methane at Low Temperature (G. Thomaes and R. Van Steenwinkel), 229
Virtanen, Prof. A. I. : Elected an honorary member of the American Institute of Nutrition, 374
Virus of Tick-borne Encephalitis : Virus and Antibodies in the Lymph and Blood of Sheep infected experimentally with the (Doubravka Málková), 716
Virus (Cucumber Mosaic), Infection Process : Direct Infra-Red Spectral Analysis of the (Prof. G. W. Cochran, G. W. Welkie and J. L Chidester), 1049
Virus (Influenza) propagated in De-embryonated Eggs · Physical Incompleteness of (Martin Hanig and Joseph M. Stern), 40
Virus (Murine Hepatitis) · Protection against Liver Injury due to (Dr J. D. Judah, G. Bjotvedt and T. Vainio), 507
Virus (Plant) : Activation of One, by Another (B. Kassanis and H. L. Nixon), 713
Virus (Polyoma) : Production of Tumours in *Rattus (Mastomys) natalensis* by (Dr. Alan S. Rabson, William J. Branigan and Frances Y. Legallais), 423
Virus (Polyoma) Mutant with a Reduction in Tumour Formation (Dr. Leo Sachs and Dan Medina), 715
Virus (Tobacco Mosaic) : Polyphenol Oxidase Activity of *Nicotiana glutinosa* Leaves infected with (Dr. Masatake Kikuchi and Akira Yamaguchi), 1048
Virus (Tumour-destroying) · Isolation of a Non-pathogenic, from Mouse Ascites (Dr. J. G Bennette), 72
Virus-infected Plants : Possible Occurrence of Interference Systems in (A. D. Thomson), 761
Virus-infected (Encephalitis) Chick Embryo Fibroblast Cells : An Interferon-like Substance released from Tick-borne (Dr. J. Vilček), 73
Virus Protein (Tobacco Mosaic) : A Difference between the Sub-Units of ? (Dr. H. G. Aach), 75
Virus-Streak Disease of Tomatoes (B. H. MacNeill and Hikmet Ismen), 903
Virus and Antibodies in the Lymph and Blood of Sheep infected experimentally with the Virus of Tick-borne Encephalitis (Doubravka Málková), 716
Viruses of Talfan and Teschen Diseases : Infective Ribonucleic Acid from the (F. Brown and Doreen L. Stewart), 714
Viruses (Plant) . Freeze-drying of (M. Hollings and R. A. Lelliot), 1078
Viruses (Sap-Transmissible), associated with Diseases of Grape Vines in Europe and North America (C. H. Cadman, H. F. Dias and B. D. Harrison), 577
Visco-elastic Behaviour of Blood Vessels of the Muscular Type (V. Hardung and Prof. L. Laszt), 330
Viscosity of Concentrated Urea—Lithium Bromide Solutions (Dr Irving I. Geschwind), 324
Viscosity Increments on Non-ionized Molecules (Alfred Polson), 482
Viscous (*Bo*) Flow Coefficients of Permeable Solids : Measurement of Slip (*Ko*) and (J. G. Biram), 865
Visible Light : Absorption of Ultra-violet and, by Ultra-thin Sections of Vitrinite from a High-volatile Bituminous Coal (Sabri Ergun, J. T. McCartney and R E Walline), 1014
Visser, A. (compiled and arranged on an English alphabetical base by) . Elsevier's Telecommunication Dictionary in Six Languages—English/American, French, Spanish, Italian, German, Dutch, *review* by Dr R. L. Smith-Rose, 1059
Visual Acuity Effect of Size of Pupil on (Dr. F. W. Campbell and Dr A. H. Gregory), 1121
Visual Discrimination . Problems of (Prof. R. W. Ditchburn), 854
Vitamin B_{12} (Dr. E. Lester Smith), *review* by Prof. John Yudkin, 889
Vitamin and Coenzyme Content of Hepatomas induced by Butter Yellow (M. H. Briggs), 249
Vitis vinifera · Toxicity of Gibberellin to Seedless and Seeded Varieties of (Dr. Robert J. Weaver), 1135
Vitrinite from a High-volatile Bituminous Coal : Absorption of Ultra-violet and Visible Light by Ultra-thin Sections of (Sabri Ergun, J. T. McCartney and R. E. Walline), 1014
Vocational Education (Technical and), in the U.S.A —a Bibliographical Survey prepared by the United States Office of Education (Unesco, Educational Studies and Documents No. 36), 741
Volatile (High-) Bituminous Coal : Absorption of Ultra-violet and Visible Light by Ultra-thin Sections of Vitrinite from a (Sabri Ergun, J. T. McCartney and R. E. Walline), 1014
von Engel, Dr. A , and Arnold, Dr. K. W. : Stepwise Ablation and Heat Transfer in Cold-Cathode Arcs, 1101
von Humboldt, Alexander, et Bonpland, A : Géographie des Plantes, facsimile edition (Society for the Bibliography of Natural History), 904
von Kármán, Prof Theodore : Opening Address at the AGARD fourth Colloquium on Combustion and Propulsion (High Mach Number Air-breathing Engines), 18
von Laue, Prof. Max : *Obituary* by Dr. P. Rosbaud, 738, *erratum*, 905
von Maltzahn, Prof. Kraft E , and MacNutt, Mary M. : Intracellular Configuration and Dedifferentiation in *Splachnum ampullaceum* (L.) Hedw., 344
von der Decken, A., and Hultin, T. : Cytoplasmic Particles and their Role in Protein Synthesis, 645
Vorbeck, Marie L., and others : Determination of Fatty Acids of Lower Molecular Weight by Gas Chromatography, 689
Vronsky, B. I. : Fossil Meteorites, 648
The Tunguska Meteorite, 1078

WADDINGTON, Prof. C. H. : Embryos of Birds, *review*, 814
Wadsley, Dr. A. D. (Andersson, Dr. Sten, and) : Five Co-ordinated Titanium in $K_2Ti_4O_9$, 499
Wain, J. : Awarded a Nature Conservancy Research Studentship for post-graduate training in Ecology (Geography), 742
Wales : Nature Conservancy in, 464
Wales (South) · Relic-Soil on Limestone in (D. F. Ball), 497
Walford, Dr. A. J. (edited by, with the assistance of L. M. Payne) : Guide to Reference Material, *review* by R. Brightman, 273
Walker, Dr. D. G. : Appointed a lecturer in biochemistry at the University of Birmingham, 117
Walker, G. F. : Macroscopic Swelling of Vermiculite Crystals in Water, 312
Walker, Dr. J. : Optical Rotatory Powers of Alkaloids, *review*, 7
Walker, Dr. P. M. B. : Grant of £3,230 from the Paul Instrument Fund (in supplement of a previous grant), for the construction of a high-speed integrating microspectrophotometer, 291
Walker, Sonia E. : Daily Food Consumption by South African University Students, 381
Walker, Prof. T. W. : Rothamsted Experimental Station, 661
Wallen, Dr. C. C. : Problems of the Arid Zones (Climatology, including Hydro-meteorology), 295
Walline, R. E., and others : Absorption of Ultra-violet and Visible Light by Ultra-thin Sections of Vitrinite from a High-volatile Bituminous Coal, 1014
Walshaw, C. D., and others : Pure Rotational Absorption of Ozone in the Region 125-500 Microns, 765
Walton, A. J. : Awarded an Overseas Scholarship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Wangersky, P. T., and others : Oceanography of Long Island Sound, 123
Ward, Prof. A. G. : The Present Position of Leather Science, *review*, 724
Traité Général de la Fabrication des Colles des Glutinants et Matières d'Apprêts, *review*, 890
Ward, Dr. A. H., and Marr, J. D. : Radioactive Fall-out in Ghana, 299
Ward, Henry Baldwin, and Whipple, George Chandler : Fresh-Water Biology, second edition, edited by Prof. W. T. Edmondson, *review* by Dr. T. T. Macan, 6
Ward, J. F., and others : Chemical Effects of Ionizing Radiations on Nucleic Acids and Nucleoproteins, 319
Ward, Prof. S. G. : Safety in Mines Research Establishment Bibliography, 1960, *review*, 1063
Wardlaw, J. (Alexander, K. M , and) : Dependence of Cement-Aggregate Bond-Strength on Size of Aggregate, 230
Ware, C. C., and others : Effect of some Aromatic Hydroxy Compounds on the Phagocytic Activity of the Reticulo-Endothelial System, 422
Effect of Three Compounds related to Diethylstilboestrol on the Phagocytic Activity of the Reticulo-Endothelial System, 1032
Ware, Dr. G. C. : Biology of Pollution, *review*, 1061
Warfield, R. W , and Petree, M. C. : Dependence on Temperature of the Electrical Resistivity of Thermosetting Polymers, 316
Wark, Dr. D. C., and others : Differentiation in *Peronospora tabacina* Adam , 710
Warner, N. L. (Burnet, Sir Macfarlane, and) Assay of Corticosteroids in the Chick Embryo, 938
Warner Memorial Medal of the Textile Institute awarded to Prof. C. S. Whewell, 201
Warren, F. W. G. : Appointed lecturer in applied mathematics at the University of Sheffield, 466
Warren Spring Laboratory : Report for 1959, 1082
Wase, Prof. Arthur W., and Feng, Dr. Yu Sheng Louise · Sialoadenectomy and the Distribution of Thyrotrophin labelled with Iodine-131, 778
Washington, Elmer L. (Mangelsdorf, jun , Prof. Paul C., and) · Packing of Mixtures of Hard Spheres, 930
Wassermann, Dr. A. (Blakely, C. F., and) : Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives—Kinetics and Mechanism, 662
Wassermann, Dr. A , and others : Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives—Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy, 662
Water : Growing Demand for (Second Report of the Sub-Committee of the Central Advisory Water Committee), 198
Infra-red Examination of the Association of Cornea Proteins with (Dr. S. Bakerman and C. Mitchell), 1033
Infra-Red Spectra of Amino-Acids and related Substances in (Prof Frank S. Parker and Prof Donald M. Kirschenbaum), 386
Interaction of Picric Acid with Sodium Hydroxide in (Takehiro Abe), 234
Macroscopic Swelling of Vermiculite Crystals in (G. F. Walker), 312
Water (Brackish) Areas : The Oligochaete Fauna of Three Danish (Ingerlise Dahl), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 26), *review* by Dr. A J. Southward, 360
Water (Fresh-) Biology (Henry Baldwin Ward and George Chandler Whipple), second edition, edited by Prof. W. T. Edmondson, *review* by Dr. T. T. Macan, 6
Water (Fresh-) Biology : North American, *review* by Dr. T. T. Macan, 6

Water (Heavy) : Effect of, on Respiratory-chain Enzymes (Dr. H Laser and Prof. E. C. Slater), 1115
  Effects of Linear Energy Transfer on the Radiolysis of Water and (Dr. E. Collinson, Prof. F. S. Dainton and J. Kroh), 475
Water (Mitochondrial and Cell) : Phosphoproteins and (Dr. J. D. Judah), 506
Water (Pure) : Changes in Conductivity of, caused by X-Irradiation (K. Schmidt), 931
Water (Sea-) : Alleged Occurrence of the Perchlorate Ion in (R. Greenhalgh and Dr. J P. Riley), 1107
Water (Surface Sea), off the California Coast (1959-60) : Fall-out Caesium In, by Gamma-Ray Measurements (Dr. Theodore R. Folsom, Dr. G. J Mohanrao and Perrin Winchell), 480
Water-Balance Principle (Frof), and Arginine Vasotocin : Evidence for the Identity of Natriferin, the (Prof Wilbur H Sawyer), 1030
Water Board, Metropolitan . Thirty-eighth Report on the Results of the Bacteriological, Chemical and Biological Examination of the London Waters for the Years 1957-1958 (E. Windle Taylor), 468
Water Committee, Central Advisory : Second Report of the Sub-Committee on Growing Demand for Water, 198
Water Evaporation : New Compounds for the Control of (A. V. Deo, N R. Sanjana, S. B. Kulkarni, M. K. Gharpurey and A. B. Biswas), 870
Water Relations (Plant- and Soil-) : Terminology In (Dr. R. O. Slatyer and Prof. S. A. Taylor), 922
Water Resources in the United States (Prof. W. G. V. Balchin), 562
'Water Rigour' as an Aid when Operating on Marine Gastropoda (Prof B. J. Krijgsman and A. C. Brown), 69
Water Solutions (Highly Enriched Oxygen-18), containing Hydrogen Peroxide-16,16 : Radiolysis of (Dr. Michael Anbar, Shmuel Guttmann and Prof. Gabriel Stein), 57
Water Vapour Content of the Air : Average (J. K. Bannon and L. P. Steele), 748
Water and Heavy Water : Effects of Linear Energy Transfer on the Radiolysis of (Dr E. Collinson, Prof. F. S. Dainton and J. Kroh), 475
Water and Sewage Works : Problems of Radioactivity at (Manchester College of Science and Technology Course of Lectures on), 743
Water and Solutes : Plants in relation to (Plant Physiology, edited by F. C. Steward, Vol 2), *review* by Prof. Walter Stiles, 889
Water-soluble, Non-fibrous Deoxyribonucleoprotein from Calf Thymus Nuclei (Dr. Richard S. Welsh), 943
Waters (Offshore), of the Sierra Leone River : Plankton of the Estuary and (V. Bainbridge), 557
Waters (Polluted) : The Biology of (Dr. H. B. N. Hynes), *review* by Dr. G. C. Ware, 1061
Watkins, Sidney B. (edited by Herbert W. Cremer and) : Chemical Engineering Practice, Vol. 11, Works Design, etc., *review* by Prof. J. M. Coulson, 887
Watson, Dr. D. G. : Awarded a Glasgow fellowship by the Ramsay Memorial Fellowship Trustees, 832
Watson, Dr. J. D. : Elected to an Overseas Fellowship of Churchill College, Cambridge, 742
Watson, Dr. J. M. : Medical Helminthology, *review* by Dr. G. Lapage, 815
Watson, Dr. W. F. : Rubber Technology, *review*, 359
Watton, E. C. (Graddon, Dr. D. P., and) : Structure of the 1:1-Adducts of Cupric β-Diketone Chelates with Heterocyclic Bases, 1021
Wave Approximation (Distorted), for Scattering Phase-Shifts (Dr. P. Swan), 589*
Waveguides : Swedish Supplement to Elsevier's Dictionary of Electronics and (W. E. Clason), *review* by Dr. R. L. Smith-Rose, 1059
Waves (Electromagnetic) : Ionospheric Propagation of, *review* by Sir Harrie Massey, 810
Waves (Electromagnetic Standing), and Ball Lightning (Dr. Lewi Tonks), 1013
Waves (Seismic Body) : Oscillatory Character of Amplitude Curves for (Dr. J. Vanek and J. Stelzner), 491
Wawrzyczek, Dr. Wiktor : *Obituary* of Prof. Tadeusz Milobedzki, 991
Weakness (Muscular), in Rats : Production of, by a Creatine Analogue (Coy D. Fitch and Prof. James S. Dinning), 421
Weapon Debris (Nuclear) : Fractionation of (Prof. C. Sharp Cook, R. L. Mather, R. F. Johnson and F. M. Tomnovec), 1100
Weather Bureau (United States) : World Weather Records, 1941-50. *review* by H. H Lamb, 727
Weather Problems in Agriculture (Royal Meteorological Society Summer Meeting), 995
Weather Records : World, 1941-50 (United States Weather Bureau), *review* by H. H. Lamb, 727
Weather Records of the World, *review* by H. H. Lamb, 727
Weaver, Dr. Robert J. : Toxicity of Gibberellin to Seedless and Seeded Varieties of *Vitis vinifera*, 1135
Weaver Finch, *Quelea quelea* . Effects of Whole-body Irradiation on the Breeding Plumage of the (Dr. B. Lofts, Prof. A. J. Marshall and Prof. J. Rotblat), 615
Weaving : New Principle in, 27
Webb, Dr. C. R. : Title of reader in mechanical engineering in the University of London (at Queen Mary College) conferred on, 904
Webb, Prof. J. E. . Appointed to the chair of zoology in Westfield College, London, 362 ; work of, 362
Webb, T. J. B. : Awarded an Overseas Scholarship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Webber, Dr. J. M. : Appointed lecturer in chemistry at the University of Birmingham, 465
Webber, N. B. : Protection against Tidal Flooding In London, 293
Wedgwood, Sir John : At the sixty-sixth Annual Conference of the Museums Association (Relations of Museums and Industry), 657
Weed Control Council (British) : Symposium on Herbicides and the Soil, 376
Wegener, P. P. : Combustion and Propulsion—High Mach Number Air-breathing Engines (Experiments with a Reacting Mixture of Nitrogen Tetroxide and Dioxide carried through a Supersonic Nozzle with a Stream of Nitrogen), 20
Weigle, J., and others : Mutations affecting the Density of Bacteriophage λ, 161
Weill, J., and others : Electronic Equipment used In the Nuclear Energy Industry in France, 1076
Weintraub, Prof. D. : Problems of the Arid Zones (Public Awareness and the Educational Problem—Agriculture-Israel), 296
Weintroub, S. : The Instrument Manual, *review*, 97
  Digest of Literature on Dielectrics, *review*, 728
  Noise in Factories and its Control, 1085
Weir, John B. de V. : Significance of the Difference between Two Means when the Population Variances may be Unequal, 438
Weiskrantz, Dr. L. : Effects of Medial Temporal Lesions on Taste Preference In the Monkey, 679
Weiss, Prof. J., and others : Chemical Effects of Ionizing Radiations on Nucleic Acids and Nucleoproteins, 319
Weiss, Jacqueline B. (Epstein, Dr. Samuel S., and) : Measuring the Size of Isolated Cells, 461
Welch, Dr. Henry, and Finland, Prof. Maxwell (edited by) : Antibiotic Therapy and Staphylococcal Diseases, *review* by Prof. R. Knox, 637
Welfare (Animal), Universities Federation for . Summer Congress, 374
Welkie, G. W., and others : Direct Infra-Red Spectral Analysis of the Cucumber Mosaic Virus Infection Process, 1049
Wellcome Medal for 1959 of the Royal Anthropological Institute awarded jointly to E. M Chilver and Dr. P. Kaberry, 114
Wells, A. F. : Dendritic Growth of Crystals, *review*, 93
Welsh, Dr. Richard S. : Water-soluble, Non-fibrous Deoxyribonucleoprotein from Calf Thymus Nuclei, 943
Welsh Emigration Overseas (Prof. E. G. Bowen), 843
Wendlandt, Prof. Wesley W , and Horton, G. Robert : Differential Thermal Analysis of some Transition Metal Ethylenediamine Tetraacetic Acid Chelates, 769
Wenk, Jun , Edward : Radio Frequency Control In Space Telecommunications, 373
Went, Dr. F. W. : Blue Hazes in the Atmosphere, 641, *erratum*, 994
West, Dr. D. : Method of Observing π-Mesonic X-Rays (Fifteenth Charles Vernon Boys Prize Address to the Physical Society), 853
West, Dr. D. J. : Beyond Science Fiction, *review*, 270
West, Dr. G. B., and others : An Unidentified Pharmacologically Active Substance extracted from Cerebral Hemispheres, 420
West, J. B. (Dollery, C. T., and) : Metabolism of Oxygen-15, 1121
West, Dr. J. M. : Metallic Corrosion, *review*, 182
  Appointed lecturer In metallurgy at the University of Sheffield, 466
West, Dr. T. F. : Appointed editor of *Chemistry and Industry*, 290
West African Religion : Oedipus and Job in (Prof. Meyer Fortes), *review* by Michael Argyle, 96
Westfield College (University of London) : New Faculty of Science, 361
  Appointment of Prof. E. H. Bellamy to the chair of physics, 361
  Appointment of Prof. W. Klyne to the chair of chemistry, 361
  Appointment of Prof. G. E. Fogg to the chair of botany, 362
  Appointment of Prof. J. E. Webb to the chair of zoology, 362
  Appointment of Prof. E. B. Sondheimer to the chair of mathematics, 363
Westland Aircraft, Ltd. : Contribution of £17,500 to the University of Southampton Centenary Appeal Fund, for a readership in helicopter engineering, 743
Wet and Dry Soils : Potash in, *review* by Dr. P. W. Arnold, 976
Wetherill, Dr. G. W. : Age of the Base of the Cambrian, 34
Whale (Humpback), of Known Age : Marked (Dr. R. G. Chittleborough), 164
Whale Feeding Grounds in the Antarctic : Southern Atmospheric Cyclones and the (Dr. C. W. Beklemishev), 530
Wharton, A. L (Brunt, A. A., and): Transmission of a Gall Disease of Cocoa, 80
Wheat Gluten : Effect of, on the Peristaltic Reflex (Dr. R. Schneider, H Bishop, Dr. B Shaw and Prof. A. C. Frazer), 516
Wheat Proteins : Starch-Gel Electrophoresis of (Dr. G. A. H. Elton and J. A. D. Ewart), 600
Wheat Seedling : Plant Hormone Activity—Stilboestrol applied to the (Dr J. J. C. Hinton and Dr. T. Moran), 258
Wheatley, P. J. : The Determination of Molecular Structure, *review* by Dr. J. W. Cook, 812
Wheeler, Sir Mortimer : Early India and Pakistan to Ashoka, *review* by M. C. Burkitt, 94
Whewell, Prof. C. S. : Man-made Fibres, *review*, 2
  Awarded the Warner Memorial Medal of the Textile Institute, 201
Whewell, Prof. C. S., and others : Action of Tetrakis (Hydroxymethyl) Phosphonium Chloride on Wool, 602
Whidden Lectures : Series 4, The Hollow Universe (Prof. Charles de Koninck), *review* by F. I. G. Rawlins, 890
Whipple, George Chandler (Ward, Henry Baldwin, and) : Fresh-Water Biology, second edition, edited by Prof. W. T. Edmondson, *review* by Dr. T. T. Macan, 6
'Whistlers' and 'Chorus' at the South Pole . Observations of (Dr. L. H. Martin), 1018
Whitby, Dr. L. G., and others : Effect of Cocaine on the Disposition of Noradrenaline labelled with Tritium, 604
White, D. A. : Awarded a Nature Conservancy Diploma Course in Conservation and Ecology at University College, London, 742
White, D. J. : Appointed Kenward Memorial Fellow in engineering production at the University of Birmingham, 465
White, Prof. Gilbert : Problems of the Arid Zones (Alternative Uses of Limited Water Supplies), 296
White, Guy K. . Thermal Expansion at Low Temperatures, 927
White, R. F. M., and others : Conversion of Cyclopentadiene into New Bicyclopentyl Derivatives—Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy, 662
White Clover : Biosynthesis of Linamarin and Lotaustralin in (G. W. Butler and Berta G. Butler), 780
White Paper on Assistance from the United Kingdom for Overseas Development, 266
White Paper on Capital Investment in the Coal, Electricity and Gas Industries, 1055
White Paper on Commonwealth Educational Co-operation, 441
White Paper on Defence 1960, 177
White Paper on the proposed International Development Association, 266
White Paper on the Nuclear Power Programme, 1055
Whitear, Dr. Mary : Chordotonal Organs in Crustacea, 522
Whitehead, Dr. J. D. (Heisler, L. H., and) : Longitude Effect in Temperate Zone Sporadic E and the Earth's Magnetic Field, 676
Whitehead, P. J . Interspecific Hybrids of *Tilapia*—*T nigra* x *T. zillii*, 878

Whitmore, Dr. R. L. (Boardman, G., and): Yield Stress exerted on a Body immersed in a Bingham Fluid, 50
Whittaker, J. B.: Awarded a Nature Conservancy Research Studentship for postgraduate training in Ecology (Zoology), 742
Whittembury, G., and others: Effect of Anti-Diuretic Hormone and Calcium on the Equivalent Pore Radius of Kidney Slices from *Necturus*, 699
Whitten, Prof. E. H. Timothy: Average Composition of Granites, the Genesis of Tektites, and Petrogenesis, 867
Whittenbury, R.: Two Types of Catalase-like Activity in Lactic Acid Bacteria, 433, *erratum*, 466
Whitworth, Dr. R. W.: Appointed a lecturer in physics at the University of Birmingham, 117
Whole-body Irradiation: Effects of, on the Breeding Plumage of the Weaver Finch, *Quelea quelea* (Dr. B. Lofts, Prof. A. J. Marshall and Prof. J. Rotblat), 615
  Labilization of Deoxyribonucleic Acid in Thymus Nucleoprotein after (Dr. Ulrich Hagen), 1123
Whooping Cough, Diphtheria and Tetanus: Vaccination against (Research Defence Society, *Conquest* Pamphlet No. 11), 649
Wide, Leif, and others: Immunoelectrophoretic Studies on Purified Human Growth Hormone, 64
Wiener, Prof. Norbert: Nonlinear Problems in Random Theory, *review* by K. Krickeberg, 727
Wigglesworth, Prof. V. B.: Annual Review of Entomology, *review*, 542
  Handbook of Toxicology, *review*, 544
  The Control of Growth and Form—a Study of the Epidermal Cell in an Insect, *review* by Prof. R. Dennell, 631
  The Yellow Fever Mosquito, *review*, 813
Wightman, Dr. William P. D.: *Nullius in verba*, *review*, 356
Wijn, Dr. H. P. J. (Smit, Dr. J., and): Ferrites, *review* by Dr. G. E. Bacon, 974
Wild, H. (edited by A. W. Exell and): Flora Zambesiaca, Vol. 1, Part 1, *review* by A. A. Bullock, 449
Wild, P. A. T., and others: A New Limit to the Galactic Magnetic Field set by Measurements of the Zeeman Splitting of the Hydrogen Line, 1088
Wild: Radioactive Labelling of Lepidopterous Larvae—a Method of Estimating Late Larval and Pupal Mortality in the (L. M. Cook and Dr. H. B. D. Kettlewell), 301
Wild Animals: Translocation of, as a Means of Game Control (Dr. A. M. Harthoorn, J. A. Lock and J. MacKeand), 518
Wild-Life (America's): Chemical Control of Agricultural Pests and Conservation of (United States National Academy of Sciences—National Research Council Committee on), 114
Wilkes, Dr. M. V.: Presidential Address at the second Annual Conference of the British Computer Society, 655
Wilkins, Dr. Malcolm B.: Effects of Light and Darkness on the Rhythm of Output of Carbon Dioxide of Excised *Bryophyllum* Leaves, 523
Wilkinson, D., and others: A New Phase in a Silicon bearing 17 per cent Chromium, 8 per cent Nickel and 1 per cent Niobium Steel, 407
Willens, R. H., and others: Non-crystalline Structure in Solidified Gold–Silicon Alloys, 869
Williams, A. R. O.: Elected president for 1961-62 of the Institution of Mining and Metallurgy, 994
Williams, Dr. C. B.: *Obituary* of Dr. H. F. Barnes, 285
Williams, D. J.: Awarded a Senior Studentship for 1960 by the Royal Commission for the Exhibition of 1851, 116
Williams, H. T. (edited by): Principles for British Agricultural Policy—a Study sponsored by the Nuffield Foundation, *review* by Sir John Russell, 721
Williams, Dr. Joan B.: Mouth and Blastopore, 1132
Williams, Prof. L. Pearce: Michael Faraday and the Evolution of the Concept of the Electric and Magnetic Field, 730
Williams, Prof. R. P. (Purkayastha, Mira, and): Association of Pigment with the Cell Envelope of *Serratia marcescens* (*Chromobacterium prodigiosum*), 349
Williams, Prof. R. Tecwyn: Detoxication Mechanisms, second edition, *review* by Prof. E. Boyland, 94
Williams, Dr. T. Ffrancon (Bates, T. H., and): Radiolysis of Terpene Hydrocarbons—Isomerization and Polymerization of α- and β-Pinene, 665
Willmott, Dr. S. G., and Shirlaw, D. W. Gilchrist: C Horizon of the Soil Profile, 966
Willis, Dr. A. T., and Gowland, G.: Egg-Yolk Reactions of *Pseudomonas* Species, 432
Willmer, Dr. E. N.: Cells and their Environment, *review*, 450
Wilson, C. St. J.: Elected to a Fellowship of Churchill College, Cambridge, 742
Wilson, J. P.: Perceptual Anomalies associated with a Single Contour, 137
Wilson, R.: Interstellar Extinction and Polarization, 288
Wilson, S. B., and others: Copper and Cobalt in Nitrogen Fixation, 79
Wilson, Dr. S. E.: The Development of Pulp and Particle Board Industries and their Effect on Forest Management (Principal Aim of Domestic Forests in Britain), 33
Winbury, Martin M. (Taylor, Dr. Richard M., and): A Potent New Benzothiadiazine Diuretic, 603
Winchell, Perrin, and others: Fall-out Caesium in Surface Sea Water off the California Coast (1959-60) by Gamma-Ray Measurements, 480
Wind: Airborne Measurements of Latitudinal Variation of Frost-point Temperature and (N. C. Helliwell), 993
Wind (Upper Atmosphere): Effect of, on the Rotation of Satellite 1958δ1 (Dr. C. R. Faulkner), 926
Wind Studies (Upper-Atmosphere), by *Skylark* Rocket Sodium Experiment (Dr. G. V. Groves), 1001
Windscale: The Deposition of Strontium-89 and Strontium-90 on Agricultural Land and their Entry into Milk after the Reactor Accident at, in October 1957 (United Kingdom Atomic Energy Authority and the Agricultural Research Council Joint Report on), 1077
Winkler, G. M. R., and others: The 'GBR Experiment'—a Trans-Atlantic Frequency Comparison between Caesium-controlled Oscillators, 914
Winslade, R.: Awarded a Travel Award for Women Engineers by the Caroline Haslett Memorial Trust, 116
Winterbottom, Dr. J. M.: Appointed director of the Percy Fitzpatrick Institute of African Ornithology, Cape Town, 201
Wires: Exploding—Based on Conference on the Exploding Wire Phenomenon, 1959, conducted by Geophysics Research Directorate, Air Force Cambridge Research Center, with the co-operation of Lowell Technological Institute Research Foundation (edited by William G. Chace and Howard K. Moore), *review* by Dr. B. A. Thrush, 726
Wisdom, Dr. J. O.: Causation and Modern Science, *review*, 92
Wise, Prof. M. J.: Land Use and the Cyprus Problem, *review*, 628
Wiseman, L. A.: The British Rayon Research Association, 121
Wish to Fall Ill: The—a Study of Psychoanalysis and Medicine (Dr. Karin Stephen), *review* by Dr. Clifford Allen, 978
Withrow, Robert B. (edited by): Photoperiodism and related Phenomena in Plants and Animals—Proceedings of the Conference on Photoperiodism, 1957, sponsored by the Committee on Photobiology of the National Academy of Sciences—National Research Council, supported by the National Science Foundation, *review* by Prof. L. J. Audus, 96
Wolfenbarger, Dr. D. O.: Dispersal in Space of Small Bodies, 1078
Wolfendale, E. (edited by): The Junction Transistor and its Applications, *review* by Dr. J. R. Tillman, 1058
Wolfram, Dr. L. J., and Speakman, Prof. J. B.: Reactivity of the Disulphide Bond in Wool, 595
Wolfson Research Professorship of the Royal Society, 24
Wolke, Dr. Robert L.: Appointed associate professor of chemistry in the University of Pittsburgh, 905
Wolstenholme, Dr. G. E. W.: Influence of Editors, 121
Women (Pregnant): Immuno-electrophoretic Demonstration of Precipitating Components in Sera from (Dr. Jan Hirschfeld and Dr. Ulf Soderberg), 332
  Inhibition of Glucuronosyl Transferase by Progestational Agents from Serum of (Dr. David Yi-Yung Hsia, Robert M. Dowben, Ralph Shaw and Aaron Grossman), 693
Women Engineers: Travel Awards for (Caroline Haslett Memorial Trust), 116
Womersley, Dr. H. B. S.: Appointed acting-head of the Department of Botany in the University of Adelaide, 740
Womersley, Dr. H. B. S. (Nizamuddin, M., and): Structure and Systematic Position of the Australian Brown Alga, *Notheia anomala*, 673
Wood, Dr. A. B.: Sound Transmission in the Ocean, *review*, 539
Wood-rotting Fungi: Nonanal as a Growth Factor for (Prof. Nils Fries), 166
Woodhouse, J. M., and others: Action of Tetrakis (Hydroxymethyl) Phosphonium Chloride on Wool, 602
Woodliff, Dr. H. J.: Effect of 6-Mercaptopurine on the Net *In vitro* Gas Production of Sensitive and Resistant *L*1210 Mouse Leukaemia Cells, 156
Woods Hole Oceanographic Institution: First Henry Bryant Bigelow Medal awarded to Dr. H. B. Bigelow, 647
Woodward, Prof. R. B.: The Chemistry of Natural Products (The Total Synthesis of Chlorophyll), 1080
Woody Plants: Survival of, at Extremely Low Temperatures (Johnson Parker), 1133; (Dr. Akira Sakai), 1134
Wool: Action of Tetrakis (Hydroxymethyl) Phosphonium Chloride on (L. S. Bajpai, Prof. C. S. Whewell and J. M. Woodhouse), 602
  Reactivity of the Disulphide Bond in (Dr. L. J. Wolfram and Prof. J. B. Speakman), 595
Wool Industries Research Association: Publication No. 214, Report of the Director of Research for 1959, 27
Woolf, A. L. (Bickerstaff, E. R., and): The Muscular Disease Myasthenia gravis, 28
Woolf, Prof. Harry: The Transits of Venus—a Study of Eighteenth-Century Science, *review* by Dr. David S. Evans, 636
Woolfson, Dr. M. M.: Origin of the Solar System, 47
Woolley, Dr. R. v. d. R.: Stellar Motions (Presidential Address to Section A (Mathematics and Physics) of the British Association for the Advancement of Science), 841
  Les Observatoires Astronomiques et les Astronomes, *review*, 1063
Wools (Merino and Polwarth): Abnormal Crimping in (R. E. Chapman, B. F. Short and P. G. Hyland), 960
Wooster, Dr. W. A.: Retirement of, 25; work of, 25
Wootton, Joyce M., and Wright, Lemuel D.: Biosynthesis of Squalene by the Annelid *Lumbricus terrestris*, 1027
Work-Hardening and Ductility of Rhenium and their relation to the Behaviours of other Metals having a Hexagonal Structure (R. A. Jeffery and E. Smith), 52
World: Galathea Report—Scientific Results of the Danish Deep-Sea Expedition round the, 1950-52 (edited by Dr. Anton Bruun, Capt. Sv. Greve and Prof. R. Spärck), *review* by Dr. N. B. Marshall, 443
  Our Developing (Prof. L. Dudley Stamp), *review* by M. K. Milne, 816
  The Under-developed Countries of the, 266
  Weather Records of the, *review* by H. H. Lamb, 727
World (Industrial): Management in the—an International Analysis (Frederick Harbison and Charles S. Myers), 537
World Around Us (edited by Sir Graham Sutton), *review* by G. R. Noakes, 975
World Food Supplies: Pastoral Systems in relation to (Dr. William Davies), 849
World Forestry Congress: Fifth, 29
World Health (Prof. Fraser Brockington), *review* by Christine Cockburn, 722
  In Pursuit of, *review* by Christine Cockburn, 722
World Health Organization (United Nations): Technical Report Series No. 192, Epidemiology of Cancer of the Lung, 115
  Classification of Pharmaceutical Preparations—A Survey of Existing Legislation, 287
  Public Health Papers No. 3, Health Services in the U.S.S.R., 379
  Technical Report Series No. 194, Local Health Service, 465
  Official Records of the, No. 98, The Work of WHO, 1959—Annual Report of the Director-General to the World Health Assembly and to the United Nations, 468
  Technical Report Series No. 193, Training of Teachers for Health Education, 648
  Guide to Hygiene and Sanitation in Aviation, 911
World Land Use Survey: Regional Monograph No. 2, The Evolution of the Rural Land Use Pattern in Cyprus (Dr. Demetrious Christodoulou), *review* by Prof. M. J. Wise, 628
World Meteorological Organization: International Meteorological Organization Prize awarded to Prof. J. van Mieghem, 740

World Population : Planning for the Changing, *review* by M. K. Milne, 816
World Weather Records, 1941-50 (United States Weather Bureau), *review* by H. H. Lamb, 727
Wormall, Prof. A., and others : Zinc Content of Erythrocytes and Leucocytes of Blood of Normal and Leukaemic Subjects, 302
Worshipful Society of Apothecaries of London : Maccabaean Prize and Medal for an essay on a subject connected with the History of Medicine or Pharmacy, 650
Worshipful Society of Apothecaries of London (Faculty of the History of Medicine and Pharmacy), and others : First British Congress on the History of Medicine and Pharmacy, 374
Worthington, Dr. C. R. (Spencer, Dr. M., and) : A Hypothesis of Contraction in Striated Muscle, 388
Wound Healing in the New-Born Opossum (*Didelphis virginianam*), (Prof. Matthew Block), 340
Wright, C. V., and others : Excited Electronic States of Lithium and Sodium Molecules, 141
Wright, Lemuel D. (Wootton, Joyce M., and) : Biosynthesis of Squalene by the Annelid *Lumbricus terrestris*, 1027
Wright, Prof. R. W., and others : Equatorial Spread-F and F-Layer Heights, 1086
Wyatt, Dr. H. V. : Protandry and Self-Fertilization in the Calyptraeidae, 520
Wye College : Grant of £50 from the Gulbenkian Foundation to the Exploration Society's expedition to Morocco, 558
Wykes, A. A., and others : New Inhibitor of Monoamine Oxidase, 941
Wyrtki, Dr. K. : The Antarctic Convergence—and Divergence, 581

X-IRRADIATION : Changes in Conductivity of Pure Water caused by (K. Schmidt), 931
X-Ray Damage in Diploid Yeast : Dye-sensitized Photo-reactivation of (Dr. David Freifelder and Prof. Robert B. Uretz), 953
X-Ray Sensitivity of *Serratia marcescens* : Effect of Glycerine on the (Dr. D. L. Dewey), 1008
X-Rays : Delayed 'Primary' Effects in *Chara vulgaris* L. subject to (C. M. Gillet), 874
X-Rays (π-Mesonic) : The Method of Observing (Dr. D. West), 853
Xanthium : Effect of Glutathione and Alloxan on the Photoperiodic Response of (J. Nitsan), 81
Xanthid Crab (A North American), New to Britain (E. Naylor), 256
Xenobiochemistry, *review* by Prof. E. Boyland, 94
Xenopus laevis (Toad) : Expanded Ilio-Sacral Joint in the (Margaret Palmer), 797
  Serotonin, a Melanocyte-stimulating Component in the Dorsal Skin Secretion of (Dr. F. C. G. van de Veerdonk), 948
Xylan of Siphonaceous Green Algae (Yoshihiko Iriki, Takao Suzuki, Kazutosi Nisizawa and Tomoo Miwa), 82

YAMADA, Dr. T., and others : Distribution of Protein-bound Aminoazo Dyes in the Rat Liver Microsome, 943
Yamaguchi, Akira (Kikuchi, Dr. Masataka, and) : Polyphenol Oxidase Activity of *Nicotiana glutinosa* Leaves Infected with Tobacco Mosaic Virus, 1048
Yamaguti, Prof. Satyu : *Systema Helminthum*, Vol. 2, The Cestodes of Vertebrates, *review* by Dr. Ben Dawes, 723
Yamazoe, Saburo, and others : Adenosine Triphosphate and Maintenance of Shape of the Human Red Cells, 945
Yapp, W. B. (edited by) : The Effects of Pollution on Living Material, *review* by Dr. G. C. Ware, 1061
Yarnold, G. D. : The Spiritual Crisis of the Scientific Age, *review* by R. Brightman, 818
Yarwood, A. J. (Simons, Dr. J. P., and) : Photochemical Formation and Stability of the CF_2 Radical, 316
Yates, F. : At the second Annual Conference of the British Computer Society (Language and General-purpose Programmes for Market Research), 656
Year Book of the Royal Society of London (1960), *review*, 97
Yeast (An Acid-tolerant and Non-sporulating), from Passion Fruit Juice (B. A. S. Rao and J. S. Pruthi), 342
Yeast (Diploid) : Dye-sensitized Photoreactivation of X-Ray Damage in (Dr. David Freifelder and Prof. Robert B. Uretz), 953
Yellow Fever Mosquito : The, *review* by Prof. V. B. Wigglesworth, 813
Yield Stress exerted on a Body immersed in a Bingham Fluid (G. Boardman and Dr. R. L. Whitmore), 50
Yoffey, Prof. J. M., and others : Pattern of Haemopoiesis in the Foetal Liver, 876
Yonge, Prof. C. M. : Physiology of Marine Animals, *review*, 630
Yoshida Ascites Hepatoma : Inhibition of Aerobic Glycolysis in, by Tartronic Acid (Dr. L. Fiume), 792
Young (Thomas) Oration of the Physical Society (Prof. R. W. Ditchburn), 854
Young, Wei : Haemodynamic Aspects of Atherogenesis, 425
Young, Dr. William J. (Boyer, Prof. Samuel H., and) : β-Globulin Polymorphism in Chimpanzees, 1035
Young Rats : Influence of Different Types of Malnutrition on the ^{14}C-Lysine Metabolism in (Prof. Kurt Schreier and Corinna [illegible]), 1117
Younger, Kenneth : The Public Service in New States—a Study in some Trained Manpower Problems, 971
Yucatan : Excavations at Dzibilchaltun in, 742
Yudkin, Prof. John : Vitamin B_{12}, *review*, 889

ZACHARUK, R. Y. (Tinline, Dr. R. D., and) : Pathogenicity of *Metarrhizium anisopliae* (Metch.) Sor. and *Beauveria bassiana* (Bals.) Vuill. to Two Species of Elateridae, 794
Zaimis, Prof. Eleanor : Parallelism of Changes produced by Cooling and by Drugs known to affect Adrenergic Mechanisms, 213
Zaitzev, V. P.: Oceanographic and Fisheries Research by the Submarine *Severyanka*, 559
Zakrzewski, K. (Koscielak, J., and) : Substance from Erythrocytes of Blood Group A, 516
Zalta, J.-P. : Cytoplasmic Particles and their Role in Protein Synthesis, 645
Zambezi Basin : Flora of the, *review* by A. A. Bullock, 449
Zambesiaca : Flora (edited by A. W. Exell and H. Wild), Vol. 1, Part 1, *review* by A. A. Bullock, 449
Zamenhof, Prof. Stephen : The Chemistry of Heredity, *review* by Dr. P. Cohn, 447
Zangwill, Prof. O. L. : Fact and Opinion, *review*, 817
Zaremba, Dr. S. K. : Appointed senior lecturer in pure mathematics at University College, Swansea, 117
Zebra (Zero Energy Breeder Reactor Assembly), (United Kingdom Atomic Energy Authority), 114
Zeeman Splitting of the Hydrogen Line : A New Limit to the Galactic Magnetic Field set by Measurements of the (Dr. R. D. Davies, C. H. Slater, W. L. H. Shuter and P. A. T. Wild), 1088
Zettlin, Prof. Harry (Anthony, Dr. Philip, and) : Solid–Solid Interactions on Active Adsorbents, 936
Zichichi, M. L., and others : Mutations affecting the Density of Bacteriophage λ, 161
Zimmerman, Joseph H. (Sheppard, Herbert, and) : A Suggested Effect on Levels of Catecholamine in Brain produced by Small Doses of Reserpine, 1035
Zinc Content of Erythrocytes and Leucocytes of Blood of Normal and Leukaemic Subjects (E. Dennes, R. Tupper and Prof. A. Wormall), 302
Zipkin, M. A., and Nucci, L. M. : Combustion and Propulsion (High Mach Number Air-breathing Engines), 19
Zirconium : The Chemical Behavior of (Warren B. Blumenthal), *review* by Prof. A. G. Quarrell, 725
Zondek, Dr. Herman, and others : Reversibility of an Inherited Metabolic Block (Inborn Error of Metabolism), 515
Zone Electrophoresis of Anthocyanins (Prof. P. Markakis), 1092
Zoological Society of London : Symposium on Tuberculosis in Animals, 996
Zoology at the University of Leeds, 197
Zoology (Medical and Veterinary) : Index-Catalogue of (United States Department of Agriculture), Supplements 9 and 10, 559
Zooplankton in the Southern Part of the Norwegian Sea : Investigations on the Quantitative and Qualitative Distribution of (V. K. Hansen), (Meddelelser fra Danmarks Fiskeri- og Havundersøgelser, Ny Serie, Bind 2, Nr. 23), *review* by Dr. A. J. Southward, 360
Zoutendyk, Dr. A., and Teodorczuk, Dr. H. : The Rh Factor C in South African Bantu, 790
Zubay, G. (Huxley, Dr. H. E., and) : Cytoplasmic Particles and their Role in Protein Synthesis (Examination in the Ultracentrifuge of Ribosomes, using *Escherichia coli*), 644
Zygaena malleus : Modification of the Neurocranium in, and the Nature of the Optic Stalk in Selachii (Dr. A. R. Hamdy), 257

Printed in Great Britain by FISHER KNIGHT & CO. LTD., The Gainsborough Press, St. Albans,
and published by MACMILLAN & CO. LIMITED, at St. Martin's Street, London, W.C.2,
and ST. MARTIN'S PRESS, INC., 103 Park Avenue, New York 17, N.Y., U.S.A.
Saturday, January 21, 1961

INTERACTIONS OF SCIENCE AND TECHNOLOGY WITH SOCIETY

In one of a series of lectures on the nineteen-sixties, printed in *The Listener* of March 24, Dr. Alex. Comfort discussed some of the factors which limit the applications of existing scientific knowledge, which determine, for example, whether or not at the end of this decade there will be no untreated cases of leprosy, yaws or malaria in the Commonwealth. The realization of such comparatively modest objectives, which are scientific possibilities and present no unusual difficulties, does not depend on fresh theoretical knowledge, lack of physical resources, or practical difficulties in the field. It depends rather on whether our vast technical resources are allocated to achieve such purposes by those in power, whether in democratic or in totalitarian society. Thus, from a completely different starting point, Dr. Comfort makes essentially the same point that was made by Sir Solly Zuckerman in his address last year on "Liberty in an Age of Science", and by Sir Eric Ashby in his oration at the Conference of European University Rectors and Vice-Chancellors.

Two other recent lectures develop very similar ideas. Mr. E. Le Q. Herbert, in his presidential address, "Chemistry, Industry and Society", to the Royal Institute of Chemistry on April 6, illustrated from one particular industry—the petroleum industry—the way in which society, science and technology interact to-day, and the limits which are set to what is technologically or socially possible. Sir Hugh Beaver, in the sixth Graham Clark Lecture to the Institutions of Civil Engineers, of Mechanical Engineers and of Electrical Engineers on March 3, assayed an even larger canvas. Under his title, "Engineering and Civilization", he reviewed the earlier five lectures as chapters in an attempt to discern the meaning of civilization and, putting these lectures into the perspective of the wide field of engineering thought, endeavour and achievement, he attempted to envisage the duty of the engineer in the new world that is so rapidly developing before us. Despite the different starting points and lines of approach, Mr. Herbert's and Sir Hugh Beaver's lectures have a good deal in common, and it is noteworthy that, like Dr. Comfort, they lay considerable stress on the importance of due attention to the problems of the under-developed territories, though incidentally Sir Hugh does not accept the view that the gap between the 'haves' and the 'have nots' is widening.

Sir Hugh Beaver starts with this fact that the population of the world is advancing at what by any calculation is a staggering rate: at the present rate of increase it will be 4,000 million in some 20–25 years time and 5,500 million by the end of the century. While the so-called under-developed countries are ceaselessly claiming the attention, service and money of the nations of Europe and North America, at the same time they are adamantly asserting their own authority and independence. The speed of advance which all these emerging countries envisage would more than tax all world resources, however mobilized, and their hopes are not in any way to be achieved by all the available money, however well used. Besides this, he pointed out, science and technology have brought us to the very edge of potential world destruction, and scientific research has brought us perhaps just to the threshold of the secret of the creation of living organisms.

The Western world is thus at a critical point in its history, and it is the basis of Sir Hugh's argument that engineers have a special responsibility because they have built this modern world of convenience and comfort, and all through the ages have not only been improving life but have also produced all the means and machines of destruction. In the first of the Graham Clark Lectures, Sir Harold Hartley reviewed the engineer's contribution to the conservation of natural resources; and without going into the picture Sir Harold Hartley displayed, Sir Hugh Beaver expresses the opinion that it is both incorrect and dangerously misleading to think that the basis of developed engineering is shortage of man-power. On the contrary, to-day we are proving that man-power is the basis of engineering, and Sir Hugh fears that we in Britain may eventually find ourselves out-distanced by our competitors simply because of their greater sources of man-power.

Sir Maurice Bowra, in the second lecture, dealing with the impact of engineering on society, suggested that without engineering civilization is impossible, and that China and Greece and Rome in turn lost their leadership in the world of their days because they treated engineering as of secondary importance. Sir Ewart Smith, in the fourth lecture, on "The Engineer and Management", claimed that the advance of science and its practical application through engineering and chemical technology had shown that mankind had the potential ability to achieve any standard of material well-being that may be desired; and whereas Sir Maurice Bowra had suggested that the engineers had gone wrong by assuming that improving the human lot just meant the greater exploitation of natural resources for the benefit of humanity, Sir Ewart Smith, more positively, but in the context of management, had added that our own civilization could continue successfully only if it achieved a balanced combination of the humanities and technology, based on both science and art. Though this criticism or suggestion is continually being made now, Sir Hugh Beaver pointed out that it was not always made: in the age of Leonardo de Vinci, the Elizabethan age or when the Royal Society was founded, this distinction between culture and art and science and engineering did not exist, and the fathers of engineering as we know it in Britain were drawn from very varied origins to the adventure of practical and creative engineering.

Recalling Bacon's use of the Sphinx's riddle in the series of mythological fables that he called the 'Wisdom of the Ancients", Sir Hugh suggested that there are two kinds of riddles, one kind relating to the nature of things and the other relating to the nature of man, and that this perplexing, harassing problem may really be all or part of the explanation of the failure of some to distinguish between their duty to their country and their duty to mankind. Unless we can solve these problems arising in the impact of science on mankind, we must face the extinction of civilization and perhaps of mankind, and that is the problem particularly of scientists, technologists and engineers. What faces us here particularly is not what are the proper proportions of our man-power to be directed or attracted to this discipline or that, but how we are best to educate this and future generations in which inevitably the preponderance of educated output must be scientific and engineering.

This was the essential theme of Sir Ifor Evans's third Graham Clark Lecture, "The Place of Engineering in University Education"; but Sir Hugh ranged far outside that lecture in his survey of the way in which a balanced combination of the humanities with technology is to be achieved, referring particularly to Sir Eric Ashby's views as expressed in "Technology and the Academics", to that expressed by Huxley in 1867–68 in evidence to the Parliamentary Select Committee on Scientific Instruction, and to Sir Patrick Linstead's Hinchley Memorial Lecture in 1957. But it is not enough, Sir Hugh Beaver urged, for educationists to be giving thought to this problem of producing adequate citizens for the new world, who can deal with the problems of a scientific age, whether they approach them from the side of arts and the humanities or from the side of science and engineering. It is a matter for thought by engineers themselves, particularly as to how to produce the scientist and engineer as fully educated citizens of their country and of the world.

There is another aspect to be considered. Sir Maurice Bowra pointed out that no engineering had ever been revolutionary in the political sense, and engineering is not a political activity. Nevertheless, no one has the right to disclaim or 'opt out' of politics, least of all the engineer. Sir Hugh Beaver urged strongly that the great professional institutions should give continuous, and not just occasional, thought to these educational and political issues; that they should consider how far they could, in part at least, rectify omissions in the post-university life, and regard themselves not solely as platforms for technical discussion but also as providing the means of studying how engineers of the future could make a greater contribution to civilization.

Mr. Le Q. Herbert's address, particularly when he discusses the relations between the refinery and the community, shows how fully some responsible professional men recognize such responsibilities. When the graduate chemist or engineer carries Western culture into less-developed countries, said Mr. Herbert, urgent and ethical problems may arise, and we cannot leave them, with their wide implications, to solve themselves. He suggested that a great responsibility lay upon the scientist, the technologist and any other professional man when it came to considering how Western technologies could best assist the emergent or resurgent countries in achieving their national aims, and here above all the relation of professional ethics to industry and society must be acknowledged and used for good.

While Mr. Herbert clearly recognized that the professional societies have their part to play, he was also convinced that industry itself had its own responsibility for taking over the broadening process where the universities left off, and, by selecting, planning and helping the young scientist or technologist in his career, to develop this vital relation between industry and society. Professional institutions, the universities and industry have all their part to play in producing the type of man required; but it is as clear from these latest addresses as from that of Sir Solly Zuckerman that it is increasingly true that limits are set in other fields to what science or technology can do. Political strategy —and even the purpose behind the strategy—may be determined by decisions taken in quite unrelated fields, by the way in which the discovery of new ways of doing things transforms the things being done. As Sir Solly remarked, the element of the unknown in government increases with every step we are now taking to apply the fruits of science; the controversy that has recently arisen over the Government's policy with regard to the *Blue Streak* missile aptly illustrates the point. The urgency of this matter of a broad education can scarcely be over-stressed; it is important from the point of view of ensuring a stream of scientists and technologists and engineers, of administrators and statesmen alive to the human as well as to the technical issues involved in major political decisions, and equally important for securing public understanding and public acceptability of wise decisions made with full realization of the way they determine the future. It is to be hoped that the Minister for Science as well as professional associations of scientists and technologists will give due heed to Sir Hugh Beaver's appeal.

MAN-MADE FIBRES

Man-Made Textile Encyclopedia
Edited by J. J. Press. Pp. xxx+913. (New York: Textile Book Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 200s.

WITH the possible exception of synthetic dyes, man-made fibres have been the most significant contribution of the scientist to the textile industry. These materials have greatly increased the scope of textile designers, and the public has been given a wider selection of interesting and attractive fabrics and garments often at low prices. Every industry has benefited from the introduction of the new fibres for they have enabled basic operations such as transportation and purification to be carried out more effectively and more conveniently. The textile industry itself has also gained much, for the advent of the new materials has stimulated research and development in all branches of textile science and technology, not least in the manipulation of natural fibres. The offspring of the chemical and engineering industries, the man-made fibre industry is forward-looking and progressive, taking full advantage of the latest scientific and management techniques. Large sums of money are devoted to long-term research which has already resulted in the appearance of many new fibres and new methods of fibre production and processing. Even though the man-made fibre industry is comparatively young, a great mass of information covering all aspects of fibre production and manipulation has been published. Much of it, particularly that dealing with the technology of man-made fibres, is not readily accessible, and the publication of an encyclopædia such as the one under review is therefore welcome. The editor has been fortunate in securing the services of many authors, each an expert in his own field. The various sections of the book are therefore authoritative and informative.

The work is divided into twenty-two chapters and covers all aspects of man-made textiles, from the chemistry of the raw materials from which the fibres are made to methods for marketing the finished fabrics and manufacturing them into garments. Such a work could have been a rather uninteresting catalogue of equipment, machine settings and recipes, but this has been avoided. Even though a great deal of information is given (often in the form of well-constructed tables) the work is essentially a collection of readable essays welded together by careful arrangement into a complete whole. While the book will undoubtedly be used mainly as a reference book on general textile principles and practice, it is also valuable in revealing current trends. The opening chapters deal with the constitution and properties of the materials from which man-made fibres are made. Very appropriately this section is edited by Dr. Herman F. Mark, to whom the encyclopædia is dedicated. Accounts of fibre-manufacturing processes follow and include a short article on the production of superfine ($< 1\mu$ in diameter) thermoplastic fibres. The properties of man-made fibres and methods of fibre identification are then discussed in some detail. The technology and principles of converting fibres into yarns and finished cloth are dealt with in a general way, interesting sections being included on significant modern topics such as tow and high-bulk staple processing, non-woven textiles, and tufted materials. Cloth production and weaving are presented in relation to specific end-uses; for example, industrial and military fabrics, apparel fabrics, and household fabrics (floor coverings and upholstery fabrics). Some sixty pages are devoted to a most important discussion entitled "Textile Engineering Principles", which illustrates the modern scientific approach to the building of textile fabrics. In the sections on the dyeing, printing and finishing of fabrics, methods of handling most of the important man-made fibres are indicated, and the work is completed by accounts of topics such as knitted fabrics, garment manufacture, dry cleaning, commercial laundry practice, modern home washing methods, performance standards, statistics and marketing. A useful list of trade names of almost every man-made fibre in production is also given.

The discussion of such a wide range of topics necessitates a general treatment of each, but in spite of this a surprisingly large amount of valuable material has been included. The presentation is excellent, and a remarkable uniformity has been achieved throughout. The book is a valuable addition to the literature of textiles, not only because of its wide coverage but also because of the many unusual topics which are considered. Few will open this book without finding something to interest them. To prepare such a work and to maintain a consistently high level throughout is in itself a great achievement, and it is perhaps churlish to suggest omissions, as no doubt the editor had to make firm decisions to cut out much which he would have liked to include. He could, however, with advantage have introduced more references to original papers and specialized review articles. These would have added considerably to the usefulness of the volume. C. S. Whewell

COLORIMETRIC ANALYSIS

Colorimetric Determination of Traces of Metals

By Prof. E. B. Sandell. Third edition, revised and enlarged. (Chemical Analysis: a Series of Monographs on Analytical Chemistry and Its Applications, Vol. 3.) Pp. xxii+1032. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 185s.

A Handbook of Colorimetric Chemical Analytical Methods

Fifth edition. Pp. 360. (Salisbury: The Tintometer, Ltd., 1959.) 30s. net.

THE chemical analysis of traces of substances is now of great importance in areas as diverse as applied nuclear physics, soil science and medical chemistry. Colorimetric procedures are generally preferred for these determinations of trace elements. Although other, and often better, techniques are available, the expensive equipment required puts them outside the scope of all but highly specialized laboratories.

Prof. Sandell's book now achieves its third edition, which is about half as big again as the previous edition despite the removal of a good deal of the original material. The appearance of this volume is a tribute not only to the increased application of colorimetric methods but also to the great variety of new reagents and procedures which have been proposed in recent years. Prof. Sandell has not attempted to compete with the encyclopædic work of Snell and Snell. He has restricted himself to metals, and has chosen only a few procedures for the determination of each metal; his broad experience of chemical analysis and his common-sense approach ensure that the selection comprises the most useful and widely applicable procedures.

The text is divided into two parts: general aspects of inorganic colorimetric trace analysis, and procedures for the determination of traces of metals. Part 1 contains penetrating discussions on general trace analysis, on the separation and isolation of traces, on the application of colorimetry and spectrophotometry to their determination, and on colorimetric reagents. Colorimetry is regarded in its widest sense, fluorimetry, nephelometry and turbidimetry being included. In Part 2, which makes up two-thirds of the text, each metal is discussed under the headings of separation, methods of determination and, where the information is available, applications.

The sad fact that the development of new reagents has far outdistanced knowledge of their applications is repeatedly emphasized. Too often, new reagents are proposed without any reference to their behaviour in the presence of likely interfering elements and without reference to any advantage which the new procedure may have over earlier methods. The examination of the new reagents seems to be undertaken as an academic exercise and frequently an incomplete one at that. However, Prof. Sandell has picked his way with sure steps through the wide variety of methods available. Although the book is large, the subject has been treated with acuity, brevity and clarity, which are the more admirable when the multitudinous original sources are considered. The text is indispensable to all who are interested in colorimetry or trace analysis.

Little need be said concerning the second book, which contains the methods recommended by Tintometer Ltd. for use with their Lovibond range of apparatus. Contained in a loose-leaf binder, the sections deal with the apparatus, *p*H measurements, inorganic and organic chemical analysis, chemical pathological analysis, noxious vapours and miscellaneous methods. Any additions will be supplied free of charge for the next two years. The fifth edition has been enlarged and almost completely revised.

This collection of methods should prove useful in routine laboratories, for the procedures have been thoroughly checked by many workers and there should be no doubt of their reliability. The claims made for the convenience of the binding method would have been more impressive had the folder not come apart on preliminary handling.

A. M. G. MACDONALD

ANNUAL REVIEWS ON INORGANIC CHEMISTRY

Progress in Inorganic Chemistry

Vol. 1. Edited by F. Albert Cotton. Pp. ix + 566. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 109*s*.

THIS book consists of seven review articles considered to be of interest to inorganic chemists. This new series, appearing so soon after the first volume of "Advances in Inorganic and Radiochemistry" edited by Emeléus and Sharpe, must raise the question of their desirability, although it would appear that "Progress in Inorganic Chemistry" was first in conception. There is only one paper which is not in English, so that we may consider that the alternative places for publication of such articles would be *Chemical Reviews* or *Quarterly Reviews*, each catering for a rather different approach from the other. The excellent article by Roland Ward on mixed metal oxides, which is particularly notable for the clarity of its diagrams, seems to exemplify the type of paper for which "Progress in Inorganic Chemistry" was created. It would not fit easily into either of the existing journals for reviews.

However, this is not altogether true of the other papers in this volume. Becke-Goehring writes on nitrogen–sulphur compounds although there is a similar review on tetranitrogen tetrasulphur in *Quarterly Reviews*. "Interstitial Compounds of Graphite" by Hennig, which is more comprehensive than the corresponding article in "Advances in Inorganic and Radiochemistry", gives a good account of a subject in which little is definitely known. Too much inconclusive work is included. Again, "Metal-Ammonia Solutions" has recently appeared in *Quarterly Reviews* although the present review is more comprehensive.

The *Chemical Reviews* type of article is exemplified by that of Wilkinson and Cotton, who give an exceptionally good account of the rapidly expanding field of cyclopentadienyl and arene metal compounds. The only criticisms that can be made of this article are that the crystallographic nomenclature (on p. 30) is very inaccurate and that certain workers come in for excessive criticism. A somewhat similar paper by Malatesta on "Isocyanide Complexes of Metals" shows clearly the need for more structural work in a field in which problems abound. The crystallographic data cited in some cases are not the most recent, and the chemical nomenclature leaves much to be desired.

The only other paper is by George and McClure, on the effect of inner orbital splitting on the thermodynamic properties of transition metal compounds and co-ordination complexes. Reviews on this topic are usually either too elementary or go to the other extreme and assume at some stage that the reader is familiar with the work of Condon and Shortley. This comprehensive article, which includes a great deal of new material, goes some way towards the intermediate stage.

Altogether the reviews are satisfying, but with the tremendous accumulation of papers to be read through in a year any new source must prove its worth. The main task here lies with the editor in a skilful choice, preferably of topics which cannot suitably be treated in other places, or where a review is necessary to stimulate interest and bring in new research workers.

There are few misprints and errors, and the text is well produced.

I. R. BEATTIE

RELATIVITY

Theory of Relativity

By W. Pauli. Translated from the German by G. Field. Pp. xiv + 241. (London and New York: Pergamon Press, 1958.) 35*s*. net.

The Theory of Space, Time and Gravitation

By V. Fock. Translated from the Russian by N. Kemmer. Pp. xviii + 411. (London and New York: Pergamon Press, 1959.) 100*s*. net.

THE distressing thing about relativity is that the part of it which deals with gravitation—the general theory—is so isolated from the rest of physics. This is understandable, since gravitational forces are unimportant in atomic and nuclear physics, and non-Newtonian effects in astronomical systems are extremely small. Moreover, Einstein's idea of geometrizing gravitation has not yet been successfully extended to other fields of force. For these reasons, the general theory, for all its beauty and profundity, has until recently been rather neglected as a subject for research. This situation changed about five years ago; since then there has been a tremendous surge of interest in general relativity. This interest is based mainly on the hope that, despite its quantitative unimportance for contemporary physics, gravitation and its geometrical description may be qualitatively important in the fundamental physics of the future.

In the light of this development the two books under review form a remarkable contrast. They are both written by famous physicists best known for their contributions to atomic theory and quantum mechanics, and they are both beautifully translated. But there the resemblance ends. For Pauli's book was written when he was a student of twenty-one, barely five years after the publication in 1916 of Einstein's definitive paper on general relativity, while Fock's is the product of a mature mind reflecting on a forty-year old theory. Yet Pauli's book reads as though the theory had already reached completion, while Fock's suggests that both its physical significance and its implications are not yet understood.

This contrast makes Pauli's book a simpler introduction to the subject, but correspondingly less stimulating to the research worker. It is better documented, more systematic in its presentation of standard material (in special as well as general relativity), and shows an astonishing breadth and mastery for so young an author and a subject. Greater glory was yet to come; but in none of his later writings did Pauli surpass in clarity, profundity or authority this juvenile performance.

To a modern eye some of his material lacks the interest which Pauli then attached to it, but this defect is balanced by the addition of twenty-three supplementary notes written in 1956 for this English edition. They contain an account of two of the main developments since 1921, namely, attempts by Einstein and others to unify gravitation and electromagnetism, and, in somewhat less detail, Friedmann's discovery of time-dependent cosmological solutions of Einstein's equations. There is a brief mention of the work of Einstein, Infeld and Hoffmann, and of Fock on the derivation of the equations of motion of material bodies from the field equations, but virtually nothing on such topics of recent interest as the initial-value problem, the quantization of the theory, and the associated problem of the existence and properties of gravitational radiation.

In contrast, it is the problems of deriving equations of motion and the properties of radiation which form the heart of Fock's book. His introduction to special and general relativity contains many interesting twists; but the main importance of his book lies in its detailed presentation of his own heroic calculations. He differs from Einstein, Infeld and Hoffmann in his systematic use of a stress tensor to describe matter, instead of regarding it as a singularity in the geometrical structure of space. He finds approximate solutions of Einstein's equations for both non-rotating and rotating masses, and obtains their post-Newtonian equations of motion and expressions for the gravitational potentials in the wave-zone. The calculations are extremely intricate, but are presented very clearly.

Fock performs his calculations in a particular co-ordinate system—the de Donder or harmonic system. If the space is Minkowskian at infinity, and if certain other conditions are satisfied, these co-ordinates are uniquely defined up to a Lorentz transformation. Fock believes that they are the natural analogue of the inertial systems of special relativity. In his view they do more than simplify certain calculations; they are of deep significance to the theory as a whole. This view is not shared by all students of relativity, most of whom believe that in general no particular significance can be attached to special co-ordinate systems. In their view all the physical implications of Einstein's theory can be expressed in terms of invariants which are completely independent of the choice of co-ordinate system. Only in special spaces (for example, those which satisfy simple boundary conditions at infinity, or which admit a group of motions) can a special co-ordinate system simplify calculations. In his book Fock defends his view in detail, and it is valuable to have this clear statement of his case. Whatever the final decision may be, his own calculations form a permanent addition to our knowledge of Einstein's theory.

D. W. SCIAMA

ENDOCRINOLOGY OF REPRODUCTION

Recent Progress in the Endocrinology of Reproduction

Proceedings of the Conference held in Syracuse, New York, June 9–12, 1958. Pp. xi+532. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 12 dollars.

CONFERENCES and symposia on endocrinological subjects have been multiplying in recent years and it is becoming more and more common for the proceedings to be published *in extenso*. The practice has, however, several disadvantages. Some of the introductory general papers often provide nothing more than a refurbishing of material that has been published already or is in press. It is only when they give a critical and up-to-date account of a particular field which has not recently been covered that such papers are valuable. Other shorter contributions tend to report work in progress in an incomplete fashion, or because the editorial hand is often more gentle with invited papers, sometimes circumvent the full rigours of the refereeing system that submission to an appropriate scientific journal would entail. Finally, the printed proceedings are often long delayed and costly and the general result is further crowding, confusion and reduplication in an already overloaded literature.

Yet, with all these reservations one has to concede a warm, if reluctant, welcome to the published proceedings of another conference on the "Endocrinology of Reproduction", this time held at the New York State University Medical Center, Syracuse, during June 1958.

The arrangement of the programme was a logical and thorough one, beginning with a consideration of ovulation and passing via the hormonal balance in the normal cycle to fertilization, implantation, pregnancy and finally to parturition and lactation. The speakers on these topics were equally well chosen.

It is inevitable that among a collection of twenty-three papers, some should stand out as especially interesting to someone who wants to keep abreast of the current trends of opinion in reproductive physiology. Such are the papers by Chang on the fertilizing capacity of sperm, by Harris on the integrations between nervous and endocrine systems where they meet and overlap to control the process of ovulation and by Folley and his colleagues on mammary growth and lactation. Others like that of Heller on the neurohypophysis during the œstrous cycle, pregnancy and lactation emphasize areas where research effort has been lacking and where fresh work, in this case on changes in water metabolism during the reproductive cycle, might be very profitable. The remaining papers are more in the nature of progress reports on work in hand. There are several on the levels of hormones to be found in the urine both during normal cycles and in pregnancy, and other topics include the capacity of the placenta to produce hormones, and the latest evidence about the status of relaxin as a hormone. A notable and pressing omission from the topics discussed at the meeting is the control of overall fertility patterns in relation to the world's population problem.

At its American price of 12 dollars this book is not perhaps an essential purchase for one's own bookshelves, but it is certainly worth reading.

P. L. KROHN

BRAIN AND BEHAVIOUR

The Central Nervous System and Behavior

Transactions of the Second Conference, February 22, 23, 24 and 25, 1959, Princeton, N.J. Edited by Mary A. B. Brazier. Pp. 358. (New York: Josiah Macy, Jr. Foundation, 1959.) 4.75 dollars.

THE verbatim recording and publication of papers and discussions presented at extended symposia is a characteristically American contribution to contemporary scientific communication. Well done, it conveys a remarkable atmosphere of actuality. Its informality is refreshing, and it permits the reader at some small remove of time to be taken to the brink of current experiment and speculation. Occasionally interruption of the text by interjection or argument is distracting; but more often it is both revealing and stimulating. The spirit of such meetings is epitomized by Dr. Fremont-Smith in his introduction to the present volume when he quotes the admonition "Don't speak when I'm interrupting".

This book presents the transactions of a conference held at Princeton in February 1959 and devoted mainly to the study of changes in animal behaviour induced by experimental cerebral lesions. The participation of a dynamically orientated psychiatrist (Douglas D. Bond) is revealing evidence of the mantle of scientific respectability worn by psychoanalysis in the United States, but still firmly denied to it in neurophysiological circles elsewhere. Dr. Bond's discussion of the possible relation between the behaviour which follows experimental hippocampal–amygdaloid lesions in the animal and that seen clinically in human anorexia nervosa is intriguing, as are some asides on the effect of a number of commonly used drugs such as amphetamine, meprobamate, and chlorpromazine, on animals subjected to similar cerebral lesions.

In other sections of the book Grastyan (Hungary) discusses electroencephalographic changes recorded in the hippocampus of the cat during the development of conditioned reflexes, and Bures (Czechoslovakia) the effect on behaviour of transient depression of cortical activity in the rat by the local application of chemical substances such as potassium chloride. Probably the chapter of greatest general interest is that by Rusinov (Moscow) on electroencephalographic work during the establishment of conditioned reflexes in man. Only here and in Dr. Galambos's (Washington) stimulating "summation" does the discussion briefly develop from technological detail to tentative philosophical generalization.

The book closes with an interesting account of Mary Brazier of a preceding colloquium on the electroencephalographic and higher nervous activity held in Moscow in October 1958. From this it is clear that the academic authorities of the U.S.S.R. have not been behindhand in sharing with the Americans the organization of similar high-level meetings for the exchange of knowledge and ideas in the neurological sciences.

It is depressing to note that although several speakers pay tribute to the contributions of Darwin, Hughlings Jackson and Sherrington to the scientific investigation of behaviour, references to current British work are almost non-existent, and that one British scientist attended the Moscow meeting, none the American. Fortunately the Macy and National Science Foundations, by making this excellent volume available at a relatively modest price, enable us to profit vicariously by the efforts of our more energetic colleagues.

HENRY MILLER

NORTH AMERICAN FRESH-WATER BIOLOGY

Fresh-Water Biology

By Henry Baldwin Ward and George Chandler Whipple. Second edition edited by Prof. W. T. Edmondson. Pp. xx+1248. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 276s. net.

THIS new edition of an old favourite that appeared in 1918, virtually a new book, covers the fresh-water fauna and flora of North America except for free-swimming cercariæ, spiders and vertebrates. Forty-two groups are handled by fifty-one authors, two of whom are survivors from the first edition. In nearly half the groups the keys go down to species, and these tend to be the groups which have been neglected, in Europe at least, such as Porifera, Coelenterata, Gastrotricha and Tardigrada. The Crustacea are treated fully; but the keys to all the insect orders and to some other large groups go no further than genera. The introductions to the book and to each chapter give no more information about morphology and technique than is necessary for an understanding of the keys, and there is less of a general nature than in the first edition.

Illustrations are plentiful and good, the text is well laid out, and more than that it would be impertinent for anyone not closely acquainted with the American fauna to say. The question is: How useful will this book be in Britain? It covers the United States and Canada, an area that extends almost from the tropics to the Arctic, which means that it includes many more species than are found in Britain and in any European book, since all are on a national basis, "Faune de France", "Tierwelt Deutschlands", "Danmarks Fauna" and so on. There are, for example, 53 genera of Ephemeroptera in America, which is 5 more than the total number of British species; all but one of the 18 British genera are included in the 53. There are 89 species of Cladocera in the

Freshwater Biological Association's key, 121 in Ward and Whipple's and 60 are common, but this is a group well known for its cosmopolitan distribution and in many others the overlap is much less.

The references vary from chapter to chapter; sometimes there are none to European work, sometimes the main ones are included, particularly if they are written in English.

It is clear, then, that whoever uses the new "Ward and Whipple" will have to struggle with keys that are larger than is necessary for his purpose and which probably do not include the species before him. Moreover, there is much more on the European fauna than was available to his predecessor using the first edition. On the other hand, almost all freshwater animals and plants are dealt with between two covers and the book must therefore contain some organism allied to any specimen the identity of which is to be ascertained. This can be comforting to somebody who has prowled in vain around a scientific library searching for a key to the group to which a specimen is thought to belong, and even more comforting to somebody who has no scientific library to prowl around. A second point that will endear this new volume to a new generation is the full treatment of neglected groups. I believe, therefore, that the book will be found not to have lost its old appeal.

T. T. MACAN

OPTICAL ROTATORY POWERS OF ALKALOIDS

Tables of Constants and Numerical Data

11: Selected Constants: Optical Rotatory Power. 4: Alkaloids. By Prof. J.-P. Mathieu and Prof. M.-M. Janot. (Publication subsidized by the Member Countries of the International Commission of Tables of Constants and by the Centre National de la Recherche Scientifique.) Pp. v+211. (London and New York: Pergamon Press, 1959.) 160s. net.

THE present volume is the eleventh in the series of "Tables of Constants and Numerical Data", founded in 1909 by C. Marie, and it is the fourth in the series devoted to the optical rotatory powers of naturally occurring substances. The preceding volumes dealing with optical rotatory power have covered the steroids (1956), the triterpenoids (1958), and the amino-acids (1959), and all four have come under the general editorship of Prof. J.-P. Mathieu with the aid of specialists in the particular fields concerned. In this volume, devoted to the alkaloids, Prof. M.-M. Janot has collaborated with Prof. Mathieu, and Sir Robert Robinson has provided a foreword.

In view of the greater chemical diversity of the alkaloids the material covered in this volume is inevitably more heterogeneous than that considered in the preceding volumes, and the main function of the book is to collect together in one place the data scattered throughout the literature on optical rotation measurements made on alkaloids. The editors have been faced with the well-known problem of defining an alkaloid, and they have therefore based their criteria for inclusion on the considerations that the alkaloids form a group of organic compounds of vegetable origin, always containing nitrogen, possessing more or less pronounced basicity, yielding precipitates with certain 'general' reagents, and being endowed with remarkable pharmacological activities. It is realized, of course, that such a classification is somewhat arbitrary, and the editors have compiled a list of the known alkaloids, including minor alkaloids and many that have no action on polarized light, provided that an empirical formula has been assigned.

In the table of rotatory powers, the alkaloids and their salts are listed in alphabetical order by trivial names with molecular (or empirical) formulæ and melting points. Other column entries are molecular weight, and solvent, concentration, temperature, and wave-length for which the recorded specific rotations have been measured, and, finally, bibliographic references. The table, which has been compiled essentially from data found in original papers, occupies 166 pages, and the bibliographic references, given in a most convenient and compact form, occupy 23 pages, followed by an author index (10 pages) and a formula index (8 pages). The references (1809) span the interval between 1873 and mid-way through 1959, and their distribution over the years provides an interesting sidelight on activity in the field of alkaloid chemistry. Thus, the six decades from 1870 to 1929 provided only 19·3 per cent of the references, and the three decades since have provided respectively 18·4, 14·7, and no less than 47·7 per cent of the references. In fact, about one-third (32·8 per cent) of the bibliography relates to the last five and a half years covered, and it is obvious that, at this time of intense activity in the field of alkaloids, the present volume will be welcomed in laboratories where alkaloids are being studied.

It is a pleasure to note that a return has been made to a conventionally printed style, employing minute but very legible type, and the binding matches that of earlier volumes in the series.

J. WALKER

A MYTHICAL SCIENCE

The Masks of God

Primitive Mythology. By Joseph Campbell. Pp. viii+504. (London: Martin Secker and Warburg, Ltd., 1960.) 35s. net.

THE publishers claim that "The Masks of God" is "undoubtedly a landmark in its own field". Alas! Like so many landmarks it is also a folly.

The author's purpose is "the first sketch of a natural history of the gods and heroes, such as in its final form should include in its purview all divine beings. . . . For, as in the visible world of the vegetable and animal kingdoms, so also in the visionary world of the gods: there has been a history, an evolution, a series of mutations, governed by laws; and to show forth such laws is the proper aim of science" (p. 5). A new-born chick, says Dr. Campbell, will dart for cover when a hawk, or a model of a hawk, passes overhead—but not when the bird is a gull, duck, heron, or pigeon, or model of these latter. This kind of response to inherited, not taught, "innate releasing mechanisms", Dr. Campbell continues, is shared by human beings; and the biology, psychology, sociology and history of the sign stimuli which release these mechanisms of inheritance "constitute the field of our subject, the science of Comparative Mythology" (p. 41).

There is here a major distinction between what is common to all men and what is culturally determined;

there is also a distinction between part of the process of 'making' myths, and mythologies, which the author seems scarcely aware of. From such beginnings, without any analysis of the mechanisms of inheritance, mythologies are classified into those of the hunter, the planter, the ancient city dweller, and the peoples of prehistory; and an attempt is made to show, using the theories of the diffusionist and *Kulturkreis* schools—unconvincingly, I think—how such types of myths might have spread or diffused. The classification is useful: there are some interesting passages on the cuckoo, divine kings, the ritual love-death, shamanism, cave painting, a stickleback, and palæolithic and neolithic man, but the relations between the inherited image—imprinted on man's mind some 600,000 years ago, the poetic vision, cultural determinism, and culture change and diffusion remain —as one would expect—wholly obscure.

Diffusionist theory is necessary to this kind of construct, and some theories might provide models for what to-day is called 'acculturation'. Why cite Forbenius and Haeckel—who failed to construct such a model—and not Perry and Elliot Smith—who did? The seminal work of Hocart, Halbwachs, Van Gennep, Levi-Strauss, and Leenhardt is not mentioned. Indeed, these authors can offer little to one who, though some sort of Jungian, is determined to take his departure from Bastian without taking Neumann into account.

If there were a personal and imaginative synthesis the strange choice of authorities would not matter. For the central problems—how myths come to exist, penetration of the divine or mystical experience, the relation of myths to particular kinds of social structure and culture—are real and outstanding. But they will not yield to grandiose pretensions, second-hand psychology, muddled sociology, bad history, and an appalling confusion of biological and cultural levels.

K. O. L. Burridge

RADIATION AND THE BROAD BEAN

Radiation Biology of *Vicia faba* in Relation to the General Problem

By Dr. John Read. Pp. xxii+270. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas, 1959.) 45*s*. net.

THE roots of broad bean seedlings are stout and not very exacting in their requirements for good growth. The meristematic and differentiating zones are well demarcated, and squash preparations can easily be made to display the chromosomes in dividing cells of the root-tip. The chromosomes themselves are large and only twelve in number. The growth-rate of the roots can easily be measured by their increase in length. These are the main characteristics which have led many of those working on the effects of radiation on living systems to adopt the broad bean as their experimental material.

Dr. Read gives a systematic account of this work, restricting himself almost exclusively to investigations published after 1939. The reader is led in the early chapters through the effects of radiation on growth-rate, to a consideration of the inhibition of mitosis by radiation. It is the contention of the author that many effects of radiation on growth-rate stem from damage to the genetic material, and it is to an analysis of chromosome aberrations in relation to radiation that much of the book is devoted. The various conflicting theories as to the nature of chromosome aberrations are considered in detail in the light of all the available evidence as to the influence of the type of radiation, the dose-rate and the various environmental factors which affect the production of aberrations. Deoxyribonucleic acid synthesis after radiation is considered briefly, as is a comparison of radiation with radiomimetic chemicals in their effects on the bean root. Throughout, the results obtained with broad beans roots are compared with those obtained from other living systems. In a final chapter a valuable summary is made of the comparisons of this type which have been made in previous chapters. Dr. Read presents a formidable case for the utility of his superficially trivial experimental material. There is a bibliography of more than two hundred titles.

The presentation of the book is excellent, the type being large and clear and the text figures bold. Those intimately concerned with the biological effects of radiation will be grateful to Dr. Read for drawing together in such an accessible manner all the important information on *Vicia faba* and radiation.

HISTORY OF ENGINEERING INVENTION

Science as History

The Story of Man's Technological Progress from Steam Engine to Satellite. By Heinz Gartmann. Translated from the German by Alan G. Readett. Pp. xvii+348+51 photographic illustrations. (London: Hodder and Stoughton, Ltd., 1960.) 25*s*. net.

"SCIENCE as History" has a more accurate subtitle "The Story of Man's Technological Progress from Steam Engine to Satellite". It is a popular account of engineering invention and development written around a number of the most important examples. The advance of the steam engine, motorcar and aeroplane, is followed by chapters on telecommunications, radio, radar, atomic physics, automation, and space exploration.

The author has not attempted a critical appraisal of the topics chosen—the work is in no way 'learned'; he has sought sensibly to recount some history in an interesting manner. In some chapters unnecessary detail clouds the overall pattern; for example, so many names appear in the steam engine section that the really important contributors never emerge. There is also a probably unavoidable national bias. When the United States, Britain, Europe and the U.S.S.R. are all working on similar problems, often under conditions of secrecy, it is exceedingly difficult to be just.

Some chapters lack balance; the space devoted to balloons and Zeppelins is twice that devoted to the immensely fertile period of aviation history from 1903 to date. Finally, the treatment of Dr. Eugen Sänger's lecture on relativistic mechanics applied to space flight is positively melodramatic.

In spite of these faults the book is immensely readable, beautifully produced, has a bibliography, and does display an appreciative understanding of the important and exciting developments selected. It deserves a wide audience.

J. L. Stollery

International Commission for Uniform Methods of Sugar Analysis

Report of the Proceedings of the Twelfth Session held at the National Bureau of Standards and at the Shoreham Hotel, Washington, D.C., U.S.A., from June 2nd to June 6th, 1958. Pp. vii+130. (Keston, Kent: International Commission for Uniform Methods of Sugar Analysis, Tate and Lyle Research Laboratories, New York: Sugar Research Foundation, Inc., 52 Wall Street, 1959.) 25*s.*; 3.50 dollars.

THE twelfth session of the International Commission for Uniform Methods of Sugar Analysis was held in Washington, D.C., in June 1958.

Its proceedings, which have now been published, contain detailed papers and discussions concerning some twenty-six problems which are primarily of special interest to those concerned with technical aspects of the sugar industry. The subjects for discussion included, among many others, such matters as the determination of sucrose and reducing sugars in molasses, the inorganic and organic constituents of raw sugars and sugar products, and factors causing deterioration of raw and refined sugars in storage and during transport. In each instance the problem had been referred to a group of experts from the various countries concerned. Their reports and recommendations for analytical methods are printed with full details of the experimental procedures. A verbatim account of the discussion which followed the presentation of each report is then given and finally the decisions of the Commission are recorded.

In some cases the referees' recommendations have been accepted only for guidance by analysts, no final decision being taken. It will be evident that this volume will be of interest mainly to professional analysts; but the methods described may be of great use also to investigators who have to deal with any aspects of carbohydrate chemistry which involve the separation and quantitative analysis of sugars.

E. L. HIRST

Precipitation Processes in Steels

Report of a Conference held in the University of Sheffield, 2–4 July, 1958, and organized by the Department of Metallurgy. (Special Report No. 64.) Pp. xiv+322. (London: Iron and Steel Institute, 1959.) 84*s.*

THIS account of a conference organized by the Department of Metallurgy of the University of Sheffield in July 1958 has been deemed of such interest by the Iron and Steel Institute as to justify its being published as a special report. With this opinion one must heartily concur. Twenty-one papers were contributed, grouped around the general themes of precipitation in ferritic and austenitic steels respectively, intergranular fracture and precipitation during creep. Such precipitation processes in alloy steels are obviously of the greatest practical importance and of very much theoretical interest; the time was ripe for such a discussion, and Prof. A. G. Quarrell, who appears to have initiated it, has clearly performed a most valuable service.

The quality of the contributions is high, a great deal of first-rate original work is included, and it is outside the bounds of possibility to review this in short space. One aspect of these papers, however, is outstandingly evident in the profuse use of electron-micrographs. After getting off to a slowish start in metallographic investigations, this technique has now established itself as an essential tool in this field. Where all is so good, it is quite unfair of a reviewer to single out for special mention the papers concerned with intergranular fracture in steel, but these four contributions, one from France and one from Sweden, go far to clarify a most important and elusive phenomenon.

This is a publication which it would not be easy to welcome in too high terms.

F. C. THOMPSON

Health Physics Instrumentation

By John S. Handloser. (International Series of Monographs on Nuclear Energy. Division 5: Health Physics, Vol. 1.) Pp. x+182. (London and New York: Pergamon Press, 1959.) 42*s.* net.

THIS book is primarily designed for those familiar with the basic physics of radiation detection who now wish to make measurements for radiation control purposes.

The commercial instruments discussed and the laboratory practices described are those currently used in the United States. This does not detract from the value of the book to users in other countries, as the writer in the chapters on portable survey instruments, fixed monitors and neutron monitors gives the basic principles used, and then describes the way in which they have been applied and developed by different instrument designers. The writer thus describes briefly the range of techniques and instruments used for the measurement of neutrons, γ- and β-radiation and leaves the reader to judge which method is most suitable for his problem. In all chapters the brief details are supported by adequate references.

The techniques described cover the range of energies from tens of kilovolts to tens of megavolts. There is no discussion of the measurement of radiation from the highest-energy accelerators as the writer considers that health physics instrumentation in this field is still a research problem.

Chapters are also devoted to counting rooms and their equipment, calibration techniques and miscellaneous instrumentation, and an introduction which discusses units of measurement and acceptable limits of exposure.

The book is a useful introduction to health physics instrumentation for those entering the field and is also interesting reading for those concerned with radiation measurement for protection purposes.

B. S. SMITH

A Manual of Practical Vertebrate Morphology

By J. T. Saunders and S. M. Manton. Third edition. Pp. viii+272. (London: Oxford University Press, 1959.) 30*s.* net.

"THE aim of this Manual is to provide the student with an accurate description of the anatomy of certain vertebrate types which are dissected in an elementary course of Zoology." Since 1931, when the first edition appeared, it is clear that this aim has been well justified. In the second edition (1949) there was a welcome addition of six chapters dealing with the dissection of certain muscle systems in the rat, pigeon, frog and fishes. Until this third edition, however, there has been no guide to the general dissection of a mammal. The new chapter on the rat has been prepared by Dr. M. E. Brown and Dr. S. M. Manton. There is little that I need add, for 'Saunders and Manton' needs no introduction to classes studying vertebrate morphology.

N. B. MARSHALL

AGEING AND RADIATION

By Dr. G. J. NEARY
Medical Research Council Radiobiological Research Unit, Harwell, Didcot, Berks.

STARTING with the pioneer work of Russ and Scott[1] and of Henshaw[2], it has repeatedly been suggested that whole-body irradiation of animals speeds up natural ageing[3-7]. Although highly specific long-term pathological effects can also be produced by irradiation[8], these may not arise in certain circumstances; for example, in animals undergoing chronic irradiation at rather low dose-rates or surviving the acute injury of single doses. Yet such animals die earlier than unirradiated controls, while the spectrum of pathological conditions present at death is about the same in both groups, that is, there is a non-specific shortening of life. Thus the evidence for a speeding up of ageing by radiation refers mainly to the late period of biological deterioration usually termed senescence (see review by Comfort[9]). Apart from fertility, physiological measures of ageing have not yet been studied as intensively in irradiated as in normal animals. Nevertheless, starting only from quantitative data on non-specific life-shortening in mice, I shall argue that there is some intrinsic process of biological ageing, enhanced by radiation, which operates from the start of life and is virtually complete by the time the changes of old age begin to appear. The argument has not been, and probably cannot be, established on a firm statistical basis from the data available. But because experiments in this field are difficult and because the establishment of some relation between natural ageing and that induced by radiation might afford a better insight into the nature of the fundamental mechanisms and lead to more fruitful experimental approaches, an attempt at an inductive generalization seems justifiable.

Theories of Ageing

In the context of ageing, two fundamental questions may be asked: Why does an individual die, and why do comparable individuals die at different times? The answers offered have fallen into two broad categories: (*a*) those which emphasize the element of randomness in mortality; (*b*) those which emphasize the genetically determinate element.

Random theories. Theories in this category, while recognizing that the outcome of the interaction between an environment and an individual depends on his genetic make-up, are concerned with the behaviour of a population of supposedly uniform individuals. Such theories attach considerable significance to the empirical age-specific death-rate, the so-called 'force of mortality', sometimes interpreted as the probability per unit time that any survivor will die in that time interval. For this to be true in an exact quantitative sense, all the individuals alive at a given instant would have to be identical, a qualification pointed out by Medawar[10], but not always sufficiently noted. The fact that the force of mortality in most populations increases with age beyond a certain point has been accepted as evidence of a progressive change in the population with age. Gompertz[11] noted that in human populations the logarithm of the age-specific death-rate increases approximately linearly with age from early maturity onwards, and so this quantity has been regarded as a general measure of physiological state, and its rate of change (approximately constant) as a measure of the rate of physiological ageing of the population, and even by tacit assumption, of each individual member thereof[12]. Sacher[13] has elaborated on these ideas in an elegant mathematical model which assumes that the individuals in the population are initially identical, but that due to random external stresses and physiological interactions there is a progressive drift and dispersion in the physiological states of those individuals. The death of an individual occurs when his physiological state transcends a certain limit. In this model the logarithm of the age-specific death-rate is directly proportional to the *mean* physiological state of the population at that age; the empirical Gompertz relation would thus seem to imply that the mean state changes linearly with time. The reality of the rate of physiological ageing so deduced will depend in any actual situation on the validity, among other things, of the assumption of initial identity of all individuals.

A progressive decline in physiological state or vitality is thus an essential feature of theories assuming random mortality, but a detailed causative mechanism for the decline itself is not usually specified.

Genetically determinate theories. These theories concentrate attention on the individual rather than the population and, in their quantitative aspects at least, on the component cells of the individual. The environment is scarcely considered explicitly, except as a more or less uniform influence; for a given environment the life-span of the individual is predetermined by the initial genetic endowment. In some theories, ageing is regarded as some process of change within cells themselves, possibly in their genetic apparatus[14-18]. These ideas are discussed further in the final section, but it is clear at once that the fate of the individual cannot be considered solely in terms of the fate of a component cell. In an animal, the cells are organized in a complex hierarchy of interacting anatomical and physiological systems. Thus while changes within cells may be the root cause of ageing and finally death, it may be inappropriate to consider the whole sequence of events solely in terms of the primary process. This idea is developed later on in this article.

A comprehensive general statement about the incidence of mortality in a group of individuals may be made in purely formal terms. An individual in a population is characterized by a particular value of some parameter τ, and the number of individuals in the class from τ to $(\tau + d\tau)$ is $N(\tau)d\tau$; there is a probability $p(\tau,t)dt$ that an individual in this class will die in the age interval from t to $(t + dt)$. The age-specific death-rate $\mu(T)$, at age T is then[19]:

$$\mu(T) = \frac{\int_0^\infty N(\tau) \, . \, p(\tau,t) \, . \, \exp\left[-\int_0^T p(\tau,t) \, . \, \mathrm{d}t\right] . \, \mathrm{d}\tau}{\int_0^\infty N(\tau) \, . \, \exp\left[-\int_0^T p(\tau,t) \, . \, \mathrm{d}t\right] . \, \mathrm{d}\tau} \qquad (1)$$

In the special case where all individuals are identical, the incidence of death as between individuals is random, and $\mu(T)$ reduces to $p(T)$. At the other extreme, where the death of a given individual occurs at a characteristic predetermined age. the parameter τ may be equated with the age at death of the individual, that is, $p(\tau,t) = 0$ for $t < \tau$ and $= \infty$ for $t \geq \tau$, so that $\mu(T)$ reduces to $N(T)/\int_T^\infty N(\tau).\mathrm{d}\tau$. In this case the age-specific death-rate is merely an expression of the distribution of individual predetermined life-spans; the concept of a 'force of mortality' liable to strike down impartially and at random any member of a collection of identical individuals is then quite inappropriate. Further, the slope of the Gompertz plot, $\partial \ln\mu(T)/\partial T$, in this case need bear no direct relation whatever to a rate of real physiological ageing either in individuals or averaged over the population.

In an actual population, the factors of randomness and genetic variation are both likely to contribute to the dispersion of life-times, and either may predominate. For the human white female population of the United States at present, Szilard[10] suggests that most of the dispersion represented by the standard deviation of about 10 years is genetic dispersion, since the component due to randomness may be estimated from records of identical twins to amount to only 3 years. Even in non-identical twins, the average difference of life-times is about twice that in identical twins[10].

It is clear, however, that the genetic determination of life-time does not operate in a void, as it were, without reference to the environment. This is shown by the appreciable increase in average human life-times in economically developed countries in the past hundred years or so[11,12]. Much of this increase is due to a reduction of mortality in early and middle age; the change in old age, though real, is much less. The causes of death showing a reduction of incidence are mainly the infectious diseases, and might loosely be termed 'accidents' along with earthquake, famine, flood and the like in the sense that they are not intrinsic and inevitable, but kill certain individuals who might otherwise have gone on to reach old age. Some types of tumour also are not diseases of old age and may be included with the 'accidents'. This kind of division of deaths into 'accidents' and 'senescent' deaths is not new in actuarial analysis[11,13,14], and it acquires a fundamental, as well as empirical, significance in theories of ageing based on changes within cells. Broadly speaking, the risk of 'accidental' death is spread over the whole life-time, whereas 'senescent' deaths are clustered closely in old age, so defining a mean potential life-span.

Jones[14], on the other hand, attaches much greater importance to the 'accidents' and suggests that disease experience short of lethality is itself the cause of ageing, through an autocatalytic process of physiological impairment which is expressed as an impartial susceptibility to further disease. He suggests that the reduction in mortality in later life that has occurred in human populations has been caused by the reduction in diseases in early life. The correlation may not be causal, however, but merely arise from a common factor of improvement of environment[12]. The results of experiments on mice exposed to infection[15,16] designed to test Jones's hypothesis were equivocal[6]. Jones also cites the fact that in human populations the age-specific death-rates for various particular diseases and the rate from all causes show similar rates of increase with age, and regards this as further evidence for an increasing general susceptibility to disease. While this process may occur, particularly during senescence, it is possible that the similarity in rates arises, at least in part, because they all primarily reflect the same thing, namely, the genetic distribution of potential life-span.

A new model of ageing. My model of ageing, arrived at from evidence on irradiated and unirradiated mice summarized below, combines elements from all the foregoing theories. It assumes that there is a common process at work in natural and radiation-induced ageing which is fundamental, inevitable and irreversible. Other processes may also contribute to ageing, some peculiar to natural and some to radiation-induced ageing[1-4], and in particular circumstances any one of these may be the dominant factor, while some may be largely irrelevant by-products of ageing so far as survival is concerned, for example, the greying of hair. The model implies, however, that even if all these other factors could be obviated, an irreducible intrinsic process would remain, which may in fact predominate in certain circumstances for carefully kept populations of laboratory animals.

This intrinsic ageing occurs in two principal successive stages, which between them occupy the whole life-time. First, a stage of intracellular changes probably accompanied by intercellular reactions proceeds insidiously and without marked physiological impairment; this stage is termed 'induction'. When a certain level of inductive change is approached, the second stage of ageing sets in rather abruptly. It involves a different level of organization and consists in physiological interactions which proceed autonomously and autocatalytically when once initiated and which lead to rapid impairment culminating in death; this stage is termed 'development'.

It is an essential feature of the model that, after development is triggered off, further inductive change is superfluous; thus radiation during development has comparatively little effect. Formally, induction corresponds to a progressive destruction of homœostatic mechanisms, while development corresponds to senescence itself. Although the distinction between the two stages is one of degree rather than of kind, it is valid in practice because the level of physiological impairment is an extremely non-linear function of level of inductive change; Yockey[17] has pointed out the analogy with Shannon's channel capacity theorem in communication theory[18]. Physiological ageing therefore is mainly a phenomenon of senescence. The small physiological impairment during induction should not be regarded as the cause of ageing during development in any direct sense; both are effects of the underlying sub-physiological change. The false assumptions (*a*) that all the injury produced by whole-body irradiation of an animal or by the simple passage of time can and must be expressed as physiological injury, (*b*) that this injury is proportional to dose or time, have caused much confusion in the discussion and quantitative analysis both of reparable and irreparable injury by radiation and of natural ageing.

There will be very little element of randomness in the overall production of intracellular change during induction in multi-cellular organisms in a given

Table 1. CHRONIC IRRADIATION OF *CBA* MICE FROM EARLY MATURITY (~ 80 DAYS) TO DEATH (ref. 30 and unpublished work by Neary, G. J., Hulse, E. V., and Mole, R. H.)

Values of mean survival time (*MST*) and standard deviation of survival time (*SD*) in days, for males (*M*) and females (*F*) calculated for all animals in a group, and for last 70 per cent of group

			First experiment					Second experiment				
Dose-rate (rems/day)			0	0·23	0 46	1·02	11 0	0	2 46	3 48	16 1	27 2
All animals	*M*	*MST* *SD*	743 137	714 102	676 166	704 99	500 90	746 182	720 126	656 104	459 79	391 36
	F	*MST* *SD*	818 140	786 141	803 116	758 125	511 101	839 128	763 138	641 100	426 99	368 62
Last 70 per cent	*M*	*MST* *SD*	817 55	770 52	770 45	758 33	550 50	825 42	782 54	702 61	494 41	406 25
	F	*MST* *SD*	892 38	859 53	859 34	829 42	565 54	896 64	825 38	685 62	460 68	397 36

environment, but the effects of environmental stresses during development will be subject to random variation. The rate of development may depend more sensitively on individual characteristics than does the rate of induction, since it involves more complex levels of organization.

Intrinsic Ageing : Evidence from Irradiated Animals

Experiments at low dose-rates would seem to offer the best chance for detecting a non-specific speeding up of natural ageing by whole-body irradiation, because, for a given degree of life-shortening, repair mechanisms make the immediate physiological effects least under these conditions. Detailed data on mice irradiated continuously throughout life are available from two groups of workers. Lorenz and his colleagues at the National Cancer Institute in the United States[29] used gamma-rays to irradiate LAf_1 mice (first generation hybrids between two inbred strains, *C57L* females crossed with *A* males). The incidence of various pathological conditions at death was broadly similar in the irradiated and control animals, apart from some increase in tumours, particularly lymphomas. My colleagues and I (ref. 30, and Neary, G. J., Hulse, E. V., and Mole, R. H., unpublished work) irradiated *CBA* mice (an inbred strain) with fast neutrons or gamma rays. In our first experiment[30], the pathology at death was about the same in all groups and there was no clear-cut increase in overall incidence of tumours. In the second experiment the pathological findings have yet to be finally assessed (Hulse, E. V., and Mole, R. H., unpublished work). I have analysed the survival data from all these experiments on the working assumption that the principal effect of the radiation was a non-specific ageing.

The broad indications of data on non-specific life-shortening by radiation are that the *mean* shortening of life in a homogeneous group of animals increases with size of dose for a single exposure, or with size of *mean* accumulated dose for chronic exposure ; in either case, approximately proportional relations are found[4,31,32]. It has therefore usually been assumed that, with chronic irradiation continued until death, the shortening of life of an individual animal should depend on its particular accumulated dose ; thus a given dose-rate should produce the same proportional shortening of life in all the individuals. The cumulative mortality curve of an irradiated group would therefore be equivalent to that of the controls with the time axis contracted, and so the rate of ageing of the irradiated animals could be said to be accelerated compared with the controls ; the dispersion of life-times in an irradiated group would be reduced in proportion to the reduction of mean life-time. The LAf_1 mice of Lorenz *et al.*[29] conform fairly well to this simple picture, but our chronically irradiated *CBA* mice[30] do not show accelerated ageing in this sense. Instead, the cumulative mortality curve for an irradiated group corresponds to that of the controls with the time axis displaced, not contracted ; similarly, the Gompertz plots are displaced but the slopes are not increased by radiation. This result was described by the term 'premature ageing'[30], though 'premature senescence' is more explicit.

In terms of my model of ageing, chronic irradiation accelerates the basic sub-physiological process of ageing so that the duration of induction is shortened, but the ensuing development is almost unaffected by radiation at low dose-rates. It is assumed that *CBA* mice are sufficiently homogeneous genetically for the length of the natural induction period to be practically the same for all individuals, and that the dispersion of life-times arises chiefly from dispersion of length of development period, some of which at least is due to randomness in effects of environmental stress. When such mice are chronically irradiated, all individuals receive the same accumulated *effective* dose and all suffer the same shortening of the induction period. Development thus sets in prematurely, but at the same time for all, just as in the unirradiated animals. Thereafter, the probable course of events is the same for both groups ; for example, the shapes of the mortality curves, the slopes of the Gompertz plots and the dispersion of life-times will be identical apart from random variation. Attempts have been made to see whether these latter features, which I have found subjectively in the data, can be demonstrated or refuted on a firm basis of statistical significance, in order to decide between the alternative hypotheses of premature ageing (contraction of induction period only) and accelerated ageing (contraction of whole life-time). Some approximate arguments on the data of the first experiment alone supported premature ageing[30], but

Table 2. CHRONIC IRRADIATION OF LAf_1 MICE FROM EARLY MATURITY (~ 65 DAYS) TO DEATH (ref. 29)

Values of mean survival time (*MST*) and standard deviation of survival time (*SD*) in days for males and females combined, calculated for all animals in a group and for last 70 per cent of group

Dose-rate (rems/day)			0	0 11.	1 1	2·2	4·4	8 8
All animals	*M* + *F*	*MST* *SD*	703 176	761 174	684 138	630 137	591 111	488 74
Last 70 per cent	*M* + *F*	*MST* *SD*	789 123	846 90	756 80	702 84	645 73	546 56

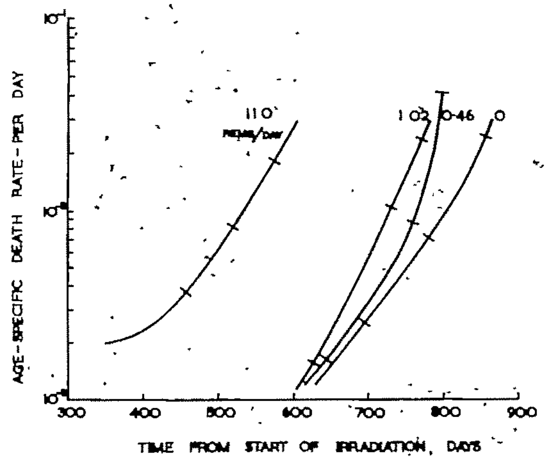


Fig. 1. Gompertz plots, *CBA* mice, males (ref. 30). The three bars on each plot in Figs. 1–5 correspond to 30, 50 and 80 per cent cumulative mortality

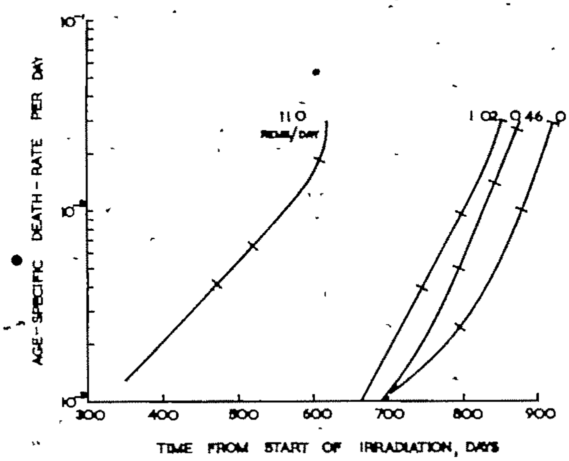


Fig. 2. Gompertz plots, *CBA* mice, females (ref. 30)

a more detailed examination of the data of both experiments suggests that they do not contradict either hypothesis at the 5 per cent level of significance (Neary, G. J., and Westgarth, D. R., unpublished work); or that neither hypothesis fits[33], though premature ageing is closer than accelerated ageing (Wise, M. E., unpublished work). Here, I shall merely present a summary of the data on mean survival-time and standard deviation of survival-time, together with graphs of the Gompertz plots with values of slope and doubling time. Some obvious differences between the *CBA* and LAf_1 mice are then apparent.

The dose-rate of all irradiated *CBA* groups has been expressed in rems/day, using the conversion factors 1 rad of cobalt-60 gamma radiation = 1 rem and 1 rad of our fast neutrons = 12 rems (determined from the intercomparison of life-shortening in our neutron and gamma groups (Neary, G. J., Hulse, E. V., and Mole, R. H., unpublished work). Doses for the LAf_1 mice were given in roentgens and the small difference for radium gamma-rays between rem and roentgen (= 0·98 rem) has been ignored here.

Certain facts stand out when Tables 1 and 2 are compared. First, the trend towards smaller standard deviation with increasing dose-rate and decreasing mean survival-time is much less marked for the *CBA* than for the LAf_1 mice. This point is shown more clearly by taking only the last 70 per cent of mice dying in a group, this being a very rough method of separating the mainly 'senescent' deaths from the mainly 'accidental' deaths (which incidentally may be shown to be far less affected by radiation in time of occurrence—data on first 30 per cent to die). Since for the LAf_1 mice the proportional reduction in standard deviation for a given dose-rate is at least as great as that in mean survival-time, it appears that, unlike the *CBA* mice, there is a considerable dispersion of induction-times, which is the main component in dispersion of total life-time. This conclusion is reinforced by the fact that the standard deviations for the LAf_1 mice are considerably larger than for the *CBA* mice, though their mean survival-times are somewhat smaller. Thus for life-time irradiation of LAf_1 mice at a given dose-rate, there is a considerable dispersion in accumulated effective dose. In fact, the individual effective doses are nearly proportional to the individual life-times, because, as shown below, induction comprises the greater part of the life-time; and so LAf_1 mice display a misleading appearance of simple accelerated ageing by radiation, that is, an apparent contraction of the whole life-time.

An examination of the Gompertz plots supports these conclusions and leads to some additional ones. From Figs. 1–5 and Tables 3 and 4 (refs. 13, 34) it may be seen (*a*) the Gompertz plots are not very linear; (*b*) with increase of dose-rate there is a trend towards steeper plots for the LAf_1, but not for the *CBA* mice up to ~ 15 rems/day; (*c*) for the unirradiated *CBA* mice the death-rates are generally greater and the Gompertz slopes steeper than for the unirradiated LAf_1 mice at a given level of cumulative mortality. If the usual interpretation of Gompertz slope as rate of ageing were accepted, these data would mean that irradiated *CBA* mice were ageing at the same rate as the controls, though their survival-time was nearly halved; and that the control *CBA* mice were ageing about five times faster than the control LAf_1 mice though they lived rather longer. The Gompertz plots for the two kinds of mice must therefore cross at some earlier time; and if each plot were extrapolated back linearly to the beginning, we should have the unlikely result that the initial death-rate of the LAf_1 mice would be some 10^3 times that of the *CBA* mice. In fact the plots do not continue straight very far backwards, and the slopes are smaller at earlier times.

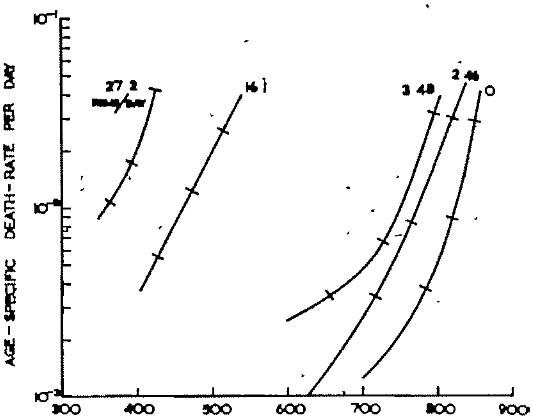


Fig. 3. Gompertz plots, *CBA* mice, males (Neary, G. J., Hulse, E. V., and Mole, R. H., unpublished work)

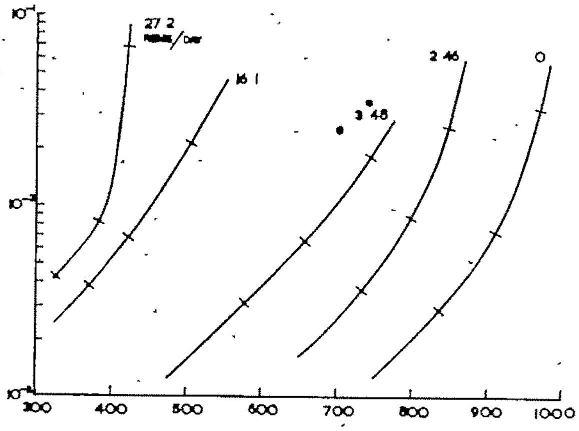


Fig. 4. Gompertz plots, *CBA* mice, females (Neary, G. J., Hulse, E. V., and Mole, R. H., unpublished work)

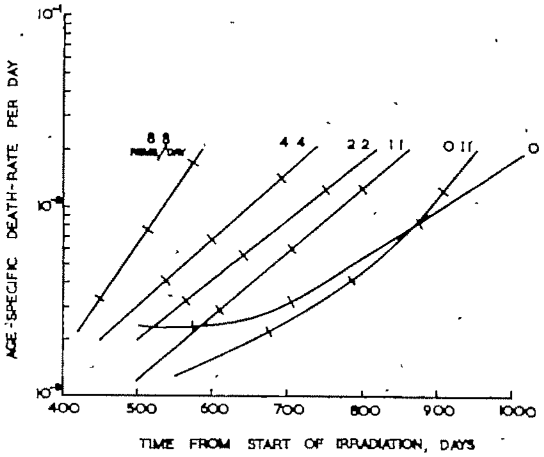


Fig. 5. Gompertz plots, LAf_1 mice, males and females combined (ref. 29)

These results provide no evidence for a process of physiological ageing proceeding at a roughly constant rate throughout most of adult life, as commonly postulated. In so far as the Gompertz slope measures rate of physiological ageing at all, this rate is much less before than during senescence, and the apparent rate before senescence is largely an artefact of the analysis due to 'accidents'. Moreover, it may be the exception rather than the rule for the innate variation between individuals to be small enough not to obscure such evidence of physiological ageing as might ideally be obtained from the dependence of death-rate on age in a uniform group. It is clear that the change in the Gompertz slope is unlikely to be a reliable index of ageing induced by radiation. When applied to the data on life-shortening in the LAf_1 mice, Failla and McClement[34] found it necessary to use the Gompertz relation in a formal sense only, as a mathematical transformation of basic data on mean survival-time. In *CBA* mice the Gompertz slope mainly reflects the rate of senescence, which is practically unchanged by life-time irradiation at low dose-rates; it tells nothing of the acceleration of the primary process of ageing during induction, which is responsible for the premature onset of senescence and for shortening of life.

The apparently much greater dispersion of induction times in the LAf_1 mice than in the *CBA* mice is unlikely to be due to an effect of differences in environmental conditions in the two laboratories, because afterwards a similar behaviour of the LAf_1 breed was found elsewhere[36,37]. Nor can the difference between the LAf_1 mice of Lorenz *et al.*[29] and our *CBA* mice be attributed to the pooling of survival data for LAf_1 males and females, since in the later work[36,37] the data for males and females are given separately. It may be that the considerable incidence of lymphomas in the control animals and its appreciable increase in the irradiated groups (up to 65 per cent in the females at 8·8 rems/day) is an indication that a particular pathological process rather than a non-specific ageing is responsible for the death of a good proportion of the mice. Brues and Sacher[38] observed an increase in the slope of the Gompertz plot for chronically irradiated female *CF* No. 1 mice, a breed usually showing a high incidence of mammary tumours. Alternatively, it is possible that there is a real dispersion of induction periods for non-specific ageing between individuals due to genetic causes, even though LAf_1 mice, being a first-generation cross between two inbred strains, would be expected to be genetically uniform. If the parent strains were absolutely uniform, then the f_1 cross would also be uniform; but if there were some variation in each parent strain, these variations would be combined multiplicatively in the f_1 cross. The possibility of a genetically determined difference in dispersion of induction times between LAf_1 and *CBA* mice thus involves the comparative genetic uniformity of the parent strains *C57L* and *A* and the *CBA* strain, and the influence of the factor of hybrid vigour.

Dose-response and the derivation of values for times of induction and development. I assume that a low dose-rate of radiation, r rems/day, produces the basic intracellular changes responsible for ageing, at a rate λr times the natural rate at any instant; the total instantaneous rate is thus multiplied by a factor $(1 + \lambda r)$. The accumulation of changed cells would be determined by the dynamics of the changed and normal cell populations; if there were competition between these cells, an alteration in the time required to attain a critical level of changed cells might depend in a complicated

Table 3. Gompertz Analysis, *CBA* Mice (ref. 30 and unpublished work by Neary, G. J., Hulse, E. V., and Mole, R. H.)

		First experiment					Second experiment				
Dose-rate (rems/day)		0	0·23	0·46	1·02	11·0	0	2·46	3·48	16·1	27·2
Slope per 100 days	*M*	1·4	1·4	1·8	2·1	1·5	3·4	2·3	1·7	1·8	2·0
	F	2·2	1·6	2·2	1·7	1·2	1·9	1·8	1·7	1·3	4·0
	Mean	1·8	1·5	2·0	1·9	1·3	2·7	2·0	1·7	1·5	3·0
Doubling time (days)	*M*	51	49	38	34	47	20	31	40	39	35
	F	32	44	30	42	57	37	39	42	53	18
	Mean	42	46	34	38	52	28	35	41	46	26

Table 4. GOMPERTZ ANALYSIS, LAf_1 MICE (ref. 29)

Dose-rate (rems/day)		0	0·11	1·1	2·2	4·4	8·8
Slope per 100 days	*	0·38	0·66	0·74	0·79	0·91	1·0
	†	0·58	0·72	0·79	0·93	1·0	1·2
	‡	0·53	0·79	0·79	0·73	0·83	1·3
Doubling time (days)	*	166	106	95	88	77	67
	†	120	97	88	75	70	56
	‡	131	89	89	95	84	52

* Analysed by Sacher (ref. 13).
† Analysed by Berlin and Dimaggio (ref. 34).
‡ Analysed in this article.

way on an alteration in their rate of production[14]. Some model of the intercellular relationship is necessary in order to derive values for times of induction and development from the empirical data on life-shortening. In a number of possible models, an increase in the rate of production of changed cells from normal cells will result in a simple inverse contraction of the time required for the accumulation of a given level of changed cells. Since the critical level is assumed to be the same in irradiated and control animals at the ends of the respective induction periods, durations I and I_0, we have:

$$(1 + \lambda r)I = I_0$$

whence

$$(I_0 - I) = \lambda r I \qquad (2)$$

that is, the shortening of induction period $(I_0 - I)$ is proportional to the dose accumulated in the induction period, rI, the accumulated effective dose. The duration of the development period, D, is unaffected by radiation at low dose-rates and therefore the shortening $(S_0 - S)$ of life-time, S, is equal to $(I_0 - I)$, and so it too is proportional to accumulated effective dose. Time and radiation-dose are thus equivalent factors in ageing, and in this sense the dose-response is linear, although the proportion of cells changed is not necessarily a linear function of time or dose and the resulting physiological injury is probably a very non-linear function of these quantities.

The derivation of values for times of induction and development and the constant λ on the basis of the linear relation (2) for chronic irradiation is straightforward in principle, but with our data the accuracy of determination of development time is very low. Since by hypothesis $(I_0 - I) = (S_0 - S)$, we have $(S_0 - S)/r = \lambda I = \lambda(S - D)$; or, more generally, when irradiation starts at age T and continues until death:

$$(S_0 - S)/r = \lambda(S - T - D) \qquad (3)$$

A plot of mean values of $(S_0 - S)/r$ against mean values of time of survival $(S - T)$, for groups of animals at different dose-rates, r, should thus be a straight line with slope λ and intercept on the abscissa axis D, the mean development time. The data used in Figs. 6 and 7 are for the last 70 per cent of animals in a group to die, so as to reduce the influence of 'accidental' deaths. The values of D for males and females so obtained are in each case about 180 days. In this analysis any error of mean shortening of life or disturbance through side-effects is greatly exaggerated for the low dose-rate groups because of the divisor r in equation (3). Errors in r, the biologically effective dose-rate expressed in rems/day, can also seriously distort the graphs, and since fast neutrons and gamma-radiation were used, the values of r depend on the relative biological efficiency factor for the fast neutrons which the experiments were primarily designed to determine. It is thus not surprising that the spread of points is large in Figs. 6 and 7. If the same treatment is applied to the data on LAf_1 mice of Lorenz *et al.*[29] (males and females not given separately) or of Sacher, Grahn and Gurian[24] (survival data of last 70 per cent not given separately), the spread is too great to permit of any estimate of D. These difficulties should be reduced by using a fixed dose-rate and varying the age at which irradiation starts (Neary, G. J., and Mole, R. H., unpublished work). The estimate of D = 180 days agrees roughly with recent observations that for $BALB/c$ mice which received 500 r. at age 435 days, the age-specific death-rate became significantly greater than in controls only at age 575 days (average for males and females), that is, 160 days before the median life-span of the irradiated animals[19].

The best estimate of λ from our present data may be obtained from equation (2), which for animals starting irradiation at age T, may be written:

$$(S_0 - S) = \lambda r(S - T - D) \qquad (4)$$

By using the value of D obtained from Figs. 6 and 7, the mean accumulated effective doses, $r(S - T - D)$ for the groups at the different dose-rates may be calculated and used to make graphs of life-shortening against dose (Figs. 8 and 9). The values of λ given by the slopes are 0·065 day/rem for males and 0·086 day/rem for females, agreeing with other data on the life-shortening efficiency of chronic irradiation of mice[4,21,29].

Nature of the Induction Process and the Problem of Extrapolation between Species

The linear form of the dose-response for non-specific life-shortening by radiation at low dose-rates is consistent with a cumulative injury due to irreversible

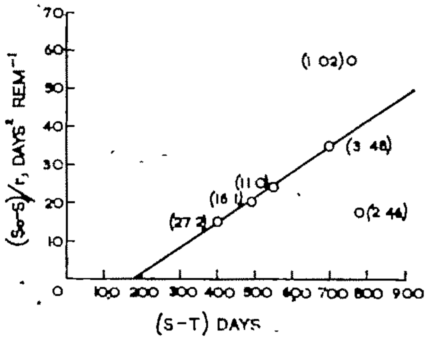


Fig. 6. *CBA* mice, males. Numbers in brackets are daily dose rates. The intercept is the mean development time (see equation 3)

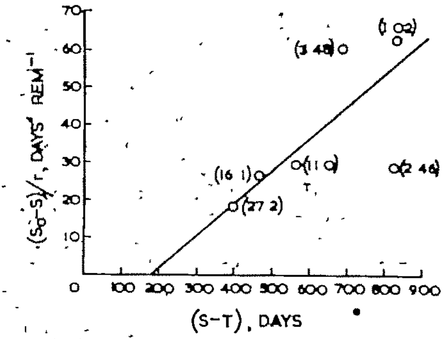


Fig. 7. *CBA* mice, females. Numbers in brackets are daily dose-rates. The intercept is the mean development time (see equation 3)

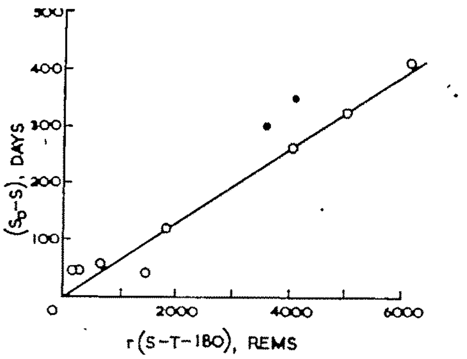


Fig. 8. *CBA* mice, males. Life-shortening against mean accumulated effective dose (see equation 4)

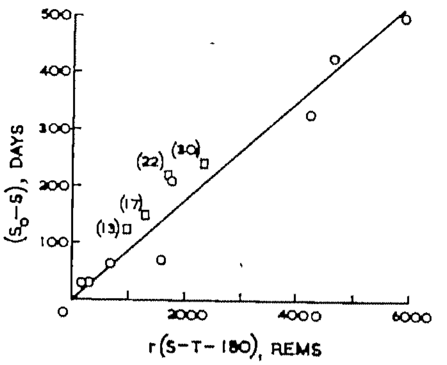


Fig. 9. *CBA* mice, females. Life-shortening against mean accumulated effective dose (see equation 4)
○, life-time irradiation; ⊡, irradiation for limited periods of weeks shown in brackets

changes in cells. This is in marked contrast with the short-term physiological injury, for which there is a very non-linear dose-response and a recovery process with a time-scale measured in days or weeks[8]. The linear relation implies that a given increment of dose would have the same effect at any time up to the completion of induction. This is confirmed approximately in the similar degrees of life-shortening produced by single, fractionated and life-time doses of fast neutrons[32,40]. Some results on our female *CBA* mice given chronic irradiation for limited periods[33] have been included in Fig. 9, and they agree fairly well with the results for life-time irradiation, considering that the animals in most of the limited irradiation groups, unlike those in the life-time groups, were used for breeding experiments. The linearity with life-time irradiation, however, may result from a precarious balance in the intercellular dynamics; if so, the balance might well be upset by a sudden fall in production of changed cells on cessation of radiation. The linearity and independence of age inferred from life-time irradiation and single-dose data could therefore not necessarily be expected for other regimes of irradiation in which, moreover, specific disease processes might assume greater importance.

Although there is approximate independence of the timing of the dose for fast neutrons, this is not the case with *X*- or gamma-radiation, single doses of which are some three times as efficient as doses spread over the whole life-time, though in each case the dose-response is approximately linear[4,31,32]. If the greater life-shortening efficiency of single doses is attributed to a greater efficiency of production of the primary intracellular change, and if the dose-response is indeed linear, then it is difficult to equate the intracellular change with chromosome structural damage[13,14], because the only types of such damage which are produced more efficiently by single doses than by protracted doses have a considerable square-law component in their dose-response[41]. These arise from the interaction of two independently produced sites of potential damage, each with a limited life-time, usually of the order of an hour. The linearity of the life-shortening dose-response for small single doses is somewhat uncertain owing to the low accuracy of the data. It has been shown, however, that the life-shortening effect of a single dose of X- or gamma-radiation is no greater than if the same total dose is delivered in two discrete fractions with intervals of as much as a month between them (Sacher, G. A., personal communication); there is no evidence with the single dose of the interaction that would be expected if 'two-hit' chromosome structural damage were important. Similarly, the relative biological efficiency for life-shortening of fast neutrons compared with X- or gamma-radiation does not increase if the dose is given in several fractions, provided the dose-rate during the actual irradiations is the same[40b,43]. These results suggest that the greater life-shortening efficiency of single doses of X- or gamma-radiation compared with chronic low dose-rates is a dose-rate phenomenon perhaps comparable with the dose-rate effect for mutations in mice[42]. If the primary intracellular process responsible for life-shortening is dependent upon dose-rate, then it cannot be equated with 'one-hit' chromosome structural damage[41]. On the other hand, fractionation of X-ray dose without change of dose-rate has in some experiments produced a decreased efficiency of life-shortening, either in absolute terms[44] or relative to the fast-neutron effect[45]. It is known for cells generally that there are qualitative differences in the spectrum of chromosomal changes produced by single and protracted doses of X- or gamma-radiation or by single doses of different magnitudes, owing to the dependence of the 'two-hit' component on time of exposure and square of the dose. These differences might lead to differences in the ensuing intercellular dynamics, which might help to account for some of the facts observed. In general, however, the influence of possible specific disease processes requires more detailed examination[46]. Thus the possibility that the primary intracellular change is one of chromosomal structural damage cannot be ruled out.

The simpler formal model that the intracellular change responsible for ageing is gene mutation[16,17] offers no simple explanation of a possible dose-rate effect for X- or gamma-radiation, or for the large size of the 'doubling dose'. A chronic dose-rate of about 13 rems/day is required to double the rate of ageing in mice[35], so that the doubling dose per life-time is around 5,000 rems or 1,500 rems as a single dose, which as Strehler[15] points out is about 25 times larger than the genetic doubling dose. It may be that the site damaged is not part of a chromosome at all; ageing in some organisms seems to be primarily a cytoplasmic phenomenon[47].

The bearing of the evidence on the relative biological efficiency of fast neutrons compared with X- or gamma-radiation for life-shortening on the nature of the intracellular change is ambiguous. The relative biological efficiency for single doses[40] is around 2, and for chronic doses[31,32] around 10. Data on the relative biological efficiency for point mutations are not available for mouse cells. Early work on mutations in *Drosophila*[41] gave values of about 1 with single doses, but more recently values near 2 have been found[42]. The relative biological efficiency of single doses of fast neutrons for chromosome damage depends on dose-level and the particular type of damage.

Examples of possible consequences of cell-change which would be relevant to ageing are: (*a*) death of non-replaceable cells; (*b*) reduced competence for particular functions; (*c*) auto-immune reactions between changed and normal cells or between changed cells themselves. Burnet[43] has suggested that ageing may be an auto-immune reaction, and this may perhaps be the essential character of what is here described as development, and most of the cells of the animal may be involved. The cells changed by the induction process may comprise all the cells, or only some particular class of cells. If induction is a process of destruction of a special class of cells, they might correspond to the homœostatic systems postulated by Burnet[44], damage to which beyond a certain level unleashes an uncontrollable chaos of reactions from spontaneous auto-immunity leading to physiological deterioration and finally death.

The idea of ageing as a gradual increase in entropy was early suggested by Perks[45], and more recently formal treatments have been given in terms of information theory[17,46]. The precise meaning of the formalism is not always clear, however; for example, How much of the information in the organism is intracellular and how much intercellular? Would an idealized point mutation in a cell reduce the information of that cell, or is it more important that the cell is now different from its fellows? The incompletely explored distinction between information entropy of form and of function[47] would seem to be important for this question. The loss of information by the whole organism caused by time and chronic radiation may be formally represented:

$$H_0 - f[(1 + \lambda r)t] = H_1 \qquad (5)$$

where H_0 is the initial level of information and H_1 the final level. H_1 is usually interpreted as the value at death, but in my model would be the value at the end of induction. Yockey[17] regards the difference of life-span between individuals as due to genetic differences in the initial level of information and assumes a fixed value for the final critical level.

If, however, loss of information due to induced differences between cells were the important process, so that because of the initial identity of the cells in a given individual all individuals initially contained the same amount of information H_0, the individual variation might be associated with the final level, H_1. That is, there would be individual differences, genetically determined, in the amount of cellular disorder which could be tolerated. This possibility is considered by Quastler[48] and Szilard[18]. There is a third possibility, that individual variation is associated with the term in equation 5 which expresses the effect of time and radiation in reducing information. This is ruled out, so far as radiation is concerned, by the fact that a single dose of radiation produces a uniform shortening of life even though there may be dispersion of induction times; for example, the shortening of life by a single dose in LAf_1 mice is the same in the long-lived as in the short-lived individuals[19,49]. The assumption that individual differences are associated with the final rather than the initial level of information is in harmony with the idea of an increasing divergence between cells leading to auto-immune conflict.

Extrapolation between species for shortening of life by irradiation. There are several difficulties about extrapolating shortening of life by irradiation between species, even if it be accepted that the postulated intrinsic ageing process is the same in different species. In general, the relative importance of this process and the 'accidents' in determining the natural life-time is unknown. Further, for any radiation condition other than very low dose-rates, highly specific processes may be important; even for low dose-rates there have been reports of a prolongation of mean life-time relative to controls[13,49,50].

Boche[51] first suggested that a given dose produced the same proportional life-shortening in different species. This hypothesis has been used as the basis of most attempts to derive the shortening of life per unit dose in man from data on laboratory animals, leading to values from 1 to 15 days per roentgen (or per rem)[24,25,52]. In the present model, however, the shortening of life per rem, λ, is the ratio of 'mutation'-rate per unit time produced by unit dose-rate to that occurring naturally. There seems to be no compelling *a priori* reason why this ratio should increase in proportion to natural life-span, only a loose analogy from the approximate constancy of doubling dose per generation for genetic effects. In organisms as biologically similar as mice and men, it is conceivable that the value of this ratio might be the same, in which case the *absolute* shortening of life per unit dose would be the same, namely, about 0·08 day per rem of chronic radiation. A radiation worker, for example, who accumulated the maximum permissible life-time dose of 200 rems would then suffer a shortening of life of 16 days, instead of a figure of the order of a year derived on the alternative assumption. It is of interest that the life expectation of radiologists does not seem to have been significantly reduced by their exposure to radiation[53].

I am indebted to my colleagues for permission to quote some unpublished material.

[1] Russ, S., and Scott, G. M., *Brit. J. Radiol.*, 10, 619 (1937); 12, 440 (1939).

[2] Henshaw, P. S., *J. Nat. Cancer Inst.*, 4, 513 (1944).

[3] Lorenz, E., in "Biological Effects of External X and Gamma Radiation", edit. by Zirkle, R. E., *NNES* IV-22B (McGraw-Hill, New York, 1954).

[4] Blair, H. A., University of Rochester Report *UR*-442 (1956).

[5] Upton, A. C., *J. Geront.*, 12, 306 (1957).

[6] Alexander, P., *Gerontologia (Basel)*, 1, 174 (1957).

[7] Comfort, A., *Radiat. Res.*, Supp. 1, 216 (1959).

[8] Mole, R. H., *Radiat. Res.*, Supp. 1, 124 (1959).

[9] Comfort, A., "The Biology of Senescence" (Routledge, London, 1956).

[10] Medawar, P. B., "An Unsolved Problem of Biology" (H. K. Lewis, London, 1952).

[11] Gompertz, B., *Phil. Trans.*, 115, 513 (1825).

[12] Strehler, B. L., *Quart. Rev. Biol.*, 34, 117 (1959).

[13] Sacher, G. A., *Radiology*, 67, 250 (1956).

[14] Muller, H. J., *J. Cell. Comp. Physiol.*, 35, Supp. 1, 9 (1950).

[15] Henshaw, P. S., *Radiology*, 69, 30 (1957).

[16] Failla, G., *Radiology*, 69, 23 (1957).

[17] Yockey, H. P., in "Symposium on Information Theory in Biology", edit. by Yockey, H. P., Platzman, R. L., and Quastler, H. (Pergamon Press, London, 1958).

[18] Szilard, L., *Proc. U.S. Nat. Acad. Sci.*, 45, 30 (1959).

[19] Beard, R. E., in "Ciba Foundation Colloquia on Ageing", 5, edit. by Wolstenholme, G. E. W., and O'Connor, Maeve (Churchill, London, 1959).

[20] Kallmann, F. J., in "Ciba Foundation Colloquia on Ageing", 3, edit. by Wolstenholme, G. E. W., and O'Connor, Cecilia M. (Churchill, London, 1957).

[21] Benjamin, B., in "Ciba Foundation Colloquia on Ageing", 5, edit. by Wolstenholme, G. E. W., and O'Connor, Maeve (Churchill, London, 1959).

[22] Spiegelman, M., in "Proc. Gatlinburg Conf. Aging, 1957" (American Institute of Biological Sciences, Wash., to be published).

[23] Makeham, W. M., *J. Inst. Actuaries*, 13, 325 (1867).

[24] Clarke, R. D., Proc. Cent. Assembly Inst. Actuaries, **2**, 12 (1950).

[25] Jones, H. B., "Advanc. Biol. Med. Phys.", **4**, 281 (1956).

[26] Curtis, H. J., and Healey, R., in "Advances in Radiobiology", edit. by de Hevesy, G. C., Forssberg, A. G., and Abbatt, J. D. (Oliver and Boyd, Edinburgh, 1957).

[27] Curtis, H. J., and Gebhard, K. L., in "Peaceful Uses of Atomic Energy", **22** (United Nations, Geneva, 1958).

[28] Shannon, C. E., and Weaver, W., "The Mathematical Theory of Communication" (Univ. Illinois Press, Urbana, 1949).

[29] Lorenz, E., Jacobson, L. O., Heston, W. E., Shimkin, M., Eschenbrenner, A. B., Deringer, Margaret K., Doniger, Jane, and Schweisthal, R., in "Biological Effects of External X and Gamma Radiation", edit. by Zirkle, R. E., *NNES* IV-22*B* (McGraw-Hill, New York, 1954).

[30] Neary, G. J., Munson, R. J., and Mole, R. H., "Chronic Radiation Hazards" (Pergamon Press, London, 1957).

[31] Curtis, H. J., in "Medical Physics", **3**, edit. by Glasser, O. (Yearbook Publishers, Chicago, in the press).

[32] Mole, R. H., *Nature*, **180**, 456 (1957).

[33] Yockey, H. P., in Oak Ridge National Laboratory Report *ORNL*-2806 (1959).

[34] Berlin, N. I., and Dimaggio, F. L., Armed Forces Special Weapons Project, Wash., Report AFSWP-608 (1956).

[35] Failla, G., and McClement, Patricia, *Amer. J. Roentgenol.*, **78**, 946 (1957).

[36] Sacher, G. A., Grahn, D., and Gurian, Joan M., in Argonne National Laboratory Report ANL-5916.

[37] Noble, J. F., Doull, J., Hasegawa, A. T., and Landahl, H. D., USAF Radiation Laboratory Report 32 (1959).

[38] Brues, A. M., and Sacher, G. A., in "Symposium on Radiobiology", Oberlin, 1950, edit. by Nickson, J. J. (John Wiley, New York, 1952).

[39] Kohn, H. I., and Guttman, P. H., *Nature*, **184**, 735 (1959).

[40] (*a*) Storer, J. B., Rogers, B. S., Boone, I. U., and Harris, P. S., *Radiat. Res.*, **8**, 71 (1958). (*b*) Curtis, H. J., and Gebhard, Katharine, *ibid.*, **9**, 278 (1958). (*c*) Furth, J., Upton, A. C., and Kimball, A. W., *ibid.*, Supp. 1, **243** (1959). (*d*) Nowell, P. C., and Cole, L. J., *ibid.*, **11**, 545 (1959). (*e*) Vogel, jun., H. H., and Jordan, D. L., Argonne National Laboratory Report ANL-5916. (*f*) Upton, A. C., personal communication (to be published).

[41] Lea, D. E., "Actions of Radiations on Living Cells" (Cambridge University Press, 1946 and 1955).

[42] Vogel, jun., H. H., Argonne National Laboratory Report (in the press).

[43] Russell, W. L., Russell, Liane B., and Kelley, Elizabeth M., *Science*, **128**, 1546 (1958).

[44] Hursh, J. B., University of Rochester Report UR-506 (1957).

[45] Evans, T. C., *Radiology*, **50**, 811 (1948).

[46] Mole, R. H., *Brit. J. Radiol.*, **32**, 497 (1959). Cole, L. J., Nowell, P. C., and Arnold, J. S., *Radiat. Res.*, **12**, 173 (1960).

[47] Lansing, A. I., *J. Geront.*, **2**, 228 (1947). Sonneborn, T. M., and Schneller, Myrtle, in "Proc. Gatlinburg Conf. Aging, 1957" (American Institute of Biological Sciences, Wash., to be published).

[48] Edington, C. W., and Randolph, M. L., *Genetics*, **43**, 715 (1958).

[49] Burnet, Sir Macfarlane, *Brit. Med. J.*, ii, 645, 720 (1959).

[50] Burnet, Sir Macfarlane, "The Clonal Selection Theory of Acquired Immunity" (Cambridge University Press, 1959).

[51] Perks, W., *J. Inst. Actuaries*, **63**, 12 (1932).

[52] Quastler, H., "Ann. Rev. Nuclear Sci.", **8**, 387 (1958).

[53] Linschitz, H., in "Information Theory in Radiobiology", edit. by Quastler, H. (University of Illinois Press, Urbana, 1953).

[54] Szilard, L., *Nature*, **184**, 957 (1959).

[55] Mendell, J. S., Oak Ridge National Laboratory Report ORNL-2532 (1958).

[56] Carlson, L. D., and Jackson, B. H., *Radiat. Res.*, 11, 509 (1959).

[57] Boche, R. D., in "Biological Effects of External Radiation", edit. by Blair, H. A., NNES VI-2 (McGraw-Hill, New York, 1954).

[58] Jones, H. B., *Kaiser Fdn. Med. Bull.*, **4**, 329 (1956).

[59] Lewis, E. B., *Science*, **125**, 965 (1957). Court Brown, W. M., and Doll, R., in "Peaceful Uses of Atomic Energy", **23** (United Nations, Geneva, 1958).

COMBUSTION AND PROPULSION

HIGH MACH NUMBER AIR-BREATHING ENGINES

THE Advisory Group for Aeronautical Research and Development, familiarly known as AGARD to aeronautical scientists, is both the concept and the achievement of one man—eminent mathematician in the field of aeronautics for so long as to have become almost legendary. Theodore von Kármán saw the need immediately after the Second World War for some organization in Europe to re-create the aeronautical strength of those countries which had been prevented from working in the field, and had, indeed, been largely isolated from the very rapid development which had then taken place during the War.

It was clear that such an organization had to be under the general sponsorship of NATO; but the orthodox solution of an international body composed largely of officials and the military was not what von Kármán desired. Instead, he created what was for all practical purposes an international learned society, having the great advantage of being supported financially by a military treaty organization; although depending upon that support, von Kármán has always insisted on an administrative autonomy for AGARD, which has been largely responsible for its scientific independence and quality. He became its first chairman and has been unanimously re-elected to that post each year since.

AGARD held its fourth Combustion and Propulsion Colloquium, on "High Mach Number Air-breathing Engines", in Milan during April 4–8. Appropriately enough, the sessions were held in the Museum of Science and Technology erected to the memory of that illustrious and most famous citizen of Milan, Leonardo da Vinci; so, surrounded by copies of diagrams from the master's sketch book and working models which showed he had, in any event, considered these problems ages ago, some three hundred and seventy scientists from most of the free European nations, the United States and Canada met for discussion. The team from the United States was extremely strong, and, as would be expected, made the largest and most vigorous scientific contributions, undoubtedly due, in part, to a very liberal interpretation of the security regulations by the American authorities.

The choice of the subject of high-speed, air-breathing engines, in the current fashion for space science, is possibly unusual. In the United States it appears that official support for research into air-breathing engines has largely been terminated in favour of the extensive programmes of rocket research and development for space exploration. The gigantic air-supplying plants at the experimental establishments of the National Aeronautical and Space Agency and the U.S. Air Force which were originally built for gas turbine and ram-jet research have been almost entirely converted into test facilities for rocket research.

It became clear in the opening speeches of the colloquium that the above state of affairs was causing a good deal of concern in many scientific quarters in the United States. Indeed, the first four papers, all by Americans, were in the nature of both an apologia and an explanation for the choice of subject. Von Kármán, in his opening address as chairman, pointed out that although one of the first to advocate the missile and rocket applications to flight, he now felt that the very enthusiasm with which this challenging branch of science and technology had been taken up was causing an unbalanced programme of research and development. He said that it was not unreasonable to expect that, considering the limitations of human physiology, the urge for yet faster manned flight through the atmosphere would be more attractive and more useful than a few space explorations using ion or plasma engines utilizing nuclear power and lasting for several years.

At present, military manned aircraft fly at twice the speed of sound, and engineers are considering seriously the building of civil airliners which will cruise at least as fast. Well-behaved missiles cruise at Mach 10–20, and von Kármán felt that it was in the intermediate range of Mach 3–10 that useful developments could take place, but only if really serious scientific effort was applied to the many research problems involved.

On the military side, von Kármán said that he strongly suspected that future study of the problems would show that the role of manned aircraft was, as yet, far from being terminated and that the development of vertical take-off techniques would broaden even further the usefulness of very high performance aircraft using air-breathing engines.

In the second paper of the opening session, Admiral J. T. Hayward, the only military speaker, who is deputy chief of development, U.S. Department of Navy, supported the same view, pointing out "the advantages of using an oxidizer, which is there for the asking". He went on to describe certain broad fields of military applications of very high speed, air-breathing engines both in missiles and manned aircraft.

Both the first two speakers said that developments of the ram-jet engine appeared to be the likely solution at speeds between Mach 5 and 8, although the disadvantage of this type of engine in having no static thrust and hence having to depend upon some other form of propulsion for take-off was stressed by Admiral Hayward.

The rest of the programme did indeed concentrate upon the problems of ram jets, apart from one session devoted to turbo-machinery. Before this, however, there were two more introductory papers by Prof. A. Ferri, of Brooklyn Polytechnic, and by M. A. Zipkin and L. M. Nucci, of the General Electric Co., which were devoted to somewhat superficial parametric studies of the different applications of ram jets in both the manned and missile fields, which the authors thought would be important in the future.

Ferri pointed out that in certain applications an air-breathing machine is the only practical solution, while in others it is an alternative to the rocket. In the former category he placed transportation and tactical warfare and in the latter a number of missile applications.

In the case of transportation, Ferri said that increase of flight speed not only decreased transit time but it also increased the range of an aeroplane. He pointed out that a great many of the major cities of the world were about 5,000 miles apart, and an aeroplane with such a range would be commercially attractive. It could only be attained economically by flying at Mach numbers of 4–8 rather than 2 or 3 and would use ram-jet engines for cruise, and turbo-jet engines designed essentially for the accelerating phases.

He also described a system for placing a large payload into orbit; and then landing without damage. Such a vehicle would take off like an aeroplane using turbo-jet engines, accelerate gently to orbital speed under full control in time and position, using ram-jet engines with subsonic burning in the lower range of supersonic flight, but at hypersonic speeds the internal flow in the combustion chambers would be supersonic. Such a vehicle would weigh between 130,000 and 400,000 lb. at take-off and could place a payload of 10,000 lb. in orbit. Although requiring much basic research, Prof. Ferri felt such a vehicle would be far more efficient and far more useful than present solutions based entirely on very large rocket motors. He made a strong plea for a small but continuing research effort in the air-breathing engine field, pointing out that if not, the existing technological ability and scientific background accumulated in many years of work would be lost. He considered that a resumption of such work at a much later date would necessitate a far larger effort.

Zipkin and Nucci elaborated the theme of composite, air-breathing systems, reviewing the performance characteristics of present engines and the trends of improvements in future engines. Performance figures from this work were then used to study a number of applications.

The first was the use of an accelerating air-breathing first stage for launching satellites or sounding rockets. In these systems, the launching vehicle might be a supersonic fighter or other very high performance aeroplane which would release the final rocket stage at 60,000–80,000 ft. Such systems, on the authors' assumptions, showed gains of as much as 60 per cent in the ratio of orbital weight to take-off weight, as compared with two-stage rocket systems. It is worth noting that the launching structure weight is much higher in the former case, but since the launcher is not expendable, a net saving in cost should ensue if the number of launchings was high enough, together with a much greater flexibility of operation since satellite launching programmes could be undertaken from conventional airports. This, in itself, would also lead to a much greater choice of initial orbit inclinations.

The second system studied by Zipkin and Nucci was a composite supersonic transport, capable of transporting sixty passengers 3,500 miles at Mach 4. Again, there were two stages and, as would be expected, the staged system was about two-thirds the weight of a single aeroplane, and less fuel was consumed by the former. This is not a convincing example, since a similar, if less strong, argument for staging can be applied to present subsonic transports, again with similar performance gains. In fact, such systems have been tried (for example, the Mayo composite aircraft), but have never been attractive to operators because of the much greater capital and maintenance costs, and of the difficulties of operation.

The main part of the colloquium dealt with the research necessary to develop ram jets up to hypersonic speeds between Mach 4 and 10. Essentially, a ram-jet engine consists of three components, namely, an air intake, a combustion zone and an exit nozzle. Air must be efficiently decelerated and compressed in the intake, then energy added by burning fuel in the air stream and finally the heated gas is accelerated and expanded to ambient pressure. At speeds of around Mach 3–4 such processes are reasonably straightforward, although, since most of the work takes place in the intake and exit nozzles, ram jets are extremely sensitive to exact matching of the three components, otherwise useful thrust (that is, thrust greater than drag) will not result.

As speeds increase into the hypersonic regions, the difficulties increase greatly. In the first place, the stagnation temperatures at hypersonic speeds are very high (around 5,000° R at Mach 8), even though the ambient temperature of the air is that associated with the stratosphere. There appears to be, indeed, a propulsion 'corridor', to high performance which relates altitude and Mach number, and bordered on one hand by maximum stagnation temperature and maximum internal working pressure, and on the other by minimum pressure for combustion. While much can be done to alleviate the temperature problem by radiation cooling and by using the evaporation of the fuel, there remain extremely serious material problems which were discussed at a later session of the colloquium. It is of interest to note that there is the possibility of compressing the air externally under a hypersonic wing, and spraying fuel into the decelerated flow. In other words, the ram jet can possibly be turned inside out with a very great gain of radiation cooling.

The design of an efficient air intake for one particular hypersonic speed is not difficult. However, in any practical ram jet the efficiency must remain high over the wide range of speeds and altitudes through which the engine accelerates to the cruise condition. This necessitates great variations in the shape and area of the intake. Ideally, a continuous variation is required, but, in general, the weight involved forces compromise solutions.

In all current ram jets and turbo jets, the air is decelerated in the intake to subsonic speed; but in the case of the hypersonic ram jet the problem of the intake would be eased if only partial deceleration took place. This, however, throws a greater burden on the design of the combustion chamber since little is known about stable combustion in a supersonic air stream.

It is of interest to note that, at hypersonic speeds, kinetic energy recovery is a more convenient way of expressing the adiabatic efficiency of an intake rather than the pressure recovery ratio used at lower speeds.

Finally, the exit nozzle has also to be designed to deal with the same wide range of Mach numbers and altitude as the intake, and consequently variable geometry is once more necessary. There are, however, two additional difficulties: first, the extremely high gas temperatures severely limit mechanical solutions. The second difficulty is of a more fundamental nature. The transit time of the air through the engine is of a similar order to the recombination times of the dissociated products of combustion. At present there is a great deal of uncertainty as to the amount of recombination which takes place before the hot gases leave the nozzle, the difference between the thrust of the equilibrium flow and the 'frozen' flow thrust of complete dissociation being enough to rule out the latter as leading to a useful engine with a thrust greater than its drag.

It will be seen, therefore, that the development of air-breathing engines for hypersonic propulsion throws open new fields of research, both in gas-dynamics and thermodynamics, which are likely to be very fruitful. The authors of the papers which followed had accepted this challenge, and presented a great deal of new and valuable work, none the less interesting because of its controversial nature. Indeed, the discussions, which at conferences of this nature are not usually very stimulating, were on occasion extremely brisk.

Both J. A. Drake and C. L. Dugger, of Johns Hopkins University, presented papers dealing with the ram jet as an entity. The former especially stressed the need for additional research effort in the determination of exhaust nozzle recombination rates. Dugger's paper consisted of a theoretical comparison of hypersonic ram jets with subsonic and supersonic combustion. His calculations assumed that stable combustion can be achieved in supersonic flow, an assumption which is open to some doubt on present evidence.

On the basis of equilibrium flow, Dugger predicts that a significantly better performance can be achieved with supersonic combustion than with subsonic at speeds in the Mach 8–10 range; in addition, lower combustion chamber pressures and temperatures may ease the design problems. However, making further assumptions about the degree of recombination, he showed that when kerosene is the fuel, the supersonic combustion chamber must be operated at pressures almost the same as in the subsonic case in order to achieve reasonable performance.

The next session was devoted to two papers by J. F. Connors and L. J. Oberry, of the National Aeronautical and Space Agency, and G. H. McLafferty, of United Aircraft, describing basic studies on air intakes. Intakes with both internal and external compression were examined and the great importance of variable geometry in both cases was emphasized. It was also shown that difficult viscous effects will be present which will necessitate complicated boundary layer control devices for maximum performance.

In logical order, the following sessions were devoted to combustion problems and to investigations of the reactions taking place in exit nozzles.

H. Behrens and F. Roessler, of the historic rocket establishment at Saint Louis, which is now under combined French and German direction, described some elegant experiments with supersonic diffusion flames, obtained by passing a supersonic jet of the hot, but not fully oxidized, gases from a solid rocket into air or oxygen. It was shown that with propellants of high heat of explosion stable flames were produced with no ignition delay at the first shock of the jet, while with propellants of low heats of explosion, ignition occurred with a delay, behind the first shock. The latter flames became unstable as the heat of explosion of the rocket propellant became less, although a greater stability was achieved with pure oxygen than with air.

P. P. Wegener, of the Jet Propulsion Laboratory, California Institute of Technology, chose the simpler and better-known system of a reacting mixture of nitrogen tetroxide and dioxide carried through a supersonic nozzle with a stream of nitrogen. By choice of conditions flows which were either in chemical equilibrium or in states between equilibrium and 'frozen' flow could be obtained, the recombination co-efficients being determined from optical absorption or static pressure measurements. As was pointed out in the discussion by K. N. C. Bray, of the University of Southampton, these experiments gave excellent agreement with his own theoretical predictions about non-equilibrium flows through supersonic nozzles and shock-waves.

E. A. Lezberg and R. B. Lancashire, of the National Aeronautical and Space Agency Lewis Research Centre at Cleveland, Ohio, described similar nozzle investigations on a much larger scale using hydrogen/air mixtures. In this case the rate of recombination of the dissociated products of combustion was derived indirectly from performance calculations based upon static pressure and temperature measurements. The results indicated that although deviations from equilibrium flow occur downstream of the nozzle throat, recombination may be occurring throughout the length of the nozzle.

A further paper in the combustion series was a distinguished contribution by A. K. Oppenheim and P. A. Stern, of the University of California, in which the applicability of detonation wave studies to hypersonic combustion was investigated. The authors pointed out that the very stability of a detonation wave makes possible very precise observation and measurement, which could lead to an understanding of many of the problems in a ram jet, such as, for example, the propagation of non-equilibrium disturbances through compressible and reactive gaseous mixtures.

Detonation waves discovered by the early classical work of Berthelot Le Chatelier and others were studied from a thermodynamic point of view by D. L. Chapman and E. Jouget around the turn of the century. These workers demonstrated that detonation waves are complicated systems of shock waves followed immediately by deflagration; and later work, by means of more sophisticated instrumentation, has enabled the structure of the wavefront to be examined in much greater detail. It is clear that the team at the University of California has made great advances in this fascinating field of thermodynamics.

Not the least useful part of the paper by Oppenheim and Stern was the historical review of earlier work on detonations and explosions, together with more than two hundred references to other published work. The paper may well, therefore, become a standard reference in this field.

Following these papers on thermodynamics was the only paper on gas-turbine engines, somewhat out of context, since the speed-range considered was only up to Mach 3, and somewhat unfortunate in that it was one of the only two British papers. Nevertheless, it did reflect the emphasis in Britain of the continued importance of the lower Mach number range. Prof. J. H. Horlock, of the University of Liverpool, presented a very interesting paper on the research in turbomachinery which was still essential for the development of gas turbines capable of propelling aircraft at speeds up to Mach 3. He reviewed the current work on component efficiency, stability of compressors, blade cooling and maldistribution in the intake and compressor, all fields in which he considered there remained many problems requiring fundamental research.

Curiously, no mention was made of combustion problems which are certainly not well understood at Mach 3, nor was there any reference to the great difficulty of dealing with the noise caused by such engines, which may be a dominating factor in the choice of efflux velocity and relative mass flow.

Again, this paper contained a very useful list of nearly sixty references to the published literature.

Finally, the last session was devoted to the materials problems raised by the very high temperatures of hypersonic air-breathing engines. Papers were presented by A. J. Murphy and A. J. Kennedy, of the College of Aeronautics, Cranfield, and by P. Duwez, which were remarkable for their similarity of thought —indeed, each contained an identical diagram relating activation energies for creep, stress rupture and self-diffusion with melting temperature. Working on these lines, but also grading on a basis of low density and high elastic modulus, the advantages of tungsten, molybdenum, chromium and beryllium as refractory materials were stated. Duwez pointed out that since ram jets were constructed mainly from sheet, metals were more attractive than cermets or ceramics; but Murphy and Kennedy stressed the surface reactivity of such metals and the need for research in surface protective methods. Both papers also referred to the use of graphite, with its very high sublimation temperature and its unusual property of increasing tensile strength with temperature up to about 2,500° C.

Duwez, however, considered that materials research would not provide the entire answer to these high-temperature problems, and that porous wall cooling and ablation would be the ultimate solution for very high combustion temperatures. In the ensuing discussion, it was generally felt that the ultimate limit was likely to be an economic one.

So came to an end an extremely useful and fruitful colloquium, which provided an excellent forum for vigorous discussions in a relatively new field of applied science. As is general with AGARD meetings, the contribution of the American workers was both massive and excellent. Unusual, however, was the rather small contribution from Great Britain, the representatives of which were, in general, in the position of assimilating, rather than contributing, new information.

W. CAWOOD

THE PLANT PATHOLOGY LABORATORY, HARPENDEN

By W. C. MOORE, C.B.E.

THE Minister of Agriculture, Fisheries and Food, the Right Hon. John Hare, formally opened the new buildings of the Plant Pathology Laboratory at Hatching Green, Harpenden, on May 13, in the presence of more than a hundred distinguished guests and a staff of nearly sixty. The Minister recalled that the Laboratory, familiarly known for years as "Path. Lab.", was one of the oldest scientific sections of the Ministry. It was founded in 1918 at the Royal Botanic Gardens, Kew, and three years later was transferred to a converted private house in Harpenden. During the next twenty years it had consolidated its position as a scientific liaison centre and a source of advice on all aspects of plant diseases and pests. The big development of the Laboratory had come in the past two decades along with advances in the study of crop protection. The Second World War had again focused attention on maximum food production, and with the need to cut down losses from diseases and pests the Laboratory became an impor-

R 321

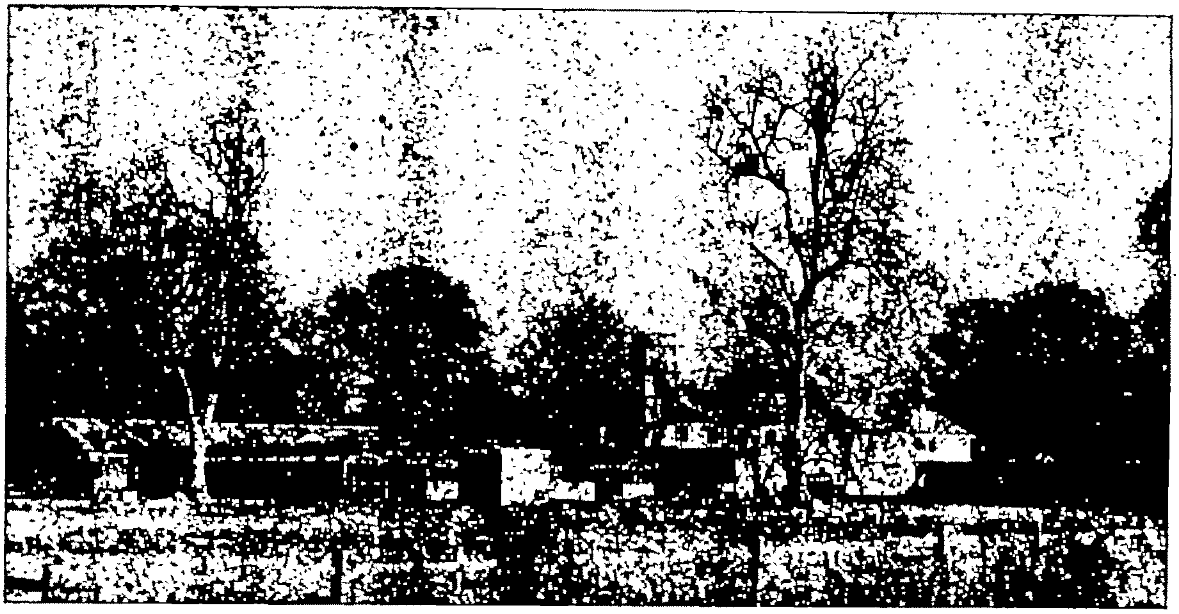


Fig. 1. General view of the Plant Pathology Laboratory, Harpenden, from the rear. (Photo by R. C. Large)

tant link in the complex relations which exist to-day between science, industry and the farmer. A private house was well enough with a staff of ten; but it became more and more inadequate as the work and staff increased. By 1955 the problem of accommodation had become acute. It was then that the Lawes Agricultural Trust purchased and leased to the Ministry of Works a site of nearly six acres on which a new Laboratory could be built, and during the period of construction it provided temporary accommodation for a substantial part of the overcrowded staff.

The new building lies on the periphery of the Rothamsted Experimental Station campus and its design is well adapted to the functions of the Laboratory, which are essentially still of a liaison nature. For example, the Laboratory co-ordinates a system of intelligence, survey and forecasting work on plant diseases and pests, and this involves almost daily contact with the regional plant pathologists and entomologists of the National Agricultural Advisory Service. It provides the scientific basis for the administration of regulatory work involved in the import and export of plants, in the internal spread of dangerous plant diseases and pests, and in official crop certification schemes for potatoes, fruit and hops, all of which is done in the closest collaboration with the Ministry's Plant Health Branch, the National Agricultural Advisory Service, and the Plant Health Inspectorate. It also works closely with the chemical industry in so far as it acts as a clearing house for information on the toxicity of insecticides, fungicides and herbicides to man, animal and plant, and houses an Agricultural Chemicals Approval Organization recently set up to grant official approval to biologically efficient proprietary chemicals used in crop protection, and to replace a somewhat similar scheme that had been in operation for nearly twenty years. The Laboratory also prepares and keeps under regular revision the Ministry's advisory leaflets and bulletins on common diseases and pests of plants, edits its own quarterly journal, *Plant Pathology*, and carries out research on problems arising out of administration. Collaboration in the work of inter-governmental organizations such as the European and Mediterranean Plant Protection Organization, the Western European Union and the Food and Agriculture Organization has become an important feature of its activities during the past decade.

The new building does little more than accommodate the present staff of sixty, including thirty-five plant pathologists, entomologists and chemists; but its construction and L-shaped design are such as to allow for ready expansion. The spacious entrance hall gives access to two corridors along which the laboratories and offices for plant pathology and crop protection chemistry are arranged on either side. The third department, for agricultural entomology, and the library are on the first floor above plant pathology. The chemistry wing has a flat re-inforced roof to allow for first-floor extension. About thirty of the rooms are designed to serve the double purpose of office and laboratory. In addition, there are two chemistry research laboratories, three air-conditioned rooms and a laboratory for experimental work on fumigation, separate laboratories for mycology, nematology and bacteriology (including the housing of the National Collection of Plant Pathogenic Bacteria), a combined conference and training room, photographic department, library, insect museum, general office, and workshop.

The two chemistry laboratories are identical in design, and are intended for the chemical evaluation of formulations in one, and of pesticide residues on crops in the other. To save wall space each is virtually divided into two by a central peninsula of four fume cupboards equipped with separate speed-controlled exhaust fans and external air intake fans, thus avoiding warm air being sucked out of the room. Titration benches and laboratory scaffolding with lateral service panels occupy the ends of each laboratory. Hot and cold water, electricity, gas, vacuum, compressed air, distilled water, carbon dioxide and nitrogen supplies are fed to the working benches and units from a service duct under the central corridor. Between the two laboratories are the balance and electrical equipment rooms housing a spectrophotometer and allied instruments. There is also a general purpose chemical laboratory containing large apparatus, such as a centrifuge and a deep freeze, and provided with fixed service panels and mobile benches to allow flexibility of arrangement.

Techniques for controlling pests on planting material either imported or destined for export will be studied in a new fumigation section, starting with methyl bromide fumigation of seeds and continuing with the effect of fumigants on a number of pests and plant species. A large general-purpose laboratory is intended to be used for gas analysis studies and for the biological aspects of the work. In the three air-conditioned rooms temperatures can be controlled between 5° and 30° C., and high relative humidities can be maintained, in order to be able to simulate some of the conditions which obtain during practical plant quarantine work. One room will house a 1.500-litre steel fumigation chamber for plant toxicity studies and for work on vacuum fumigation techniques, while the other two will be used for small-scale studies on the sorption of fumigants by seeds and for the rearing of insect pests.

Ancillary buildings adjoin the main laboratory. The glasshouse block includes insectaries, glasshouses of a total area of 2,000 sq. ft. divided into a number of isolated compartments, a small laboratory for plant inoculations, and a working area with potting bench, etc. Ventilators are protected by removable metal gauze panels, so that any compartment can be made aphid proof. The virus disease section has additional forced fan ventilation. The bench tops are concrete troughs so that the plants can be watered by sub-irrigation. The glasshouses are heated by small-bore hot-water pipes and auxiliary electric fan heaters, both thermostatically controlled; and there are facilities for supplementary lighting when required.

The ancillary buildings also include a room specially designed for washing soil samples to determine pest populations of soils, and a pest assessment sample room equipped to deal annually with large numbers of experimental yield samples of cereals and forage crops. A small, unique, electrically driven, highly versatile, loss-free threshing machine, designed and built at the National Institute of Agricultural Engineering, has been installed along with other equipment, including a sample dryer which can deal with wet samples before threshing as well as grain after threshing, and a modified small commercial grain cleaner.

OBITUARIES

Mr. H. W. Robinson

H. W. Robinson, who died suddenly on April 22, was a familiar and much-consulted figure in the Library of the Royal Society, with which his association was so long, so close and so valuable that the loss seems irreparable. He was born on March 23, 1888, in Wood Green, a part of London with which he was closely associated all his life, being in many ways a prominent local figure, held in affectionate regard by the residents. He joined the staff of the Royal Society in 1902, as a boy of fourteen, and soon became particularly associated with the Library, of which he was appointed assistant librarian in 1930 and librarian in 1935. When, at the age of sixty, he retired from this post, his services were retained by the Society to assist in editing the Newton correspondence, of which, happily, he was spared to see the appearance, some months ago, of the first of the seven volumes that are anticipated. With this work, to which his contributions were a model of clarity and accuracy, he was prominently associated until the day of his death.

Robinson took an enthusiastic interest in everything to do with the Royal Society's Library and with its extensive and invaluable archives. He was a self-taught scholar of considerable attainments, whose specialized acquaintance with many branches of the history of science was remarkable. He was always ready to place this exceptional knowledge, which included the whereabouts of rare books and manuscripts other than those in the Society's possession, at the disposal of students of the history of science, including many from abroad who made use of the Library, and frank acknowledgments of his generous and valuable aid are to be found in many important publications. With Prof. Harcourt Brown and Prof. D. M. McKie he founded the *Annals of Science* and he took a prominent part in founding the British Society for the History of Science.

He was particularly well acquainted with the events of the early days of the Royal Society. He had, for example, made a particular study of Robert Hooke: he identified as written by Hooke the diary in the British Museum that had always been attributed to James Petiver, and, in conjunction with Walter Adams, he edited the "Diary of Robert Hooke", in the possession of Guildhall Library, which was published in 1935. Reference has already been made to his exceptional knowledge of the correspondence of Newton and his contemporaries.

Robinson was a most friendly man, who knew his own mind and inspired confidence. He was devoted to the Royal Society, which he served for fifty-eight years, and the Society repaid his devotion with a warm regard and a respect for his specialized knowledge and achievements. He was very happy when his son Norman was appointed assistant librarian to the Royal Society, thus continuing the association which Robinson himself so long represented.

E. N. da C. Andrade

Mr. J. R. MacCabe

Jack R. MacCabe, a familiar figure to the many visitors to the European Organization for Nuclear Research, died on April 17.

Born at Edmonton, Canada, on May 4, 1914, he entered the University of Alberta in 1930. Two years later, he went to McGill University, Montreal, where, by 1937, he had taken his degrees of bachelor of science and master of science (natural sciences), while working as a demonstrator and lecturer in physiology at the University's Faculty of Medicine.

Jack MacCabe went to Europe soon after finishing at McGill and continued medical and biological studies and research at the University of Munich, up to the outbreak of the Second World War in 1939. When he arrived in Switzerland, he found a position as a lecturer at the International School and at the

Interpreters' School of the University of Geneva, where he remained until 1944. In the meantime, in 1942, he had joined the staff of the well-known aviation magazine *Interavia* and, in 1951, became executive editor of its "Air Letter".

In September 1955, he joined CERN (European Organization for Nuclear Research) and eventually became senior information officer. His considerable energy and intelligence were used to good purpose in meeting the thirst of the informed public for more information about the Organization and in bringing CERN'S existence and achievements to the notice of the lay press and public. He was extremely successful in putting across to visitors the philosophy, the technology and the science of CERN, and his broad outlook and his pleasant personality had won him countless friends among the many visitors to the Organization.

NEWS and VIEWS

Wolfson Research Professorship of the Royal Society: Dr. Dorothy C. Hodgkin, F.R.S.

Dr. Dorothy Hodgkin has been appointed by the Council of the Royal Society as the first holder of the Wolfson research professorship, endowed by the Isaac Wolfson Foundation. Dr. Hodgkin gained recognition as an expert in X-ray crystallography early in her career, while still working with Bernal, contributing frequently to the crystallography section of the Chemical Society's Annual Reports from 1933. Educated at Somerville College, Oxford, she returned there as chemistry tutor; later she was appointed as University reader in X-ray crystallography and became a Fellow of the College. Academic distinctions came quickly—honorary D.Sc. of the University of Leeds, election in 1947 as one of the small handful of women Fellows of the Royal Society, and a Royal Medal of the Society in 1956. She is also a foreign member of both the Netherlands and the U.S. Academies of Sciences. Instead of choosing between career and family, Dorothy Hodgkin has made a brilliant success of both, with three children and one grandchild to her credit, besides being a charmingly informal hostess. With the help of devoted groups of research students, she has contributed much new knowledge to her chosen field of X-ray crystallography. More significantly, however, she has forged ahead in seemingly impossible directions with the investigation of ever more complex biological molecules—calciferol, cholesterol, penicillin, a virus, and finally vitamin B_{12}. With intuitive insight she can not merely extract the utmost information from a complex round of calculations, but can also make the next round uncannily informative by inspired predictions. As research professor she will remain at Oxford to continue this work.

Barnard Medal of Columbia University, New York: Prof. I. I. Rabi

Prof. I. I. Rabi, Higgins professor of physics at Columbia University, New York, has been awarded the Barnard Medal for 1960 for "meritorious service to science". The award, presented every five years by the Trustees of Columbia University, is made on the recommendation of the U.S. National Academy of Sciences. Dr. Rabi was born in Rymanow (old Austria-Hungary) in 1898. He graduated from Cornell University in 1919 with a bachelor's degree in chemistry; he received his Ph.D. in physics from Columbia in 1927. He has taught at Columbia University since 1929. In 1940 Dr. Rabi and a group of physicists organized the Radiation Laboratory at the Massachusetts Institute of Technology; the laboratory was devoted to the development of radar for military purposes. He was awarded the Nobel Prize for physics in 1944 for the general application of the resonance method to the magnetic properties of atomic nuclei. During 1952–56 he was chairman of the general advisory committee to the U.S. Atomic Energy Commission. He is a member of the President's Science Advisory Committee and was chairman in 1957.

The Barnard Medal was established by the will of the late Dr. Frederick A. P. Barnard, president of Columbia University during 1864–89. It is presented to "the person, if any, whether a citizen of the United States or any other country, who within the preceding five years has made such a discovery in physical or astronomical science, or such a novel application of science to purposes beneficial to the human race, as in the judgment of the National Academy of Sciences of the United States, is esteemed most worthy of such honor". Former Barnard medallists include Albert Einstein, Niels Bohr, Enrico Fermi, Frédéric Joliot and Mme. Irène Joliot-Curie, and M. A. Tuve.

United Kingdom Scientific Mission in Washington: Dr. H. T. Hookway

Dr. Harry T. Hookway has been appointed director of the United Kingdom Scientific Mission in Washington, D.C., and scientific attaché at the British Embassy there. He will succeed Mr. E. S. Hiscocks, who is returning to Britain in the autumn on completion of a three-year tour of duty to become director of the Tropical Products Institute. Dr. Hookway, who is thirty-eight, is the assistant director of the National Chemical Laboratory, where he has been since joining the Department of Scientific and Industrial Research in 1949. He is well known for his work on polymers, ion-exchange resins and saline-water conversion, and was the United Kingdom representative on the International Steering Committee for Co-operative Research in Electrodialysis (the purification of brackish water) during 1953–58. Educated at the Trinity School of John Whitgift, Croydon, and the University of London, Dr. Hookway held research posts in industry, working on oil additives, before becoming, in 1947, lecturer in organic chemistry in Battersea Polytechnic (now the Battersea College of Advanced Technology), where he obtained his Ph.D. in 1949.

Seismological Observatory, Wellington, N.Z.: Mr. R. C. Hayes

On May 31, Mr. R. C. Hayes, superintendent of the Seismological Observatory, Wellington, New Zealand, retired after forty years scientific work in the N.Z. Government service. He joined the staff of what was then the Hector Observatory in 1920, and worked under the late Dr. C. E. Adams until 1936, when he was appointed acting-director of what had become the Dominion Observatory. In 1948, the Observatory assumed its present name, and Mr. Hayes became director. This title was changed to superintendent when the Observatory became part of the Geophysics Division of the N.Z. Department of Scientific and Industrial Research in 1951.

Under the direction of Mr. Hayes, N.Z. earthquake recording grew from two Milne pendulums—at Wellington and Christchurch—to a network of modern instruments extending from Afiamalu in Samoa to Scott Base in the Antarctic. He has pioneered many branches of seismological work in the south-west Pacific, publishing papers on deep-focus earthquakes, crustal structure, ground tilting, and the general seismicity of the region, as well as assuming the responsibility for a growing burden of standard measurements, and training the staff to deal with them. He was the first to direct attention to the appearance of the phase *sSoS* in seismograms, and to its usefulness as an indicator of focal depth. The work of the Observatory also included the keeping of a national time service; and during the International Geophysical Year, Mr. Hayes undertook the organization of the N.Z. latitude and longitude programme. He personally made many of the observations with the Danjon astrolabe, as well as undertaking an augmented programme in seismology. Observational astronomy has been an important spare-time interest, and for many years Mr. Hayes carried out regular sunspot observations from his home at Karori. He also made a complete sweep of the southern heavens with a 4-in. refractor, and compiled a catalogue of all the nebulæ, clusters, and double and coloured stars visible through it. In addition to his scientific interests, Mr. Hayes is a keen musician and a church organist.

Crystal Physics at Cambridge:

Dr. W. A. Wooster

A FAREWELL dinner was given on June 10 by Prof. C. E. Tilley, head of the Department of Mineralogy and Petrology at Cambridge, to mark the retirement of Dr. W. A. Wooster. Invited by the late Prof. A. Hutchinson to start courses for undergraduates in theoretical and experimental crystal physics, Dr. Wooster was appointed in 1927. These courses, in conjunction with courses in X-ray crystallography, have formed a good basis for the understanding of the modern science of crystals. Dr. Wooster has published two books, "A Text-book of Crystal Physics" and "Experimental Crystal Physics", the latter of which has been translated into four foreign languages. During the War, in collaboration with his wife, Dr. Wooster established a private laboratory where it was possible to make some contribution to the national needs in connexion with diamonds and quartz crystals. The first hydrothermal synthesis of quartz in Britain was carried out in this laboratory. Dr. Wooster has also been concerned with the development of X-ray crystallographic instruments. During the past decade he has worked in the Cavendish Laboratory on diffuse reflexions of X-rays from crystals, and with his research students he has developed methods of determining the elastic constants of crystals. Dr. Wooster intends to do research work in his own laboratory and to continue his efforts for international co-operation in science through the World Federation of Scientific Workers.

Mullard Cryomagnetics Laboratory at Oxford

THE development of iron-free magnets giving large magnetic fields over a fairly large volume has been in progress at the Clarendon Laboratory, Oxford, using a 2-mW. generator installed in the Simon Building in 1949. Such magnets led to success in nuclear orientation experiments in 1951, and nuclear cooling experiments in 1956. At present the magnets give fields up to 50 kilogauss over a volume of 500 cm.^{3}, and are used at four 'stations', two of which, owing to the serious overcrowding of the Laboratory in all departments, are housed in a lean-to shack. A much-needed extension of the Simon Building has been made possible by the generous gift of £25,000 by the Mullard Co., together with grants from the Oxford University Higher Studies Fund and other University sources. Two floors of this extension will be devoted to the high magnetic field work, and will be known as the Mullard Cryomagnetics Laboratory. Seven magnet stations are planned, with fields up to about 120 kilogauss. These will be used for further development of nuclear orientation and nuclear cooling under the direction of Dr. N. Kurti, reader in physics, together with work in the field of solid state physics including semiconductors, antiferromagnetics and ferrimagnetics. It is hoped there will be sufficient facilities to accommodate occasional visitors who wish to carry out important experiments requiring high magnetic fields.

The Royal Society of Edinburgh

To help visitors to the Library and Museum of the Royal Society of Edinburgh, the Curator, Dr. Douglas Guthrie, has prepared an account of the many portraits and has added suitable biographical notes ("Year Book of the Royal Society of Edinburgh, 1959–60"). Altogether, the note contains descriptions of twenty former presidents, ten general secretaries and thirty other distinguished men of science. Among the presidents are such well-known names as Sir Walter Scott, who was the only 'literary' president ever to hold office; Sir James Hall; Sir David Brewster, whose mathematical career was dogged by his 'heretical' religious views; Lord Kelvin, president on three occasions; Sir Alfred Ewing, who built up the school of engineering at Cambridge; Thomas Stevenson, a member of the famous family of lighthouse engineers and father of Robert Louis Stevenson; the famous botanist, Prof. F. O. Bower; Sir Edward Sharpey-Schafer, whose method of resuscitation known as the 'prone-pressure system' became widely adopted; and Sir D'Arcy Wentworth Thompson, "so versatile that he could speak acceptably on almost any subject, even in an age of specialists". Other distinguished men of science include such names as James Watt, William Murdock, Sir Humphry Davy, David Hume, Georges Cuvier, J. J. Berzelius, Lord Raleigh, Sir Joseph Barnes, Sir J. J. Thomson; they reveal the debt which the world owes to the Royal Society of Edinburgh. Portraits of the first four presidents illustrate the paper.

The European Federation of Corrosion

THE British Association of Corrosion Engineers has been elected a member of the European Federation of Corrosion. The object of the Federation, which is a non-profit making union, is to promote European co-operation in the field of research on corrosion and methods of combating it for the benefit of the community at large. Membership of the Federation is restricted to non-profit-making European technical and scientific societies the activities of which are connected with the field of corrosion or the protection of materials. The Federation seeks to achieve its objects by convening joint European meetings for the discussion of subjects of general interest; by convening meetings of working parties for the discussion of specific problems; by the creation of working groups for investigating special problems; by the organization of study trips; and by other means. The General Secretariat of the Federation is managed jointly by the Dechema in Frankfurt a.M. and the Société de Chimie Industrielle in Paris.

The British Association of Corrosion Engineers was formed last year (see *Nature*, 183, 1779; 1959) generally to promote the dissemination of technical information about corrosion matters; to develop the free interchange of information among members; and to promote such educational and other facilities as may be required for the establishment of corrosion engineering as a recognized profession. Individual membership (two guineas a year) is open to everyone interested and associated with corrosion engineering. The address of the Honorary Secretary is 97 Old Brompton Road, London, S.W.7.

The British Hydromechanics Research Association

THE twelfth annual report of the British Hydromechanics Research Association covers the year October 1958–September 1959, in which the membership increased by 14 to 89 ordinary and 104 associate members. Brief summaries are given of some of the research in progress, including the construction of a new apparatus for testing mechanical and radial-face seals, an attempt to explain the sealing mechanism of fabric-rubber seals for reciprocating shafts, and a study of the effects of internal leakage of energy from centrifugal pumps through neck rings. Careful tests with a modern design of a large fan showed that velocity measurements in a rectangular discharge-duct at equidistant points in the cross-section gave results 2·7 per cent or more too high. Work is also complete on model tests for the National Coal Board to study flow-conditions and determine pressure losses in gallery-type fan drift junctions and shaft insets, and experimental work has been completed on the influence of size distribution on the flow-characteristics of liquid/solid mixtures, where the solid particles are larger than about 100 mesh. The National Physical Laboratory electronic simulator has been used to investigate surge problems associated with the design of the siphon draw-off tower for Tryweryn reservoir, and the possibilities of de-priming a siphon while passing a high discharge were also examined. Results have been obtained for the fatigue of four flexible high-pressure hoses, and work continued on a model valve for automatic control systems. As a result of tests on a model of the four tidal gates and diversion channel, and on another large model of one pair of gates for a new tidal outfall proposed by the Cheshire River Board for the River Birkett at Birkenhead, a silt deflector and other hydraulic improvements have been added to the original design and gates calibrated as a means of measuring river flow.

Medical Research in France: the Paris Hospitals

French Science News (No. 1, 1960, January–March) includes a special article on medical research in the Paris hospitals, covering both the more or less autonomous organizations such as the Pasteur Institute, the Cancer Institute, the National Blood Transfusion Centre, the Atomic Energy Commission at Saclay with the d'Orsay Hospital and laboratory and the research centres set up within the Hospitals of Public Assistance. These hospitals include about twenty research organizations which have the advantage of being in intimate contact with the patient any time it is necessary. Some of these centres have been grouped since 1955 into the Claud Bernard Association, founded in June 1953, to facilitate the development of medical and biological research in these hospitals. The article outlines the organization and orientation of research in these various centres, including the leukaemia and blood disease research centre, the research centre for the medical application of isotopes, the allergy and immunology research centre, the renal insufficiency research centre, the centre of immuno-pathology, the biological research centre for new-born infants, the neurophysiology, the pharmacological, the experimental surgery, and the cardiological research centres, the gerontological centre, the medical biochemistry research laboratory, the laboratory for medical biochemical research, the neurorespiratory revival centre of the clinic for infectious diseases, the clinic for medical and social rheumatology, the dietetic and human nutrition research unit, and the gastro-enterological research centres, Saint-Antoine and Bichat Hospitals.

Darwin's Notebooks on Transmutation of Species

IN his "First Notebook", on transmutation of species, Darwin satisfied himself that it had occurred when populations were isolated and no longer able to prevent variation that resulted from sexual reproduction, and is normally kept in check by breeding throughout the population. In this way varieties become split off from the species and eventually become species themselves, while old species become extinct, thereby increasing the separation between surviving species, many of which after being split into daughter species become genera. In his "Second Notebook", which represents his train of thought from the beginning of February until the first half of July 1838, Darwin was already concerned with the problem of expressing his views on paper and gave himself instructions for presenting his theory. Like the "First Notebook" (see *Nature*, 185, 580; 1960), the "Second Notebook" has been edited by Sir Gavin de Beer and issued with explanatory notes (Bulletin of the British Museum (Natural History). Historical Series. 2, No. 3: Darwin's Notebooks on Transmutation of Species. Part 2. (February to July 1838.) Pp. 75–118. (London: British Museum (Natural History), 1960.) 15*s*.). The "Second Notebook" not only describes Darwin's methods of presenting his theory but, incidentally, gives his views on slavery, education, and "the improvement of women".

English Rural Life

THE report of the Museum of English Rural Life for 1959 is, as usual, far more than a formal statement (pp. 22, 5 plates. Reading: Museum of English Rural Life, The University, 1960. 1*s*.). This Museum in the University of Reading is still engaged in its threefold task of collecting objects from the countryside, accumulating a library of documentary information and carrying out research on the material acquired. The Museum is, however, concerned that, owing to lack of financial support, it is not possible to send experienced field workers on collecting and recording expeditions to obtain information when so much detail is being lost almost daily. A voluntary panel of Museum correspondents gives much assistance, and again it is stressed that the Museum is not in competition with other institutions having collections of rural material, but is seeking rather to increase the total amount available for study. Miss Anne Sheppard contributes an illustrated article on traditional dairying which includes a catalogue of the Museum material on this subject. It is emphasized that the rapid increase in milk-production during this century, and the policy of supplying an ever-increasing population with milk and its products, have stimulated scientists and engineers to produce methods and machines far removed from the original crafts.

New Principle in Weaving

The first new basic principle in the weaving of woollen and worsted cloth to be introduced since the Middle Ages has recently been announced by the Wool Industries Research Association (Wool Industries Research Association. Report of the Director of Research for 1959. Pp. 39. Publication No. 214. Headingley, Leeds: Wool Industries Research Association, 1960). Since foot-power looms were first used, the warp threads have been raised and lowered according to the pattern required; the weft has been shot across and beaten into place by the 'reed' and the selvedges of the cloth have been maintained at their proper width by the 'temple'. Ever since that time—particularly since the introduction of power looms at the end of the eighteenth century—the strain on the warp threads due to beating-up of the reed has been a common cause of the threads breaking. The new invention is the full-width temple of the Wool Industries Research Association, which not only maintains the width of the cloth during weaving, but also virtually relieves the warp threads of all extra strain due to the beating of the reed. The new temple holds the cloth firmly across its whole width about a quarter of an inch behind the place where each new pick is inserted. The essential principle is that the weft is forced into its proper place by means of a reduction of the tension in the cloth rather than an increase of the tension in the warp threads.

The Library Association

Besides its reference to approaches made by the Library Association to the Minister of Education, requesting the introduction of legislation to implement recommendations of the Roberts Report, the annual report of the Association for 1959 deals with several matters of interest to the scientist and technologist (pp. 27. London: Library Association, 1960). A deputation met the Secretary and other officers of the Department of Scientific and Industrial Research in July to press the Association's proposals regarding the scope and organization of the National Lending Library for Science and Technology. It was urged that the professional staff of the Library should be chartered librarians, and further representations on the issue of staff were afterwards made to the Consultative Committee for the Library set up by the Department later in the year. A strong protest was made to the Department regarding the composition of that Committee. Criticisms and suggestions regarding the draft regulations for borrowing facilities at the Library were also made at the invitation of the Department. Representations were made to the Publishers Association regarding an increase in the number of imperfect copies, and evidence was submitted to that Association; and in protesting to the American Chemical Society following the large increase in the subscription rates of *Chemical Abstracts*, the Association urged that the concessional rates of subscription granted to teaching institutions should be available to public libraries also. The report records a total membership of 12,536, of which 1,164 are institutional and 3,601 Associates and 1,601 Fellows on the Register at December 31, 1959.

Bibliographical Citation

A second edition of the articles by C. C. Barnard, "Bibliographical Citation", first published in *The Librarian* in 1950, has now been issued to facilitate even wider circulation (Bibliographical Citation. By Cyril C. Barnard. Second edition. Pp. ii+20. Reprinted, with revision, from *The Librarian*, May, July and August 1950. London: James Clarke and Co., Ltd., 1960. 2*s.* 6*d.* net). These notes embody the results of Mr. Barnard's own long experience and of his critical study of what has been written on this subject. The purpose of lists of references, bibliographies and of reading lists is clearly distinguished, and citations of manuscripts of printed books and of periodicals are likewise discussed separately. On the subject of abbreviations for periodicals, Mr. Barnard writes cogently and logically, and for this section alone his pamphlet merits attention by every scientist who is concerned with the citation or location of such references. Elementary as the four canons enunciated by Mr. Barnard appear to be, they are not always observed even by learned and professional societies, particularly those canons relating to ambiguity and to the order of words. These canons prescribe that the abbreviation should be: (1) readily intelligible without the use of a key; (2) free from ambiguities; (3) full enough to enable a reader to find the full title in an alphabetical list of periodicals; and (4) follow the same order of words as the original title. Finally, Mr. Barnard gives some guidance to authors on the arrangement of citations in lists. This scholarly pamphlet could well be widely used in technical colleges and universities to check the widespread habit of imperfect and incorrect citation which all too many graduates appear to acquire as students and maintain uncorrected in their professional life.

A Revised Geological Time-Scale

Throughout the past year, in the columns of *Nature* and elsewhere, there has been keen discussion on the geochronology of the fossiliferous formations. Until recently the geological time-scale established by Prof. Arthur Holmes in 1947 found world-wide acceptance; but much new evidence on the ages of rocks, deriving principally from argon/potassium and rubidium/strontium datings, consistently demands an extension of this chronology, with the beginning of the Cambrian period carried back from 520 million years to about 600 million years. The full arguments favouring "A Revised Geological Time-Scale" have now been presented by Prof. Holmes (*Trans. Edinburgh Geol. Soc.*, 17, 183; 1960; preprint, price 3*s.* 6*d.*, published by Oliver and Boyd, Edinburgh). On this scale the geological periods open at the following dates: Cambrian, 600 ± 20; Ordovician, 500 ± 15; Silurian, 440 ± 10; Devonian, 400 ± 10; Carboniferous, 350 ± 10; Permian, 270 ± 5; Triassic, 225 ± 5; Jurassic, 180 ± 5; Cretaceous, 135 ± 5; Tertiary, 70 ± 2 million years. A contemporary review of much the same data, on "Aspects of Radiogeology", has been published by Prof. C. F. Davidson (*Liverpool and Manchester Geol. J.*, 2, 311; 1960); and another comparable analysis of "The Distribution of Mineral Dates in Space and Time" has been made in California by Dr. Gordon Castil (*Amer. J. Science*, 258, 1; 1960). Although in North America the various dated orogenies exhibit a crudely concentric pattern with the younger dates outwards, similar arrangements have not been found elsewhere. On the contrary, the age determinations from Africa, Australia and Eurasia are in direct conflict with the much canvassed hypothesis that the continents have accreted around nuclei of greenstones (see also p. 34 of this issue).

Brain

A RECENT issue of *Brain* (83, Pt. 1), a journal of neurology, includes two communications on the muscular disease myasthenia gravis, one by E. R. Bickerstaff and A. L. Woolf and the other by Violet MacDermot. In both studies, biopsy specimens of muscle from patients were used and the nerve endings studied, following vital staining with methylene blue. Histochemical methods for demonstrating the distribution of cholinesterase were also used by the first authors. In both communications, photomicrographs or drawings show that in the muscle of patients there is an abnormality of the distal nerve fibres with an unusual pattern of nerve branching. Elongation of the motor end-plates was a regular finding. These changes were found in muscles in which the classical staining methods showed no abnormality of the non-neural tissues. The authors were unable to establish any definite correlation between the observed changes and the disorder of neuromuscular transmission, though they make a number of cautious suggestions regarding the possible nature of the primary defect in this disease. Another communication (by R. A. Taylor) describes an unusual family in which, through five generations, certain members have shown attacks of acute neuritis, usually brachial in location. Of 119 individuals, 23 per cent of the males and 22 per cent of the females were affected by the condition, which, the author considers, is transmitted by an autosomal dominant gene with a high degree of penetrance.

Chromosome Numbers in *Amaranthus*

IN further studies of the genus *Amaranthus*, Prof. W. F. Grant (*Canad. J. Genet. Cytol.*, 1, No. 4; 1959) has reported on the chromosome numbers for 30 species. These taxa represent approximately two-thirds of the described species. With the exception of one tetraploid species (*A. dubius*, $2n = 64$), all the species are diploid, and somatic chromosome numbers of 32 (14 species) and 34 (15 species) are found in all sections of the genus. The genus is thus characterized by two basic chromosome numbers, namely, 16 and 17, which are found with equal frequency in the different taxa. In contrast to aneuploidy, euploidy has contributed very little to speciation within the genus. Chromosome number determinations for two natural hybrids of which one is considered to be the result of triple hybridization, namely, *A. cruentus* ($2n = 34$) × *A. hybridus* ($2n = 32$) = hybrid ($2n = 32$), and *A. cruentus* ($2n = 34$) × *A. powellii* ($2n = 34$) × *A. retroflexus* ($2n = 34$) = hybrid ($2n = 32$) have indicated differences in chromosome numbers between the putative parents and the hybrids. A survey of the natural interspecific hybrids reported in the literature indicates that at least half the species of the genus have been involved in hybridization. Natural interspecific hybridization and aneuploidy are considered as the major factors which have lead to species variation, speciation, and to the taxonomic complexity of the genus.

Electronic Figure Reader

THE EMI Co., Ltd., has recently held a series of public demonstrations of its 'figure reading electronic device'—*Fred*. This is a relative newcomer to the field of machines which are able to read directly from printed characters; but, because it uses a specially designed type face, it is unlikely to provide a general solution to the pressing problem of direct input to data processing machines. Nevertheless, for the more limited objective of cheque sorting for the banking industry, this new British development is likely to have a considerable future, particularly in view of the fact that an accurate arrangement of the documents is unnecessary.

Science and Faith

"QUESTIONS of Science and Faith" is one of a series, "Foundations for Faith", likely to appeal to those who have reached the final stage of their school course or are in the early terms of their university studies (pp. 63. London: The Tyndale Press, 1960. 2*s*.). A short bibliography is added for any who wish to pursue the subject further. Writing as a biochemist, Dr. Hawthorne covers most of the points raised by students genuinely interested in the validity of the Christian faith. Misunderstandings are removed concerning the so-called conflict between science and religion. The Bible, creation, the origin of life, and miracles, are some of the themes included in this short survey. It is to be commended for its clarity and is a welcome addition to the growing volume of literature which seeks to view the world of science in its relation to the realm of the spirit.

Royal Meteorological Society: L. F. Richardson Prize

THE Council of the Royal Meteorological Society has decided to institute a new award, to be known as the L. F. Richardson Prize, for the encouragement of research by young meteorologists. The Prize will consist of £25 together with a book, and will be awarded for meritorious papers contributed to the Society's *Quarterly Journal* by members who were under the age of twenty-eight at the time the papers were submitted for publication. It is intended that the award shall be made annually, subject to the attainment of certain standards. The full regulations for the new award will be printed from time to time in the Society's *Quarterly Journal* and in its monthly magazine, *Weather*.

Training Grants in Plastics Technology

APPLICATIONS are invited from young men and women now working in the plastics industry for a limited number of training grants towards the cost of full-time study on an approved course leading to a degree, diploma or other equivalent qualification in science or technology, or in industrial design. The grants are to be awarded by the trustees of the Plastics Industry Education Fund and will be made for periods of one year at a time. The value of the grants will normally be of the order of £100. Applications must be submitted in writing to the Secretary, Plastics Institute, 6 Mandeville Place, London, W.1, by July 15.

International Conference on High-Energy Physics

THE tenth annual international conference on "High-Energy Physics" is to be held at the University of Rochester during August 25–September 1. The Conference has been authorized by the Commission on High Energy Physics of the International Union of Pure and Applied Physics. Other sponsors are the U.S. National Academy of Sciences, the U.S. National Science Foundation, the U.S. Atomic Energy Commission, Office of Ordnance Research and a number of industrial organizations. Approximately 175 delegates from more than 30 countries will attend the conference including India, Australia, Sweden, Brazil, Pakistan, Israel, Mexico, Turkey, Yugoslavia, Argentina, Poland and Greece. The U.S.S.R. has signified its intention of sending a 40-man delegation. One of the most important aspects of the Conference will be the first official reports on activities of the new 25×10^9-eV. accelerator at the European Centre for Nuclear Research in Geneva. The chairman of the Conference is Prof. Robert E. Marshak, chairman of the Department of Physics and Astronomy, University of Rochester, and also secretary of the organizing committee, and from whom further information can be obtained.

Biology of Space Travel

THE Institute of Biology is arranging a symposium to consider various biological problems connected with space travel. It will be held during September 29–30, and the topics to be considered will include: the possible existence of some form of life on other planets; the danger of contamination of other planets and the Earth by space vehicles; effects of high and extremely low gravitational forces on the human body; the effects on man of radiation in space; maintenance of life in space ships; psychological problems connected with the choice of personnel for conditions of solitude and confinement. Further information can be obtained from the General Secretary, Institute of Biology, 41 Queen's Gate, London, S.W.7.

Announcements

THE following have been elected officers for the year 1960–61 of the Salters' Company: *Master*, Mr. R. S. H. Callingham; *Upper Warden*, Sir Alexander Todd; *Second Warden*, Mr. T. G. Hicks.

DR. W. R. AYKROYD, senior lecturer in the Department of Human Nutrition at the London School of Hygiene and Tropical Medicine, and recently director of the Nutrition Division of the Food and Agriculture Organization of the United Nations, has been made an honorary member of the American Institute of Nutrition.

THE United Nations Educational, Scientific and Cultural Organization Centre for Scientific Co-operation in Latin America, Montevideo, has issued as Vol. 4 of "Scientific Institutions and Scientists in Latin America" a list of scientific institutions of Argentine (pp. vi+136. Montevideo: Unesco, Centro de Co-operación Científica para America Latina, 1959).

THE seventeenth International Congress of Pure and Applied Chemistry is to be held in Munich during August 26–29. Further information can be obtained from the secretary-general of the International Union of Pure and Applied Chemistry, Dr. R. Morf, c/o Sandoz, S.A., Basle 13.

THE fifth World Forestry Congress, organized by the Government of the United States and sponsored by the Food and Agriculture Organization, will be held in Seattle, Washington, during August 29–September 16. Further information can be obtained from Dean Hardy L. Shirley, State University College of Forestry at Syracuse University, Syracuse 10, N.Y.

DURING August 29–September 9 the "Association des Cours Internationaux de Lyophilization" will be holding the second international course on "Lyophilization" at the Institute National des Sciences Appliquées in Lyons. Further information can be obtained from Dr. Louis R. Rey, Laboratoire de Physiologie, Ecole Normale Supérieure, 24 rue Lhomond, Paris 5e.

UNDER the auspices of the International Federation of Electron Microscope Societies, the Nederlandse Vereniging voor Electronenmicroscopie is organizing a European regional conference on "Electron Microscopy". This is to be held at Delft during August 28–September 3. Further information can be obtained from A. L. Houwink, secretariat of the European Regional Conference on Electron Microscopy, Julianalaan 67a, Delft.

THE first International Pharmacological Meeting is to be held in Stockholm during August 22–25, 1961. The meeting is to be held under the auspices of the Section of Pharmacology of the International Union of Physiological Sciences. Further information can be obtained from the secretary-general, A. Wretlind, First International Pharmacological Meeting, Karolinska Institutet, Stockholm 60.

THE first International Congress of Histochemistry and Cytochemistry is to be held in Paris during August 28–September 3. The Congress is organized under the auspices of the Société Française d'Histochimie in collaboration with histochemical societies in many other countries. Further information can be obtained from the secretary-general, Dr. R. Wegmann, First International Congress of Histochemistry and Cytochemistry, 45 rue des Saints-Pères, Paris 6e.

THE Czechoslovak Academy of Science is to organize an international conference on "Semiconductor Physics" at Prague during August 29–September 2, under the auspices of the International Union for Pure and Applied Physics, and which will continue the series of conferences held in Reading (1950), Amsterdam (1954), Garmisch–Partenkirchen (1956) and Rochester (1958). Further information can be obtained from Dr. Miloš Matyáš, Institute of Technical Physics, Prague 5, Cukrovarnická 10, Czechoslovakia.

ERRATUM. Mr. M. W. Hardisty, writing with reference to the communication "Sex Ratio of Ammocoetes" in *Nature* of June 18, p. 968, states that the symbols ♂ and ♀ should be reversed.

THE DECIMAL SYSTEM IN BRITAIN

DURING the past two years, committees appointed by the British Association and by the Association of British Chambers of Commerce have been examining the merits or demerits of the adoption by the United Kingdom of the decimal system of coinage and/or the metric system of weights and measures. A joint report, to which Sir Alexander Fleck contributes a foreword, has now been issued*, based on inquiries made of some 2,000 organizations, including trade associations, chambers of commerce, individual companies, learned societies and professional institutions. The report is in four parts, examining first the question of decimal coinage and then that of the metric system. In each of these parts, earlier inquiries in the United Kingdom are reviewed, and then the implications and merits of a change are considered, the cost factors and, for the metric system, the international aspects. In the third part, the improvement of the Imperial system is discussed, and in the fourth, the educational aspects such as the problems for schools and adult education.

On all the available evidence, the Committees consider that there is a strong case for the adoption of a decimal system of coinage, and, as Sir Alexander Fleck points out, this is a policy that lies wholly within our own control to determine: no international complications are involved. The Committees found little dissatisfaction expressed with the present system of coinage in industry and commerce, but wide approval of the concept of decimal coinage. There was some disagreement as to the preferred method of decimalization, but an overwhelming wish to retain the pound sterling as the major unit. If this is accepted, the pound/mil, or pound/cent, with the cent suitably subdivided, systems appear to be the most suitable, and these systems are also the most popular. Decimalization of the coinage would be helpful by simplifying money calculations, with particular advantages in the fields of business machines and education. It is primarily a domestic question; but any system which involved abandoning the pound as the major unit might lower the status of British currency. Decimalization of the coinage would give only slight advantage in international trade, and while, so far as the Committees could ascertain, the transitional costs of decimalization would be heavy, they would not be unduly large in relation to the resources of the country and the long-term benefits that would accrue. The question should be considered on its own merits independently of the system of weights and measures, but decimalization of the coinage should precede any future plan for the adoption of the metric system.

Since the evidence before the Committees was received mainly from industry and commerce, it may not accurately reflect public opinion either on the principle or the method of decimalization. General approval and understanding on the part of the public would be essential, and the report is intended in the first place to stimulate such informed discussion. The Committees believe, however, that the time has come for a decision to be made in principle on this question, and this decision can only be made by the Government. They recommend that the Government should aim at taking an early decision in principle for or against the adoption of a decimal coinage; but that before taking such a decision further inquiries should be made, including a sounding of public opinion and efforts to inform the public on the issues involved. The Committees find that a minimum of three years notice would be required to make essential preparations for the adoption of decimal coinage, and this period of notice should provide ample time to familiarize the public with the new system.

Even more emphatically, so far as weights and measures are concerned, gradualness is the keynote of the Committees' recommendations, although they do not recommend compulsory adoption of the metric system by the United Kingdom at the present time. The metric system is already legal for most purposes in the United Kingdom, and it would be possible for adoption to proceed piecemeal on a voluntary basis. For the purpose of the inquiry the view was taken that 'adoption' of the metric system by the United Kingdom meant a general adoption over a limited term of years, at the end of which the metric system would become the generally accepted system, and the Imperial system would fall into disuse.

The Committees found that little use is made to-day of the metric system in the United Kingdom except for scientific and laboratory purposes and in a few specialist fields, particularly the pharmaceutical and optical industries and scientific instruments. There is little sign here of any significant trend towards increased use, except in manufacture for, or packing for, export to metric countries, and there is no strong feeling in industry or commerce that Britain is being adversely affected either internally or in exports to metric countries by the retention of the Imperial system. Conversely, the same appears to be broadly true of manufacturers in metric countries in their efforts to sell in non-metric countries. The Committees agreed that the question of units of weights and measures is of minor importance compared with many other factors influencing the flow of international trade. There is a majority opinion that the United Kingdom should keep in line with the Commonwealth and the United States.

Although there is general agreement on the desirability of increasing standardization, there is some divergence of opinion as to how this should be achieved. At present, there still appears to be an inadequate body of agreed international standards as between the various metric countries, and certain sections of the engineering industry hold that the United Kingdom would be ill-advised to abandon such standardization as already exists in the non-metric world. Moreover, non-metric usage exists in a few industries on a world-wide basis, for example, in the oil industry, shipping, and to a high degree in aircraft manufacture and air navigation.

Generally, it is clear that transitional costs would be very heavy in some spheres, particularly engineering, but the financial benefits are difficult to assess. Should the United Kingdom decide to adopt the metric system, at least ten and sometimes 20–30 years would be required for the complete change-over, and the longer the period of change-over the lower the total transitional costs. Educational benefits are real, but are not easily measurable in terms of money. The Committees stress the existence of a general feeling that the metric system will in course of time become more widely used in the rest of the world and the United Kingdom. They recommend, therefore, a regular two-yearly review by the Board of Trade in consultation with industry and commerce, and in conjunction with corresponding bodies in the Commonwealth and the United States, and paying particular attention to trends in Japan and India and the under-developed countries of Asia and Africa. These reviews should indicate what stimulus might be given to more rapid change-over to the metric system in the United Kingdom and in what sections of industry and commerce metric usage could be introduced with most benefits and the least transitional dislocations. It is suggested that there may be a case for the British Standards Institution publishing further metric standards to facilitate manufacture in metric dimensions for export.

---

* Decimal Coinage and the Metric System: Should Britain Change? (A joint report of Committees appointed by the British Association for the Advancement of Science and the Association of British Chambers of Commerce.) Pp. xi+107. (London: Butterworths Scientific Publications, 1960.) 7s. 6d.

The Committees agree that there is real advantage to be gained now by increased rationalization of the Imperial system, and they recommend that this should be further studied. This is a specialist matter for each industry; but they suggest that all Government departments and nationalized industries could examine the practicability of eliminating intermediate units of weight between the ton and the pound avoirdupois; alternatively, use of the cental (100 lb.) should be encouraged in place of the hundredweight, and there should be a short ton of 2,000 lb. in place of the long ton of 2,240 lb. They also recommend that the apothecaries' troy and pennyweight systems be removed from school curricula, and that the rod, pole or perch of 5½ yards and the corresponding square measure of 30¼ square yards be officially abolished, and that use of the decimalized inch in place of fractions be increased. Finally, under educational aspects, they recommend that even if no action be taken on decimal coinage or the metric system, much greater emphasis should be placed forthwith on the teaching and use of decimals and the metric system in the educational curriculum of Britain from the earliest stages. This would not only promote 'decimal thinking' at an earlier age than at present, but would also be of value to entrants into industry and commerce, where the practical use of decimals is increasing.

Appendixes to the report present extracts from evidence received on decimal coinage and the metric system, and group the countries of the world according to their adoption or not of the metric system.

SELECTION OF EXECUTIVES

DURING the years immediately after the Second World War, it was the fashion for amateur and professional psychologists to see 'significance' in a great variety of phenomena, from handwriting to the choice of a wife, from remarks made during a group discussion to readiness to become angry at an interview, from imagined shapes seen in an ink-blot to the design created with a set of mosaics. That any one of these actions can be significant of itself was an assumption which has invalidated much of the psychology of personality testing during the past ten years, and such is the subject of a recent article in the *European Productivity Agency Bulletin* (No. 34; February 1960).

The recent trend has been a healthy one. Amateur psychologists are not so respected in their assessment of significant revelations. Professional psychologists have considerably limited their claims and disciplined their methods, thereby increasing their effectiveness. But much indisciplined personality testing still goes on. Recently, a works manager was appointed solely on the judgment of the managing director's wife's interpretation of the applicant's handwritten signature to a typewritten letter. A brilliant technologist was rejected in favour of a less-qualified man because he did not take a lead in a discussion with other candidates during a specially organized hotel dinner. A psychiatrist employed by a large organization in London interviews candidates for the higher staff grades and deliberately sets out to anger them, judging from the time it takes them to lose their tempers whether or not they have initiative.

Warren Lamb suggests that it is an imposition to subject a candidate to having his individual actions judged as to their significance and what they reveal without being able to defend himself. The existence of significance testing is due to two fallacies underlying the most scrupulous application of pure psychological research within industry and commerce: (*a*) that a test situation can be so devised that the candidate's response will be identical with what it would be on other occasions; (*b*) that a quality once measured (for example, dominance, perseverance) will apply in all conditions.

Validating procedures have so narrowed down the aims under (*a*) that the results of properly validated present-day performance tests are so prescribed as to make only a minor contribution to industrial selection and appraisal. The simplest of casual observation will dispose of (*b*). One would not have to search far to find the dominant business man and the submissive husband. A recent survey of top-ranking business executives in England revealed that the greatest common characteristic was extreme shyness.

Is it possible to have any form of personality testing which does not depend upon attributing significance to any one action or response? One method has been devised based on an analysis of constant elements in a person's movements.

No two people move in exactly the same way; in habitual adjustments of posture, gestures, handling of objects, a way of walking and so on, there are distinct individual differences. It has been found that everyone has certain movement co-ordinations which are constant to all his activities. That is to say, there are certain elements in the total movement which remain constant whatever the person's behaviour or emotion. For example, these elements will remain constant during an occasion when the person is sitting relaxed enjoying a casual conversation, and on another occasion when he is giving a demonstrative, angry, fiery political speech. Sets of observations taken on each occasion, and analysed separately, produce an identical result.

A person's movements are different on varying occasions. It is only part of his movement—a part even of each action—which remains constant. The full range of the constant elements will never be present in any one action. A large number of observations are needed, based on a statistical sampling method in order to have sufficient data to analyse. It has proved practicable to obtain this data in the course of a normal business interview.

The development of this work needed a more penetrating investigation into the details of a movement than has usually been the case with other investigations. The present methods have been made possible by the work of Rudolph Laban. The codification of the elements of movement upon which Laban established his notation has made it possible to record the process of variation of at least seven different movement components occurring simultaneously in the course of one action.

Movement analysis reveals those capabilities which can be expressed spontaneously. A person who can present himself or exercise authority spontaneously would not have to depend upon 'props' such as the correct dress or a conferred status. A distinction can be made between those whose authority is fixed, dependent upon a static set of circumstances, and who would have little range of the relevant movement variation, and those whose authority is spontaneous and adaptable, and who would have a good range of variation.

If a person is asked to perform a number of actions unassociated with any particular purpose and built up from within his range of constant elements, he enjoys the movement. If he is asked to perform actions built up from outside the range, he invariably feels awkward and unco-ordinated. Many experiments with people of many different vocations have shown this to be true. The range of constant elements is the range within which a person 'feels right'.

That there is a relationship between mental functioning and physical movement is implied in the development of psychosomatic medicine during the course of the present century.

The application of this work within industry has been on the basis that if a person is able to work within a set of conditions by meeting the needs from within his range of constant elements (that is to say, the range within which he 'feels right'), then he has aptitude for that set of conditions. This gives a precise definition to what is meant by 'aptitude', a word which is often used loosely as a synonym for ability, potentiality, capacity or even intelligence.

In order to make an 'aptitude assessment', it is necessary to specify the particular set of conditions, and this is done according to current techniques of job evaluation, differentiating between those aspects of the job which can be satisfied through purely technical competence and those aspects which can be met effectively only through the appropriate aptitude. It is obvious, but often little considered, that a man of a certain technical competence may be able to apply his skill effectively in one set of conditions and ineffectively in another. The aptitude assessment which derives from the analysis of constant elements in movement is a measure of a person's readiness to apply his technical skills or knowledge within a specified set of conditions.

Whereas much investigation of the 'significant response' type seeks to classify phenomena, reduces differences and generalizes, the methods of aptitude assessment based on movement observation follow a contrasting procedure. There is no classification of phenomena, differences are magnified, both within the individual and the conditions, and the resultant assessment is a particular yardstick, applying only within specified conditions. The procedure brings forward the exceptional, distinctive 'man of the moment', as against the average, conformist 'type for the job'.

The procedure is not itself exceptional and is akin to existing practices. An appreciation of the techniques is easily gained during practical study. A number of intensive two-week courses have successfully been given to executives wishing to incorporate the techniques within their own company practices.

T. H. HAWKINS

SCOPE FOR EXPANDING PULP AND BOARD INDUSTRIES IN BRITAIN

THE conclusions and recommendations of two reports prepared by Sandwell and Co., Ltd., on pulp and board mills in Great Britain (see *Nature*, March 26, p. 894) were used as the basis of a discussion organized by the Society of Foresters of Great Britain and held during November of last year. This Society is concerned with "the knowledge of technical forestry in all its aspects" and it was fitting that on this, the first, of its ventures into special discussion meetings it decided to examine the implications of the Sandwell reports. The proceedings of this meeting have now been published as a supplement to the Society's journal, *Forestry*, which is available to non-members*. The programme was designed to give a balanced picture of the problems involved in development and the individual views of industrialists, technologists, and competitors for the wooden raw material. The growers' point of view was discussed under forest management considerations and the whole idea was subjected to the economist's evaluation, and a careful summing up.

As the Society of Foresters of Great Britain included few industrialists in its membership, invitations were sent to leading personalities in the industries concerned. Dr. T. H. Frankel, of Sudbrook Pulp Mill, Ltd., a subsidiary of Wiggins Teape and Co., Ltd., said that in his view the Sandwell reports implied that the smaller the mill the less efficient it would be. In exploring the possibility of setting up a pulp mill in the Scottish Highlands, he stressed the unlikelihood of a newsprint mill being sited in Britain. He examined some of the technical and economic problems of the industry and urged that the criterion for growers of timber should be to produce the maximum bone-dry weight, bark free, per acre per annum. The development of the chipboard industry was reviewed by Mr. F. O. Lynam, of Airscrew Co. and Jigwood Ltd., who criticized the Sandwell Board Mill Survey because it did not do justice to the possibilities of development. Its most important conclusion, he believes, is that even in a large plant the economic price would have to be about £11–£12 per ton of bone-dry wood. Mr. B. J. Rendle, of the Forest Products Research Laboratory, and Dr. L. Chalk, of the Department of Forestry, University of Oxford, explained the anatomical criteria for industrial use and the problem of 'juvenile' wood, respectively. If it were known what the pulp mills would like to have, this could be taken into account in plans for improving trees by selection and breeding and by forest management. The problem of 'juvenile wood' is often over-simplified, especially by the assumption that it is a matter of age.

---

* The Development of Pulp and Particle Board Industries and Their Effect on Forest Management. Pp. 68. (Oxford University Press, 1960.) 5s.

The requirements for the coal mining industry were reviewed by Mr. B. C. Hollingsworth, of the National Coal Board, who explained that the Board has followed a policy of purchasing home-grown timber, of which it has greatly increased its consumption since 1947 and still has room for increased softwood demand. Rising production from thinnings may well meet the needs of the pulp and of the coal industries, and the arrival of a new market for the raw material would solve problems and confer benefits on all consumers as well as on producers. The prospects of greater demand from the furniture industry were explored by Mr. J. P. Pritchard, of the Furniture Development Council. In his opinion there are several ways in which growers and chipboard manufacturers could help to raise the demand for their products. The industry was progressive and expanding, like the size of the firm, thus making possible greater expenditure on design and development. As a consultant in wood technology, Dr. S. E. Wilson, who is well placed to examine the needs for housing and packing, declared that the principal aim of domestic forests in Britain has been, and still was, to supplant the imported deals, battens and boards used mainly in the building and packaging trades.

The Forestry Commission's director of forestry for England, Mr. G. B. Ryle, questioned the view that in Britain we should be justified in running our forests primarily for the pulp and board industries. Forest management, he said, implied three things in this context: the right trees for the industry; the optimum rate of growth and right specifications and operational efficiency.

The evaluation of the economists was provided by Mr. G. W. Troup, of Albert E. Reed and Co., Ltd. He said that he could not give the final answers on the prospects for small-scale pulping in Britain—about which the Sandwell reports had been rather discouraging—but he did suggest some of the questions which remained for investigation, for example, on such matters as roundwood yields and price and costs trends. One of the interesting points emphasized in the economics discussion was that the 'Outer Seven' proposals have no bearing on pulp mills, although they will affect board mills because the existing tariff protection will be gradually reduced over, at the most, ten years. This will almost certainly lead to greater integration in the pulp and paper and board industries, for example, in the Scandinavian countries, and thus add to the competitive power of imported supplies.

Many searching questions and observations were a feature of the seven discussions which followed the main papers, and many leading authorities among the members and guests of the Society of Foresters were asked to open the discussions in a formal and thorough fashion. It was held by Mr. K. N. Rankin, of the Economic Forestry Group, when he summed up what had emerged from the meeting, that there is a clear need for all to see themselves as one industry—growers, saw-millers, and processors. There is need for over-all planning as one industry and for the utmost efficiency in all sectors in order to be competitive by world standards. The objects of the planning should be 100 per cent utilization of forest products and the highest return on the capital employed in the industry. With these objectives in mind, Mr. Rankin went on to suggest what kind of pattern production should follow. Pulp and paper demand is rising at 7 per cent per annum and if supplies cannot keep pace there is a fair prospect of rising prices. The directions in which growers could more satisfactorily produce what is wanted was also reviewed in some detail. Mr. Rankin ended with the challenging questions: Why should we not export more timber products and why should we not have vertical as well as horizontal integration in the industry?

J. J. MacGregor

ATOMIC ENERGY RESEARCH IN DENMARK

The third annual report of the Danish Atomic Energy Commission describes the activities of the organization during the period April 1, 1958–March 31, 1959 (pp. 85. Copenhagen: Danish Atomic Energy Commission, 1959). It deals with the erection of the Risø Research Establishment; the reactors *DR*1, *DR*2 and *DR*3; the work of the six departments of the Establishment; international co-operation in the peaceful uses of atomic energy through the International Atomic Energy Agency, the Organization for European Economic Co-operation and the European Atomic Energy Society; and includes the texts of the addresses delivered by Mr. Viggo Kampmann, Minister for Finance, and by Prof. Neils Bohr, the president of the Commission, at the inauguration of the Establishment on June 6, 1958.

During the period under review the Commission met seven times and its executive committee thirty-three times. Prof. Neils Bohr continued as chairman of the Commission, with Dr. H. P. Christensen as vice-chairman, and H. H. Koch as chairman of the executive committee. The total staff on March 31, 1959, numbered 385, of which 214 were employed in the technical and scientific division and distributed over the six departments. The secretariat, headed by the chief of Commission secretariat, had a staff of twenty-six, including three law and one economics graduates. The office of the Commission was at the Christiansborg Palace, but the secretariat had a subsidiary office at Risø.

The physics department of the Establishment consists of the physics laboratory, the meteorology station and the reactor *DR*1. During the year a cooling system for the reactor was installed, and the power brought up to 1,100 W. Various technical measurements were carried out on the reactor, and training procedures and instructions for courses were revised and improved. The solid-state group continued work on instruments for the study of radiation damage to metals and graphite, and other groups were occupied with planning a new laboratory and its equipment in connexion with the linear accelerator ordered from the United States and with the assessment of the energy and particle balance in a very hot hydrogen plasma.

In the electronics department an analogue computer, the equipment for a 'gas-flow' proportional counter for use at the waste-water treatment plant at Risø, and a fluorimeter for the measurement of uranium content in samples with concentrations of about 10^{-9}, in addition to a number of special pieces of apparatus, have been constructed. The work of the reactor engineering department was largely concentrated on the study project for the heavy-water-moderated power reactor with an organic cooling medium to be known as *DOR*. The department has been concerned also with constructional and safety problems related to reactor-powered ships.

In addition to its direct educational and training activities in technical and scientific subjects, the report states that the Commission tries to satisfy general public interest in nuclear energy and in the Research Establishment by publications, radio and television broadcasts and exhibitions. A documentary film about Risø is being prepared. Visits to the Establishment are limited to Saturdays, and during January 1–March 31, 1959, about 1,200 persons visited Risø.

The report concludes with a list of the publications by members of the staff of the Commission, and with a detailed map of the layout at the Research Establishment.

AGE OF THE BASE OF THE CAMBRIAN

IN a recent publication[1], Prof. Arthur Holmes has proposed a revision of his 1947 time-scale. This revision was necessitated by the wealth of new age measurements made since 1947, and it is a tribute to Prof. Holmes's insight that his first time-scale, proposed in 1911 when the science of geochronology was in its infancy, has required only relatively minor revisions since that time. In view of Prof. Holmes's past successes in drawing correct conclusions from fragmentary data, it might seem unwise to question his present conclusions regarding the age of the base of the Cambrian system. Furthermore, it is true that imaginative speculation frequently proves more fruitful than sterile scepticism. Nevertheless, in this case, I feel that a critical discussion of the grounds for fixing the age of the base of the Cambrian is in order in the hope that workers may recognize that a problem exists. Otherwise the figure 600 ± 20 million years may prematurely find its way into texts and into the minds of Earth scientists as an established fact of geology.

At the outset, it must be realized that the concept of the base of Cambrian is different from that of the base of the other periods. The base of the Devonian, for example, is defined by the disappearance of characteristic Devonian fossils as one moves down the column and by the appearance of Silurian fossils. In contrast to this, the base of the Cambrian is either defined locally as an unconformity beneath strata containing Cambrian fossils or by the failure to discover lower Cambrian fossils in lower strata. In the first case, there is no reason at all for the local unconformity to have world-wide time significance, and in the latter case, the evidence is of necessity purely negative; the apparent absence of a Cambrian fauna may be due to causes other than age. For purposes of discussion, it is more useful to fix some definable horizon within the Cambrian, for example, the base of the Middle Cambrian and at least for some purposes mentally lump the Lower Cambrian with the Precambrian. This point of view does not significantly alter the discussion of the evidence cited by Holmes; it merely sharpens the definitions employed. This approach relegates to future research such difficult questions as the time of the first appearance of *Olenellus* and its simultaneity in various regions of the Earth. It will be shown that the data used by Holmes do not yield a firm upper limit to the age of the base of even the Middle Cambrian, and it therefore follows that they do not permit an upper limit to the age of any part of the Lower Cambrian, however it may be defined. (In order to avoid any ambiguity it should be pointed out the expression 'an upper limit to the age' is used to mean that the age is less than a certain number of years. In this expression the word 'upper' is therefore used in a numerical, not a stratigraphical, sense.)

The principal data used by Holmes in placing an upper limit to the age of the base of the Cambrian are those of Kulp (reported by Campana[2]) and Greenhalgh and Jeffery[3] for absite from pegmatites overlain by the Precambrian Adelaide System in South Australia. Since the Adelaide System lies below recognized Lower Cambrian strata, it is clearly pre-Middle Cambrian.

These authors report ages in million years as follows:

	^{206}Pb/^{238}U	^{207}Pb/^{235}U	^{207}Pb/^{206}Pb	^{208}Pb/^{232}Th
J. L. Kulp	520	600	915	585
Greenhalgh and Jeffery	610	674	895	675

Following Greenhalgh and Jeffery, Holmes interprets these data as a "typical loss of radon pattern", and in accordance with this a probable age of 674 million years is assigned to the sample analysed by Greenhalgh and Jeffery, with 915 million years considered an improbably high upper limit. However, it should be pointed out that there is no age pattern for a single mineral which is diagnostic of loss of radon. There are two independent uranium–lead ages, that calculated from the ratio lead-206/uranium-238 and that calculated from the ratio lead-207/uranium-235. In the data under consideration, the former age is younger than the latter, and this pattern can arise equally well from any of several mechanisms, namely, preferential loss of lead relative to uranium, additions of uranium, gain of radiogenic lead of some isotopic compositions, or preferential loss of an intermediate daughter product of the uranium-238 series, for example, radon. By simply examining the pattern of discordant ages one can never distinguish between these possibilities. The relative importance of the different possible causes of discordance must be evaluated by independent methods. I am not aware of any experimental data for absite, but measurement of the radon-loss from minerals possessing reasonably well-defined crystal structures has shown such loss to be of minor importance[4,5]. In contrast to this, there is abundant evidence from intercomparison of uranium–lead ages with ages measured by other methods that loss of radiogenic lead or, equivalently, gain of uranium, is a common cause of discordance in uranium–lead ages. If this more common process is responsible for the discordant data on the sample in question, the limit of 915 million years is a lower limit to the age rather than an improbably high upper limit. The lead-208/thorium-232 age contributes little to the argument since for unknown reasons these ages are almost always badly discordant.

Greenhalgh and Jeffery also report a potassium–argon age of 520 million years on a sample of biotite from the same rock. Even if one postulates loss of radon as the cause of discordance, this result cannot be reconciled in any simple way with the absite data. Taken altogether, the absite and biotite data indicate that for some reason the minerals in question have been open with respect to either the parent or daughter elements, or both, since the time of their original crystallization and their apparent ages are scarcely suitable for fixing a critical point in the geological column.

Some further data bearing on this matter are the results of measurements of Tilton *et al.*[6] on igneous rocks in the Wichita Mountains of Oklahoma. As pointed out by Holmes, the result of 500–550 million years places at best a limit on the age of a portion of the Upper Cambrian, since there are no Middle or Lower Cambrian strata in the region. It should be further noted that the granitic samples which have been dated are not seen in actual contact with the Cambrian strata and the inference that they are pre-Upper Cambrian is based on the assumption that they are the same age as the neighbouring Carlton rhyolite which is actually overlain by Reagan sandstone of Upper Cambrian age, or on the correlation of these rocks with pre-Reagan granites found in sub-surface drillings.

The remaining evidence cited by Holmes is that based on analysis of uraninite from Katanga, Belgian Congo. The results of age measurements of these samples are reasonably concordant and indicate an age of about 625 million years for the uranium mineralization. As quoted by Holmes, L. Cahen states that the uranium mineralization is later than the Kundelungu formation, which is assigned to the Precambrian by the absence of Cambrian fauna and by the presence of 'Late Precambrian' fossils. Cahen further concludes, as is necessary for the argument, that we can dismiss the idea that the Kundelungu sediments are much older than the uraninites. While this is the best evidence given by Holmes for saying that the age of the base of the Middle Cambrian is less than 600 million years old, the evidence is obviously not clear-cut, in view of the dubious status of Precambrian palæontology and the uncertainty in the inference that the uranium mineralization does not greatly post-date the Kundelungu sedimentary rocks. It would be of considerable interest if Dr. Cahen would discuss critically the reasons for his opinions quoted above and by Holmes.

These remarks have been made with the hope of acquainting workers both in the field of geochronology and stratigraphy with this unsolved problem. A start might be made by demonstrating unequivocally that the base of the Middle Cambrian is less than 1,000 million years old. Rocks of this age are found in many parts of the world, but I do not know of any localities where the relationship of dated rocks of this age to the Cambrian is clearly established. If the possibility that rocks of Grenville age (1,000 million years) and their age equivalents in other regions are Upper or Middle Cambrian can be definitely excluded in this way, then one may go to the rarer areas of rocks in the 600–900 million years age-range in order to see if more strict limits can be obtained.

G. W. WETHERILL

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington 15, D.C.

[1] Holmes, A., *Proc. Edin. Geol. Soc.*, 17, 183 (1959).

[2] Campana, B., *Austral. J. Sci.*, 16, 240 (1954).

[3] Greenhalgh, D., and Jeffery, P. M., *Geochim. et Cosmochim. Acta*, 16, 39 (1959).

[4] Giletti, B. J., and Kulp, J. L., *Amer. Mineralogist*, 40, 481 (1955).

[5] Starik, I. E., *Geokhimiya*, No. 5, 18 (1956).

[6] Tilton, G. R., Davis, G. L., Wetherill, G. W., and Aldrich, L. T., *Trans. Amer. Geophys. Union*, 38, 360 (1957).

WHILE in principle I am in general agreement with Dr. Wetherill, I feel that he over-rates some of the difficulties to which he refers and exaggerates their geochronological consequences.

The "base of the Cambrian" is not a natural phenomenon that can be discovered and objectively investigated. It is a mental concept, entirely dependent on definition and, until agreement is reached, subject to argument and dispute. Geologists are still actively discussing whether the criteria for defining it should be: (*a*) palæontological, for example, the first appearance of the earliest trilobites or of other fossils elsewhere associated with them; (*b*) stratigraphical, for example, the first deposits of the corresponding marine transgression; (*c*) palæoclimatological, for example, tillites and other evidence of the glaciations commonly regarded as having occurred towards the close of the pre-Cambrian; or (*d*) geochronological, a hope for the future which may eventually command widespread assent[1]. Meanwhile, most geologists consider (*b*) and (*c*) to be inappropriate because the events concerned are likely to have varied from place to place much more widely in time than the appearance of the earliest Cambrian fauna. Adopting the "lowest formation in which the biozone of *Olenellus* or its equivalent is represented" as the base of the Cambrian, I found 600 ± 20 million years to be "a reasonable estimate" for the beginning of the Cambrian Period in the light of the evidence then available[2]. Surely this is neither "imaginative speculation" nor "fixing the age". I see no reason why any geologist, however naïve, should suppose the figure provisionally adopted to be "an established fact". However, referring to "Earth scientists", Dr. Wetherill thinks otherwise, and in so far as there are now many Earth scientists who are not geologists he may be right. If so, his warning to them will serve a very useful purpose.

With regard to the age pattern for the South Australian absite (Greenhalgh and Jeffery's data) it is true, as Dr. Wetherill points out, that it could arise from a variety of different mechanisms, among which he seems to favour loss of lead and/or gain of uranium. In this case, 895 million years would approximate to the real age, leaving the lead-208/thorium-232 age to be regarded as wrong. In contrast, I was impressed by the equality of the lead-208/thorium-232 and lead-207/uranium-235 ages (675 and 674 million years, respectively), particularly because this coincidence means that all four 'ages' can be brought into concordance by the single assumption of loss of radon. Greenhalgh and Jeffery[3] say: "One might expect some radon loss in a mineral such as this abaite which has been situated in a porous shear zone since its formation in Upper Proterozoic times". If this be the correct interpretation, loss of argon from biotite would be expected to be even greater. The argon-40/potassium-40 age of 520 million years found by Greenhalgh and Jeffery for biotite from the same rock is readily accounted for by loss of argon and is therefore not so irreconcilable with the abaite data as Dr. Wetherill supposes.

However, this disagreement over the interpretation of inconclusive data is of minor significance in the light of the age determinations of Lower Cambrian and Late Precambrian glauconites summarized on p. 195 of my paper[2]. Working at the Massachusetts Institute of Technology, Cormier obtained a rubidium/strontium age of 584 ± 30 million years for glauconite from a sandstone in the Murray Shale formation of Blount Co., Tennessee. It is notable that the first diagnostic Lower Cambrian fossils appear in shales 500 ft. higher up in the section. This result agrees closely with the argon-40/potassium-40 ages of Lower Cambrian glauconites which have been dated by Russian workers.[1] One particularly valuable set of results refers to drill-cores from the Serdobskaya Borehole R-2, which passes through flat-lying Lower Cambrian strata and penetrates well into the Late Precambrian formations of the Upper Sinian, which are also flat-lying. Here, in the central part of the Russian Platform, which has long remained undisturbed by igneous or tectonic activities other than gentle vertical movements, only a slight disconformity separates the Cambrian from the Sinian. There could scarcely be a better environment for the retention of radiogenic argon. The age determinations, summarized in Table 1, have been recently revised by Polevaya, Kazakov and Murina[4], using $\lambda_e = 0 \cdot 557 \times 10^{-10}$ yr.$^{-1}$ and $\lambda_\beta = 4 \cdot 72 \times 10^{-10}$ yr.$^{-1}$ for the age calculations. In the last column the ages are re-calculated with $\lambda_e = 0 \cdot 585 \times 10^{-10}$ yr.$^{-1}$ to correspond with current American and British practice.

Table 1

	Depth from surface	$\frac{^{40}Ar}{^{40}K}$	Ages in m.y. (± c. 10%) P., K. and M.[4]	Ages in m.y. (± c. 10%) Re-calculated
Lower Cambrian	1,380 m.	0·0398	606	566
Disconformity	1,630			
Upper Sinian	1,758	0 0499	734	692
	1,787	0·0499 0 0515	732 753 } 743	692 710 } 701

Dating of these specimens by the rubidium/strontium method is in progress and it may reasonably be hoped that Dr. Wetherill's doubts will be resolved during the next two or three years. Perhaps even better evidence may be forthcoming from the dating of Lower Cambrian and Late Precambrian lavas. Here a start has already been made, stimulated by the International Geochronological Conference organized by the New York Academy of Sciences in March, and likely to be still further advanced as a result of the discussions of the Cambrian/Precambrian problem which are scheduled for the forthcoming meetings at Copenhagen of the International Geological Congress.

ARTHUR HOLMES

Grant Institute of Geology,
University of Edinburgh.

---

[1] "Les Relations entre Précambrien et Cambrien" (Colloques internationaux 76, Centre National de la Recherche Scientifique, Paris, 1958).

[2] Holmes, A., *Trans. Edin. Geol. Soc.*, 17, 183 (1959).

[3] Greenhalgh, D., and Jeffery, P. M., *Geochim. et Cosmochim. Acta*, 16, 45 (1959).

[4] Polevaya, N. I., Kazakov, G. A., and Murina, G. A., *Geochemistry* (Russian with English summary), No. 1, 1 (1960).

NUCLEAR FISSION IN THE EARLY HISTORY OF THE EARTH

By PROF. P. K. KURODA

Department of Chemistry, University of Arkansas, Fayetteville, Arkansas

IT has long been speculated that at least part of the heavier isotopes of xenon in the Earth's atmosphere are fissiogenic[1–3]; but it was not possible to treat this problem on a quantitative basis until Reynolds[4] showed that the abundance ratio of the stable xenon isotopes in the Richardton meteorite was different from that in the Earth's atmosphere[5].

The difference indicates that at least 10 per cent of the atmospheric xenon-136 is fissiogenic. This is much greater than that expected from the uranium-238 spontaneous fission alone, but can be explained as due to the spontaneous fission of some of the extinct trans-uranium elements and/or the induced fission of uranium-235 in the early history of the Earth. The contribution from the natural fission processes is estimated to be at least 10^4 times that from the recent artificial nuclear explosions.

Differences in the isotopic rations of xenon in the Earth's atmosphere and in the meteorite may be written as:

$$\delta_i = \left(\frac{Xe^i}{Xe^{130}}\right)_T - \left(\frac{Xe^i}{Xe^{130}}\right)_M \qquad (1)$$

where Xe^{130} is used as a reference standard for the following reasons: (*a*) the abundance of this nuclide is fairly large, and hence the errors in the mass-spectrometric measurements are expected to be small; (*b*) it is shielded by tellurium-130 (the half-life for the double β-decay of tellurium-130 was estimated by Inghram and Reynolds[4] to be $1 \cdot 4 \times 10^{21}$ years), and the amount produced by fission can be regarded as negligible; (*c*) possibility of the production of this nuclide by other nuclear reactions appears to be comparatively small[6].

Table 1. COMPARISON OF THE ISOTOPIC COMPOSITIONS OF XENON IN THE ATMOSPHERE AND IN THE RICHARDTON METEORITE

Mass No. (i)	Atmosphere $(Xe/Xe^{130})_T$	Meteorite $(Xe^i/Xe^{130})_M$	δ_i	Δ_i
124	0·024 ± 0·000	0·035 ± 0·004	−0·011 (±0·004)	−0·0005
126	0·022 ± 0·000	0·029 ± 0·004	−0·007 (±0·002)	−0·0003
128	0·470 ± 0·003	0·528 ± 0·082	−0·058 (±0·085)	−0·0002
129	6·47 ± 0·06	9·18 ± 0·29	−2·71 (±0·35)	−0·02
130	1·000 ± 0·000	1·000 ± 0·000	0·000	0·000
131	5·18 ± 0·05	5·05 ± 0·17	+0·13 (±0·22)	+0·01
132	6·58 ± 0·05	6·15 ± 0·16	+0·43 (±0·21)	+0·03
134	2·56 ± 0·01	2·40 ± 0·06	+0·16 (±0·07)	+0·02
136	2·17 ± 0·01	1·98 ± 0·03	+0·19 (±0·04)	+0·03

The values of δ_i calculated from the data by Reynolds[4] and Nier[5] are shown in Table 1.

The large negative value of δ_i for xenon-129 is due to the decay:

$$I^{129} \xrightarrow{1{\cdot}7 \times 10^{7}\ \text{yr.}} Xe^{129}$$

as pointed out by Reynolds[4]. The small negative values of δ_i for the lighter isotopes are probably due to mass fractionation or cosmic-ray-induced nuclear reactions.

Suess[7] derived the following equation which correlates the ratio of the terrestrial abundance ($N_{\text{ter.}}$) and the cosmic abundance ($N_{\text{sol.}}$) of the rare gases with the mass (M/m_1):

$$-\log \frac{N_{\text{ter.}}}{N_{\text{sol.}}} = 10 \cdot e^{-0{\cdot}045 M/m_1} + 7{\cdot}1 \qquad (2)$$

Differences (Δ_i) in the isotopic ratios of xenon in the Earth's atmosphere and the cosmic abundance ratios $(Xe^i/Xe^{130})_C$:

$$\Delta_i = \left(\frac{Xe^i}{Xe^{130}}\right)_T - \left(\frac{Xe^i}{Xe^{130}}\right)_C \qquad (3)$$

can be calculated from equation (2).

The values of Δ_i thus calculated are shown in column 5 of Table 1.

It is interesting to note in Table 1 that the values of δ_i and Δ_i vary in the same direction; but the absolute value of δ_i is always much greater than that of Δ_i, suggesting that the effect of the mass fractionation is probably small.

A maximum contribution from the uranium-238 spontaneous fission can be calculated from the terrestrial abundance ratio of uranium to xenon. The number of atoms of Xe^i produced by the uranium-238 spontaneous fission is:

$$(Xe^i)_f = \frac{\lambda_f}{\lambda_\alpha + \lambda_f} (U^{238}) [\exp\{(\lambda_\alpha + \lambda_f)T\} - 1] \,.\, Y_i \qquad (4)$$

where λ_α and λ_f are the decay constants for the alpha decay and the spontaneous fission of uranium-238, respectively, (U^{238}) is the number of atoms of uranium-238 in the system, Y_i is the fission yield for Xe^i, and T is the age of the system.

From equations (1) and (4):

$$\delta_i = \left[\left\{\frac{(U^{238})}{(Xe^{130})}\right\}_T - \left\{\frac{(U^{238})}{(Xe^{130})}\right\}_M\right] \cdot \frac{\lambda_f}{\lambda_\alpha + \lambda_f} \cdot [\exp\{(\lambda_\alpha + \lambda_f)\, T\} - 1] \,.\, Y_i \qquad (5)$$

Damon and Kulp[8] found that the present rate of escape of helium-4 and argon-40 from the Earth's crust is far too small to account for the quantity of argon-40 in the atmosphere, and concluded that most of the argon-40 was introduced into the atmosphere in the first billion years of Earth history from the mantle and crust. The positive values of δ_i for the heavier isotopes of xenon indicate that the uranium/xenon ratio in the meteorite system is smaller than that in the terrestrial system and hence:

$$\delta_i < \left\{\frac{(U^{238})}{(Xe^{130})}\right\}_T \cdot \frac{\lambda_f}{\lambda_\alpha + \lambda_f} [\exp\{(\lambda_\alpha + \lambda_f)(4{\cdot}5 \times 10^{9})\} - \exp\{(\lambda_\alpha + \lambda_f)(3{\cdot}5 \times 10^{9})\}] \,.\, Y_i \qquad (6)$$

From the total amount of uranium in the crust and in the mantle (1·3 p.p.m. uranium in the crust and 0·01 p.p.m. uranium in the mantle; mass of crust = 23·7 × 10^{24} gm.; mass of mantle = 4,060 × 10^{24} gm.) and the number of atoms of xenon in the atmosphere = 8·14 × 10^{36}, given by Damon and Kulp, we have from equation (6), $\delta_i < 0{\cdot}004$ for xenon-136. (Damon and Kulp gave a range of 0·01–0·1 p.p.m. for uranium in the mantle; but in view of the recent data obtained by Hamaguchi, Reed and Turkevich[9], which indicate that older analyses for uranium were generally too high, the lower value 0·01 p.p.m. uranium was accepted.)

The observed value of $\delta_i = 0{\cdot}19 \pm 0{\cdot}04$ for xenon-136 is much greater than the calculated maximum contribution from the uranium-238 spontaneous fission, thus indicating that the uranium-238 spontaneous fission alone could not have caused such

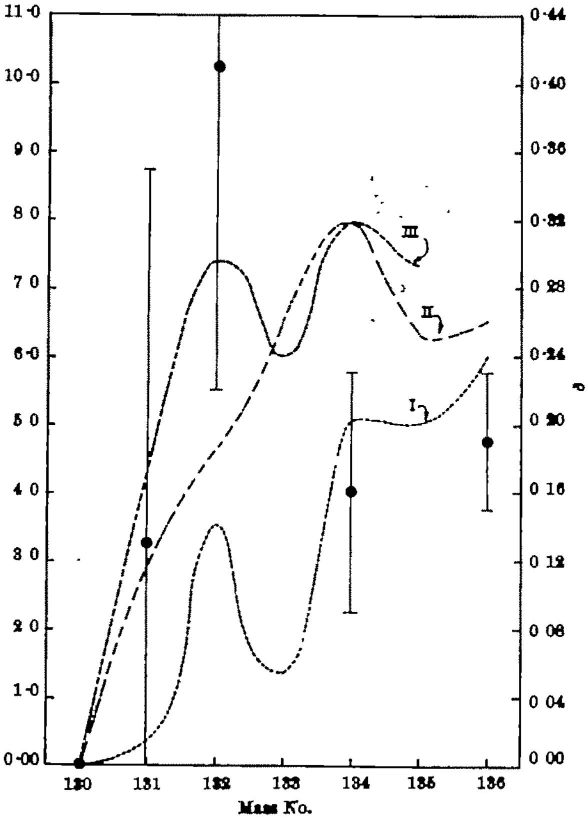


Fig. 1. Comparison of the value of δ_i with the mass-yield curves for various types of fission. I, uranium-238 spontaneous fission; II, uranium-235 neutron-induced fission; III, curium-242 spontaneous fission

The mass-yield curve for uranium-235 neutron-induced fission was taken from the report by Katcoff (ref. 18), that for curium-242 spontaneous fission was taken from the data by Steinberg and Glendenin (ref. 19), and that for uranium-238 spontaneous fission was constructed from the xenon data by Wetherill (ref. 13) and from the iodine data by Kuroda, Edwards and Ashizawa (ref. 10) and Ashizawa and Kuroda (ref. 11) a large difference in the xenon-136/xenon-130 ratio between that in the atmosphere and in the meteorite.

The values of δ_f are plotted in Fig. 1, together with the mass-yield curves for the spontaneous fission of uranium-238 and curium-242, and also for the neutron-induced fission of uranium-235.

The mass-yield curve thus obtained from the values of δ_f differs from that for the uranium-238 spontaneous fission in that the fission yield at mass 132 seems to be abnormally high. The presence of a peak at mass number 132 in the mass-yield curve for uranium-238 spontaneous fission was found by Kuroda *et al.*[10],[11]. It is interesting to note a similar peak in the curium-242 spontaneous fission mass-yield curve. This leads to a speculation that the abnormally high yield at the mass 132 might be due to the spontaneous fission of some of the extinct trans-uranium elements.

The only known trans-uranium element, which might have been present in an appreciable quantity in the early history of the Earth is plutonium-244. The half-life of plutonium-244 (8×10^7 years) is not too short as compared with the time-interval between the formation of the element and that of the Earth.

If it is assumed that plutonium-244 and uranium-238 were formed in equal abundance at the time of formation of the element, then the plutonium-244/uranium-238 ratio at the time of the formation of the Earth would have been approximately 0·05.

The ratio of the α-decay half-life and the spontaneous fission half-life of plutonium-244 is $8 \times 10^7/2{\cdot}5 \times 10^{10} = 3{\cdot}2 \times 10^{-3}$, while that of uranium-238 is $4{\cdot}5 \times 10^9/8{\cdot}0 \times 10^{15} = 5{\cdot}6 \times 10^{-7}$. Thus, the ratio of the contributions from plutonium-244 and uranium-238 is calculated to be:

$$\frac{0{\cdot}05 \times 2 \times 3{\cdot}2 \times 10^{-3}}{5{\cdot}6 \times 10^{-7}} = 570$$

or the contribution from the plutonium-244 spontaneous fission would have been several hundred times greater than that from the uranium-238 spontaneous fission.

Another important source of contribution to the atmospheric inventory of xenon is the neutron-induced fission of uranium-235. It has been pointed out by Kuroda[12] that an assemblage of uranium and water could have easily become a self-supporting chain-reacting system in the early history of the Earth. The ratio of induced fission versus spontaneous fission in some of the pitchblende ores is known to be as high as 30–50 per cent[13-15]. Kenna and Kuroda[16] have recently estimated from the radiochlorine data that the ratio in Belgian Congo pitchblende is 50 ± 5 per cent. Considering the fact that the age of the pitchblende is only about 500 million years, it is quite reasonable that the ratio in such uranium ore deposits could have been much greater than unity in the early history of the Earth.

In connexion with the contribution of uranium-235 induced fission, it is of some interest to compute the contribution from the recent nuclear bomb tests. According to Libby[17], the estimated total stratospheric injection of strontium-90 since 1952 is 66 megaton-equivalents, which correspond to an addition of about 0·5 ton of xenon-136. The total inventory of fissiogenic xenon-136 in the atmosphere is calculated to be of the order of 10^6 ton, or at least one million times greater than the contribution from nuclear bomb tests.

This work was supported by the U.S. Atomic Energy Commission. I am grateful to Prof. Edward Anders of the University of Chicago for his valuable suggestions and encouragement.

[1] Khlopin, V. G., Gerling, E. K., and Baranovskaya, N. V., *Bull. Acad. Sci. U.R.S.S., Classe Sci. Chim.*, 599 (1947).

[2] Khlopin, V. G., and Gerling, E. K., *Doklady Akad. Nauk S.S.S.R.*, 61, 297 (1948).

[3] Festa, C., and Santangelo, M., *Ann. Geofis.* (Roma), 5, 551 (1952).

[4] Reynolds, J. H., *Phys. Rev. Letters*, 4, 8 (1960).

[5] Nier, A. O., *Phys. Rev.*, 79, 450 (1950).

[6] Inghram, M. G., and Reynolds, J. H., *Phys. Rev.*, 78, 822 (1950).

[7] Suess, H. E., *J. Geol.*, 57, 600 (1949).

[8] Damon, P. E., and Kulp, J. L., *Geochim. Cosmochim. Acta*, 13, 280 (1958).

[9] Hamaguchi, H., Reed, G., and Turkevich, A., *Geochim. Cosmochim. Acta*, 12, 337 (1957).

[10] Kuroda, P. K., Edwards, R. R., and Ashizawa, F. T., *J. Chem. Phys.*, 25, 603 (1956).

[11] Ashizawa, F. T., and Kuroda, P. K., *J. Inorg. Nucl. Chem.*, 5, 12 (1957).

[12] Kuroda, P. K., *J. Chem. Phys.*, 25, 781 (1956).

[13] Wetherill, G. W., *Phys. Rev.*, 92, 907 (1953).

[14] Fleming, W. H., and Thode, H. G., *Phys. Rev.*, 92, 378 (1953).

[15] Purkayastha, B. C., and Martin, G. W., *Can. J. Chem.*, 34, 293 (1956).

[16] Kenna, B. T., and Kuroda, P. K., *J. Inorg. Nucl. Chem.* (in the press).

[17] Libby, W. F., speech delivered on March 13, 1959, at University of Washington, Seattle, Washington.

[18] Katcoff, S., *Nucleonics*, 16, 78 (1958).

[19] Steinberg, E. P., and Glendenin, L. E., *Phys. Rev.*, 95, 431 (1954).

GLUCOSAMINE VALUES OF MURAMIC ACID AND OTHER AMINO-SUGARS BY THE ELSON AND MORGAN METHOD

By R. E. STRANGE

Microbiological Research Establishment, Porton, Wiltshire

WHEN muramic acid is determined by the Elson and Morgan method as described by Rondle and Morgan[1], its glucosamine value on an equal weight basis (light absorption at 530 mμ of the coloured derivative divided by that of the derivative formed from an equal weight of glucosamine multiplied by 100) is about 30 per cent[2]. If 0·5 *N* sodium carbonate used in this method is replaced by a buffer containing equal volumes of *M* sodium carbonate and *M* sodium bicarbonate *p*H 9·6[3], other conditions being the same, a glucosamine value of about 50 per cent is obtained[4]. Crumpton[5] has pointed out that glucosamine values for mannosamine and galactosamine reported by different laboratories vary significantly, presumably due to variations in the method of estimation. In my experience such values are reproducible within the limits of error of the method, and the use of a predetermined value is not likely to introduce serious errors when conditions of analysis are kept constant. However, pure samples of certain amino-sugars are not always available and this leads to the use of independently reported figures. Errors will arise if

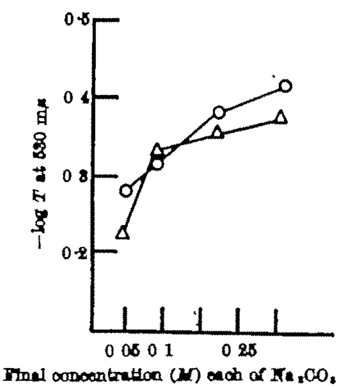


Fig. 1. Absorption values at 530 mμ of the coloured derivatives obtained in the Elson and Morgan reaction from 100 μgm. muramic acid (○) and 60 μgm. glucosamine hydrochloride (△) when the concentration of buffer salts present during reaction with acetylacetone is increased

the concentration of an amino-sugar as glucosamine determined using one set of conditions is converted to concentration of specific amino-sugar by means of a factor determined using different conditions.

Solutions containing weighed quantities of crystalline muramic acid, galactosamine hydrochloride and glucosamine-6-phosphate were determined by three modifications of the original Elson and Morgan method. The methods were : (1) according to Rondle and Morgan[1]; (2) as for (1), but a buffer containing equal volumes of *M* sodium carbonate and *M* sodium bicarbonate, *p*H 9·6[2] was used in place of 0·5 *N* sodium carbonate; (3) as described by Boas[3] (2 ml. of sample heated with 1 ml. *N* sodium carbonate containing 2 per cent (v/v) acetylacetone for 45 min. at 90° C.). Each amino-sugar was tested in triplicate by these methods, the average of the spectrophotometric readings at 530 mμ being compared with that given by an equimolar solution of glucosamine hydrochloride. With the exception of muramic acid[4], the coloured derivatives absorbed most strongly when light with a wave-length near 530 mμ was used. In all cases the glucosamine value varied with the method used, results for muramic acid being 48, 75 and 34 per cent with (1), (2) and (3) respectively (Table 1). The difference in results obtained with methods (1) and (2) was not due to difference in the *p*H value of the reaction mixtures containing acetylacetone for this was nearly the same (*p*H 9·5–9·6). Nor was there a significant change in *p*H in either case during heating for 20 min. at 100° C. Therefore, the only difference was the composition and concentration of the alkaline salts present. When the final concentration each of sodium carbonate and sodium bicarbonate was varied from 0·042 to 0·25 *M*, acetylacetone concentration being kept constant, the amount of coloured derivative formed with Ehrlich's reagent increased with increasing buffer concentration, particularly in the case of muramic acid (Fig. 1). The *p*H values of the reaction mixtures decreased as the buffer salts were reduced, but this was probably significant only in the case of the lowest concentration.

The lowest result for muramic acid, obtained using the Boas method, could not be due to the alkaline salt concentration, for this was twice that used in method (1). Here the *p*H value of the solution during reaction with the same concentration of acetylacetone as used in (1) and (2) was near 10, and it was shown that *p*H is an important factor by the following experiment : buffers of *p*H 8·8, 9·1, 9·6 and 9·8 were prepared by mixing appropriate volumes of *M* sodium carbonate and *M* sodium bicarbonate. Acetylacetone (2 per cent v/v) was added to each buffer (which reduced the *p*H values in all cases) and the resulting solutions were used in the determination of equimolar amino-sugar solutions according to method (1). Figs. 2 and 3 show how the amount of chromogen produced and the glucosamine values for each amino-sugar depended on the *p*H of the buffer used. Glucosamine values for muramic acid were 160 and 64 per cent when buffers with initial *p*H values

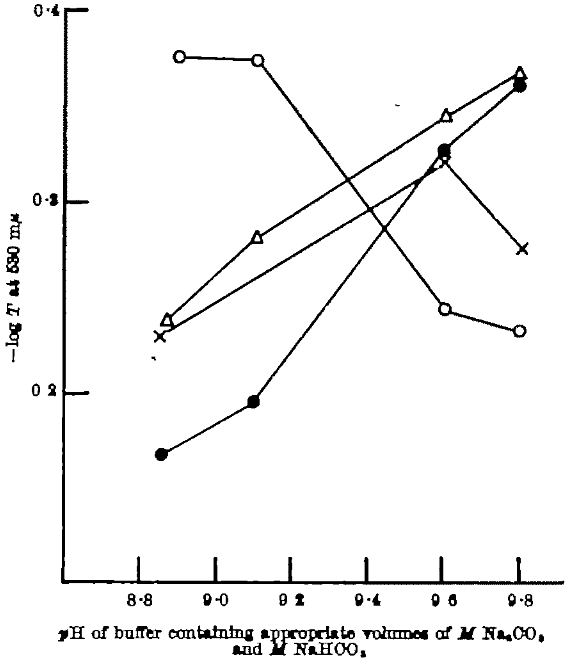


Fig. 2. Absorption values at 530 mμ of the coloured derivatives obtained in the Elson and Morgan reaction from equimolar solutions of amino-sugars when the *p*H of the buffer present during reaction with acetylacetone is increased. ○, Muramic acid; ●, glucosamine-6-phosphate; ×, galactosamine hydrochloride; △, glucosamine hydrochloride

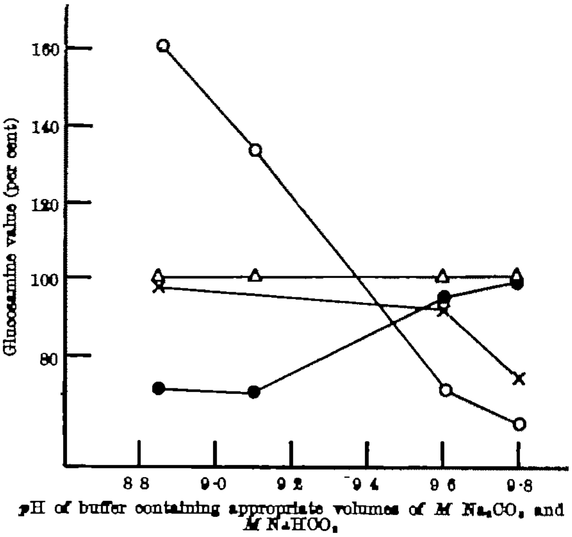


Fig. 3. Glucosamine values for equimolar solutions of amino-sugars calculated from the data given in Fig. 2. ○, Muramic acid; ●, glucosamine-6-phosphate; ×, galactosamine hydrochloride; △, glucosamine hydrochloride

Table 1. GLUCOSAMINE VALUES FOR EQUIMOLAR SOLUTIONS OF AMINO-SUGARS DETERMINED BY THREE MODIFICATIONS OF THE ELSON AND MORGAN METHOD

Method	Per cent (at 530 mμ)			
	Muramic acid	Glucosamine-6-phosphate	Galactosamine hydrochloride	Glucosamine hydrochloride
(1) Rondle and Morgan (ref. 1)	48	82	83	100
(2) Rondle and Morgan with sodium bicarbonate + sodium carbonate buffer (ref. 3)	75	96	93	100
(3) Boas (ref. 5)	34	98	69	100

of 8·8 and 9·8 respectively were used, whereas under these conditions values for glucosamine-6-phosphate showed the opposite trend (70 and 100 per cent respectively). Galactosamine gave significantly more colour when a buffer of *p*H 9·6 was used and thus showed an intermediate response.

The amount of coloured derivative formed from an amino-sugar in the Elson and Morgan reaction depends on both the *p*H and concentration of the alkaline salts present during the reaction with acetylacetone. Amino-sugars vary with respect to their stability in alkaline solutions, for example when muramic acid and glucosamine were incubated in 0·1 *N* sodium hydroxide for 1 hr. at 38° C. losses of hexosamine-reacting substance were 90 and 13 per cent respectively. The solution of alkali-treated muramic acid contained ammonia, and after acidifying the mixture with hydrochloric acid, a significant amount of substance was extracted with ether which gave a positive reaction for hydroxy fatty acid. After treatment with copper lime, the ether-extracted material gave a positive reaction for lactic acid[6]. About 10 per cent of the weight of original amino-sugar was recovered as lactic acid, and since significant amounts of this product were not obtained when either glucose or glucosamine was similarly treated it seems probable that the side chain on carbon atom 3 of the hexosamine moiety of 3-O-α-carboxyethylhexosamine[7] is released as lactic acid on treatment with alkali under relatively mild conditions. During this process the hexosamine moiety is destroyed.

From the results reported here it is clear that, particularly in the case of muramic acid, the conditions used for the determination of amino-sugars by the Elson and Morgan reaction should be rigidly controlled. Whenever possible, a pure sample of the amino-sugar being determined should be included as the standard, and the use of independently reported glucosamine values is not recommended.

I am grateful to Prof. W. T. J. Morgan for a sample of galactosamine hydrochloride and to Mr. A. G. Ness for some analyses.

[1] Rondle, C. J. M., and Morgan, W. T. J., *Biochem. J.*, 61, 586 (1955).
[2] Crumpton, M. J., *Biochem. J.*, 72, 479 (1959).
[3] Immers, J., and Vasseur, E., *Nature*, 165, 898 (1950).
[4] Strange, R. E., and Dark, F. A., *Nature*, 177, 186 (1956).
[5] Boas, N. F., *J. Biol. Chem.*, 204, 553 (1953).
[6] Barker, S. B., and Summerson, W. H., *J. Biol. Chem.*, 138, 535 (1941).
[7] Strange, R. E., and Kent, L. H., *Biochem. J.*, 71, 333 (1959).

PHYSICAL INCOMPLETENESS OF INFLUENZA VIRUS PROPAGATED IN DE-EMBRYONATED EGGS

By MARTIN HANIG and JOSEPH M. STEIM

Department of Biophysics, University of Pittsburgh, Pittsburgh 13, Pennsylvania

'FAST' and 'slow' sedimentable components of the *PR*8 strain of type *A* influenza virus may be selectively propagated in de-embryonated eggs[1,2]. Because the 'slow' form lacks several of the biological characteristics of the 'fast' form, it has been called 'incomplete' virus[1]. Hanig and Bernkopf[2] observed that the two forms exhibit 'fast' and 'slow' classes of sedimentation coefficients with overlapping distributions. These authors considered, nevertheless, that the 'fast' and 'slow' classes were distinctly different, and the overlapping was interpreted as resulting from differences in viscosity caused by differences in dilution of the various preparations. 'Incomplete' virus corresponding to slowly sedimenting overlapping components can also be propagated in embryonated eggs[3,4]. This effect has alternatively been ascribed to varying degrees of 'incompleteness' in a physical sense, a most attractive interpretation implying a parallelism in the development of the physical particle and its biological characteristics[5]. This may be the proper explanation for the overlapping observed in 'incomplete' virus propagated in embryonated eggs. Here, a gradual transition from 'complete' to 'incomplete' virus seemingly takes place during the several successive passages which appear to be necessary when using embryonated eggs for propagation[6–9]. In de-embryonated eggs, however, either component may be obtained directly in a single passage and alone, within the resolution of the optical system of the ultra-centrifuge.

Other differences between the two hosts are also apparent. The infectivity to agglutination ratios (*I*/*A*), after 24 hr., employed to characterize the viruses from the successive passages in embryonated eggs, seem to be appreciably lower than the ratios obtained from the 'incomplete' virus directly propagated in de-embryonated eggs. Thus, the mean infectivity to agglutination ratio reported[6–10] is 2·7 for virus from the third passage, the form which typifies the 'incomplete' virus from embryonated eggs. The mean, however, of the infectivity to agglutination ratios reported for the 'incomplete' virus propagated in de-embryonated eggs for the present investigation and elsewhere[1,2] is 5·0. Another, more obvious, difference is that virus grown in de-embryonated eggs is propagated only in the allantoic membrane while that from embryonated eggs may also be formed in other tissues, notably the yolk sac[8].

These differences suggested that, for influenza viruses, extrapolation of interpretations based upon observations in one host to another, even very similar, host may not be a valid procedure without well-considered justification. It then follows that the interpretation of Hanig and Bernkopf[3] that the 'fast' and 'slow' forms of virus propagated in de-embryonated eggs are distinctly different physical entities may be correct. Should this be so, it is evident that if there is a physical transition from one form of the virus to another, it must take place in one discrete, large step rather than in many intermediate steps unless the intermediate forms are transient and unidentifiable. Accordingly, this communication is concerned with a more rigorous investigation than the earlier one[3] concerning the 'fast' and 'slow' forms of *PR*8 virus selectively propagated in de-embryonated eggs.

Variations from preparation to preparation in the sedimentation coefficients of influenza virus may be caused by the intrinsic viscosity of the virus solutions *per se*[11] determined at different concentrations. Concomitantly, variations may be caused also by the presence of extremely viscous contaminants such as the normal 30 *S* component[12,13]. It is to be expected, then, that the sedimentation coefficients determined at a number of decreasing concentrations for a single preparation and extrapolated to infinite dilution would eliminate both viscous effects and would yield values more representative of the 'fast' and 'slow' classes of virus.

'Fast' and 'slow' forms of the *PR*8 strain of type *A* influenza virus were propagated in 17-day de-embryonated eggs for 24 hr. by the method of Bernkopf[3] employing inocula diluted to 10^{-5} and 10^{-1}, respectively. Each of four preparations of eight dozen eggs yielded about 1,600 ml. of the 'fast' component. A similar four preparations of the 'slow' component were prepared. Purification and concentration were accomplished by (*a*) two, three or four alternate high- and low-speed centrifugations at 4° C., or (*b*) a combination of these preceded by adsorption and elution from chicken erythrocytes. One preparation of the 'fast' component was divided in half and each portion was purified by (*a*) and (*b*). The sedimentation coefficients at infinite dilution ($S^{w}_{20}\,\infty$) were not significantly different for the two halves, 688 and 695 (Table 1, 6, 6*a*) indicating that the method of preparation probably had little effect on the sedimentation coefficient at infinite dilution. All operations were carried out in *p*H 7·4, *M*/15 phosphate buffer as follows: (*a*) infectivity was titrated in embryonated eggs[1] and calculated according to the Reed and Muench method[14]; (*b*) hæmagglutinating activity was measured by a modification of Salk's method[17].

Each preparation of virus of 6–8 mgm./ml. was diluted into five aliquots of decreasing concentrations in *p*H 7·4, *M*/15 phosphate buffer[15]. The uncorrected sedimentation coefficients, *S*, were determined at 20° C. in a Spinco model *E* analytical ultra-centrifuge employing a Philpot–Svensen optical system. Exposures were made at 4-min. intervals for 10 sec. at 12,590 r.p.m. Bar angles varied from 30°–45° depending upon the concentration of the sample in a 2°, 12 mm. cell. Both 'fast' and 'slow' components exhibited typical influenza virus boundaries in that there was considerable flattening of the schlieren peaks during a determination. No difficulty was encountered, however, in locating the maxima of the patterns. For each preparation *S* was plotted against *C* and extrapolated to infinite dilution by the method of least squares. In the range of concentrations employed, the curves were essentially linear whether plotted as $1/S$ versus *C*, or *S* versus *C*. The extrapolated values of *S* were corrected to the viscosity and density of water at 20° C. using $\rho_{20} = 1·0081$ and $\eta_{20} = 1·0467$ centipoise for the stock *p*H 7·4, *M*/15 phosphate buffer.

In calculating *S* for the 'fast' and 'slow' forms the apparent partial specific volume, $\bar{V}$, employed was 0·80 for both forms. This is the mean value of $\bar{V}$ reported by Lauffer and Stanley[16] for the 'fast' component propagated in embryonated eggs and the 'slow' form propagated by us in de-embryonated eggs. We were compelled to resort to this device because of insufficient 'fast' material from de-embryonated eggs on which to complete a determination. The value reported by Lauffer and Stanley was $\bar{V} = 0·79$ and that determined by us employing identical procedures was $\bar{V} = 0·806$. Because of the intrinsic experimental uncertainties in the determination of $\bar{V}$, we have considered these two values to be not significantly different from each other or from the 'fast' form in de-embryonated eggs, and have arbitrarily assigned $\bar{V} = 0·80$ to both our 'fast' and 'slow' components. Calculations of the sedimentation coefficient at infinite dilution using the separate values of $\bar{V}$ in no way affects the interpretation of the results.

The results of the extrapolations of the sedimentation coefficients to infinite dilution (Table 1, Fig. 1) show that the two forms of virus fall into two discrete distributions. That produced from the 10^{-4} inoculum has a mean of 697 svedbergs, and that from the 10^{-1} inoculum a mean of 541 svedbergs with standard errors of the mean, SE_{m}, of 4·3 and 4·1, respectively. This difference in sedimentation behaviour is quite unambiguous. Statistical analysis for the significance of the difference between means shows that $t = 14·97$. Indeed, even when the extreme values of the two distributions that most closely approach one another, rather than the means, are chosen to calculate *t*, the result is still clear, $t = 12·60$. Both these values of *t* are beyond the limits of conventional tables of probability and correspond to $P < 0·001$ so that the

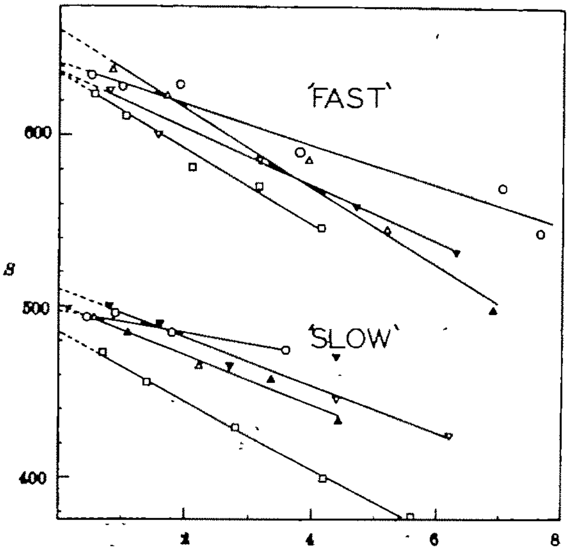


Fig. 1. Extrapolations to infinite dilution at 20° C. of sedimentation coefficients versus concentration for the 'fast' and 'slow' preparations of virus (uncorrected for ρ and η of medium)

Table 1. SEDIMENTATION COEFFICIENTS EXTRAPOLATED TO INFINITE DILUTION FOR 'FAST' AND 'SLOW' COMPONENTS

Prep.	*HA**	ID_{50}	*I*/*A*	Purif.	$S^{w}_{20}\infty$
	10^{-1} inoculum				
1	—	—	—	Cent.	541
2	2·8	5·3	2·5	Cent.	526
3	2·8	6·2	3·4	*CRBC*	554
4	2·8	5·7	2·9	*CRBC*	543
	10^{-4} inoculum				
5	2·8	8·9	6·1	Cent.	718
6	2·6	9·1†	6·5	*CRBC*	696
6*a*	2·6	9·1†	6·5	Cent.	688
7	2·6	8·6†	6·0	*CRBC*	687

* Adjusted from 0·125 to 0·25 per cent *CRBC*. † Mean value of pool.

two distributions could be from the same population. In view of these results, the hypothesis[6,7,10] that overlapping continuous values of sedimentation coefficients for the two forms of virus are indicative of biological transitions of 'incompleteness' is untenable for virus propagated in de-embryonated eggs. The ranges of S reported earlier for the 'fast' and 'slow' forms of virus were correctly interpreted by Hanig and Bernkopf[2]. They arise simply from the dependence of S upon concentration in the ultracentrifuge cell.

It is still possible that virus with many intermediate sedimentation coefficients could be produced by inocula of dilutions intermediate between 10^{-1} and 10^{-4}. This experiment has not been performed in de-embryonated eggs. In embryonated eggs, inocula diluted to 10^{-3} result in two distinct components which sediment concurrently and which correspond to the 'fast' and 'slow' components of de-embryonated eggs[2,16]. In an extensive study, Gard *et al.*[10] have reported for 'incomplete' *PR*8 virus obtained from embryonated eggs that the sedimentation coefficients ranged widely when extrapolated to infinite dilution. They do not, however, report details of their extrapolation procedures, so that a comparison of their results with ours, unfortunately, is not possible.

On the basis of the data available, it is valid only to state that for embryonated eggs there may or may not be continuous transitions from one form of the virus to the other and that the 'fast' form ranged from 757 to 810 svedbergs, while the 'slow' form ranged from 430 to 679. For the two forms of virus propagated in de-embryonated eggs, however, it is clear that they are completely disparate with $S^{w}_{20}\infty = 697 \pm 4{\cdot}3$ and $541 \pm 4{\cdot}1$. It is also clear that any hypothesis which attempts to explain a physical transition of one form of virus into the other when propagated in de-embryonated eggs must consider strongly the evidence that the transition probably would take place in a single, large, discrete step. At present, a conservative interpretation would be simply that, in the de-embryonated allantoic membrane, concurrent biological and physical developments proceed up to a certain point in the cell and then stop before release. The inoculum diluted 10^{-1} results in the physically 'slow' and biologically 'incomplete' form. The inoculum diluted 10^{-4} goes a discrete step further resulting in release of the physically 'fast' and biologically 'complete' virus. In embryonated eggs an inoculum diluted 10^{-3} results in the concurrent growth of both discretely different forms before release from the host cells.

Thus sedimentation coefficients extrapolated to infinite dilution have clearly demonstrated that there is no detectable gradual transition in $S^{w}_{20}\infty$ from one component to the other. Rather, the probability is much less than 1 in 1,000 that the two distributions, $541 \pm 4{\cdot}1$ and $697 \pm 4{\cdot}3$, could be from the same population. It follows from this that any hypothesis attempting to explain a physical transition of one form of virus to the other when propagated in the allantois must consider the evidence that the transition most probably would take place in a single, large, discrete step.

This investigation was supported by research grant *H*-2789 from the National Heart Institute of the National Institutes of Health, United States Public Health Service, and taken in part from a thesis submitted by one of us (J. M. S.) to the Graduate School of the University of Pittsburgh for the degree of master of science.

[1] Bernkopf, H., *J. Immunol.*, 65, 571 (1950).

[2] Hanig, M., and Bernkopf, H., *J. Immunol.*, 65, 585 (1950).

[3] Friedewald, W. F., and Pickels, E. G., *J. Exp. Med.*, 79, 301 (1944).

[4] Gard, S., and von Magnus, P., *Arkiv för kemi, mineralogi o. geologi*, 24, *B*, 8, 1 (1947).

[5] Burnet, F. M., "Principles of Animal Virology", 135 (Academic Press, 1955).

[6] von Magnus, P., *Acta Pathol. Microbiol. Scand.*, 28, 278 (1951).

[7] von Magnus, P., *Acta Pathol. Microbiol. Scand.*, 29, 157 (1951).

[8] von Magnus, P., *Acta Pathol. Microbiol. Scand.*, 30, 311 (1952).

[9] von Magnus, P., "Advances in Virus Research", 2, 59 (1954).

[10] Gard, S., von Magnus, P., Svedmyr, A., and Birch-Andersen, A., *Arch. ges. Virusforsch.*, 4, 591 (1952).

[11] Lauffer, M. A., and Miller, G. L., *J. Exp. Med.*, 80, 521 (1944).

[12] Knight, C. A., *J. Exp. Med.*, 80, 83 (1944).

[13] Lauffer, M. A., and Stanley, W. M., *J. Exp. Med.*, 80, 531 (1944).

[14] Reed, L. J., and Muench, H., *Amer. J. Hyg.*, 27, 493 (1938).

[15] Clarke, W. M., "The Determination of Hydrogen Ions" (The Williams and Wilkins Co., Baltimore, 1928).

[16] Steim, J. M., M.S. thesis, University of Pittsburgh (1959).

[17] Hanig, M., *Proc. Soc. Exp. Biol. Med.*, 68, 385 (1948).

BIOLOGICAL FUNCTION OF FRUIT

By DR. I. GINDEL

Agricultural Research Station, Rehovot, Israel

RESEARCH work carried out by me has revealed the accepted conceptions concerning the biological function of fruit, that is, the influence of the fruit on seed germination, to be misleading. It should be kept in mind that many cultivated fruits have changed entirely from their original form. This is particularly true of fruits having a pulpy pericarp, which, through selection, hybridization and cultivation, has steadily increased in size, for example, apple, peach, pear, etc. Thus only an ecological approach, a study of the fruit in its natural form and habitat, can elucidate its biological functions.

The developmental cycle of fruit may be divided into four periods: (1) from fertilization until final development in size; (2) the period of chemical changes within the fruit, partly visible to the naked eye by changes in colour of the fruit; (3) the period of final fruit ripening during which a corky layer is

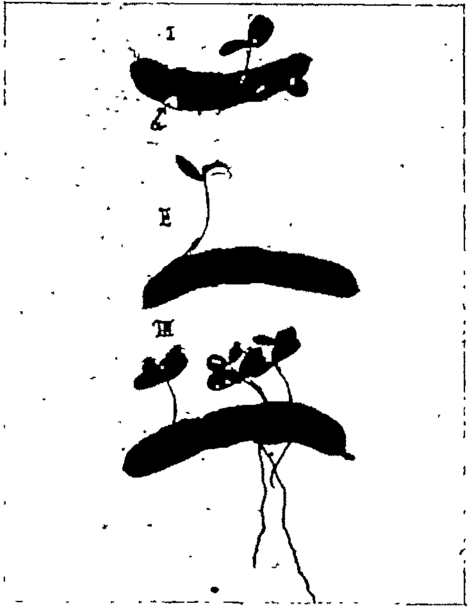


Fig. 1. Three developmental stages of the carob bean germ

formed between the pedicel of the fruit and the branch of the mother-tree ; (4) the period of chemical changes in the fruit when found on its natural litter.

While relatively sufficient information is available on the first three periods, data are scarce with regard to the fourth one. Research has been confined to the period when the fruit is best suited for consumption, or in determining storage conditions most suitable for preserving the fruit.

Fruits from indigenous indehiscent forest-trees and shrub species were collected soon after they had matured and stored at room temperature until sowing. One hundred fruits from each tree sample were sown in sandy seed-beds on the grounds of the Agricultural Research Station, Rehovot.

Fig. 2. A germ breaking through the split stony coat of a mango seed

Only healthy whole fruits were used, since my assumption is that the fruit represents a vital organism which, like the seed, continues to live after reaching maturity.

These experiments were supported by observations on the seeds of various fruit trees grown in Israel, for example, apple, anona, avocado, melon, tomato, pumpkin, grapefruits, lemons, *Artocarpus integrifolia* and others. These fruits were left in various storage conditions until maturity and carefully cut to see if their seeds had meanwhile germinated.

Table 1 shows percentage germination of various forest seeds when left within their fruits. Only the seeds of fruits not attacked by fungi or insects germinated. The low percentage obtained is not representative for the various species as the fruits were sown in poor sand ; on natural litter percentage of germination would obviously have been greater.

Table 1. GERMINATION OF SEEDS WITHIN THEIR FRUITS

Species	Germination (per cent)	Length (days)
Arbutus andrachne	32	62
Celtis australis	78	102
Ceratonia siliqua	9	76
Elaeagnus angustifolia	14	49
Laurus nobilis	19	106
Melia azedarach	64	61
Pyrus syriaca	40	102
Rhamnus alaternus	44	61

Fig. 1 shows the developmental stages of the carob bean germ. Fig. 2 shows a germ breaking through the split stony coat of a large mango seed.

When testing fruits of *Arbutus andrachne*, *Ceratonia siliqua* and *Mangifera indica*, the seeds of which germinated in the sown beds, we found that, before sowing, their pH was 4·12, 4·85 and 4·2, respectively. After germination within the fruits their pH increased to 5·38, 6·34 and 5·5, respectively. Even the germination of the seed of the avocado in its fruit is no rare occurrence. In this fruit there is a pH change after harvesting from 6·8 to 7·05 at the time of germination of the seed.

Germination of seeds within the fruit itself was observed in tomato, apple, *Cucurbita maxima*, avocado, anona, grapefruit and lemon. Within the last two fruits green cotyledons developed from the germinating seeds when the fleshy pericarp was still entirely closed. The roots of the germs were in all cases tightly attached and had partly penetrated into the body of the fruit.

From our experiments and observations it seems therefore clear that the so-called inhibiting substances which prevent the seed from germinating change, in the course of the metabolism of the fruit, into new compounds which favour seed germination. The biochemical composition of the fruit reaches a stage whereby the radicle of the germ is enabled to come in touch with the pulpy content of the fruit and thus provide it with its first food before it reaches the mineral soil in the forest litter.

It appears, therefore, that the fruit is naturally a disseminating organ the structure of which is adjusted to the ecological conditions of its habitat. The better results obtained by extracting the seeds artificially should not diminish the positive function of the fruit in Nature as a disseminating organ.

The supposition that flavour and taste of fruit attract the senses of animal and man to eat and disseminate the fruit is therefore not necessarily justified, and it is only a happy accident in Nature that man or animal consumes the fruit at a stage suitable to his taste. The conclusion drawn by different workers that the fruit in Nature is an inhibitor to the germination of its seeds or should be destroyed by insects or fungi and freed for germination also does not seem warranted.

Examining the sown fruits from time to time showed that seed germination occurred wherever the fruit was fresh. On the other hand, wherever germination did not take place, the fruit was found to have been destroyed by fungi or insects. Within the germinating fruit the roots steadily increased in size by making use of the food in the pulpy pericarp, many of these roots branching within the fruits rather than penetrating the soil through the perforated coat.

AUSTRALIAN BIVALVE GASTROPODS

By ROBERT BURN*

As already intimated by me (*Nature*, April 9, p. 179), *Edenttellina typica* Gatliff and Gabriel[1] has been collected alive at Torquay, Victoria, and it is congeneric with the Japanese *Tamanovalva limax* Kawaguti and Baba[2]. Thus the latter genus is a synonym of the former. Furthermore, I suggest that the Victorian and Japanese species are conspecific with *Edenttellina corallensis* Hedley[3] from Queensland and *Scintilla ? chloris* Dall[4] from California, but not with *Edenttellina typica* as described and figured from South Australia by Verco[5] and Hedley[6]. My reasons for suggesting this synonymy are given in the discussion following the description of the Victorian species.

Overseas correspondents inform me that the Eocene Paris Basin fossil genus *Berthelinia* Crosse[6] is applicable to the present species, and with this I wholly agree. This means that the two synonymous recent genera must themselves become synonyms of this earlier name. It is then under this genus that I thus describe the animal and shell of the Victorian species: *Berthelinia typica* (Gatliff and Gabriel).

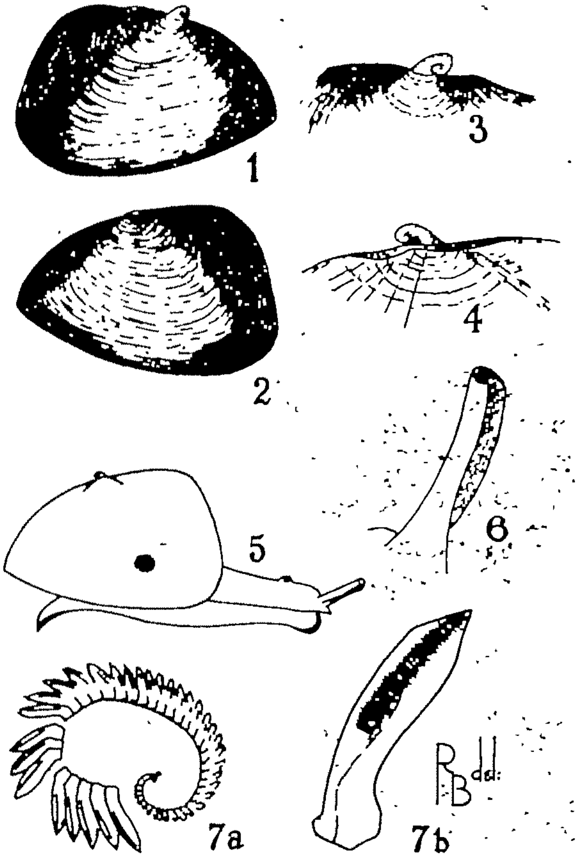
Notice of a second species from the same habitat was also given in my communication in *Nature* of April 9. This species presents a new problem within the order Sacoglossa, for the protoconch, although always present on the umbo of the left valve, shows lateral torsion away from the vertical plane of the initial whorl. Together with other shell characteristics and the very different animal, the species deserves generic separation, and to this end I propose the name *Midorigai australis gen. et sp. nov.* for it. *Midorigai* is chosen to perpetuate the Japanese ordinal name for the sacoglossan opisthobranchs.

A specimen of each species has been presented to the Japanese authors in exchange for topotypes of their own find. The remainder of the material, including the exchanges, has been presented to the National Museum of Victoria, Melbourne.

I wish to thank Mr. C. J. Gabriel of Melbourne for allowing me to examine cotypes and topotypes of both *Edenttellina typica* and *E. corallensis* from his collection. To Tom Iredale of Sydney go my special thanks for directing my attention to this matter in the first place and for urging me to try to resolve the *Edenttellina–Tamanovalva* problem.

Berthelinia typica (Gatliff and Gabriel)

The animal (Figs. 1–7) does not differ essentially from that described for *Tamanovalva limax* Kawaguti and Baba (ref. 2, 179–180, Fig. 1, 4–5). The few points of difference are: (1) the smaller size of the whole animal; (2) the more elevated rounded protuberance upon the neck containing the eyes; and (3) the slightly larger and broadly pointed oral tentacles. The length of my largest specimen is 6 mm. The body colour is leaf-green; the neck, transparent edges of the foot and the mantle inside the shell are minutely speckled with cream pigment. The rhinophores have larger denser patches of creamy yellow towards the tips, while the lateral slit is similarly pigmented. The mantle in each valve

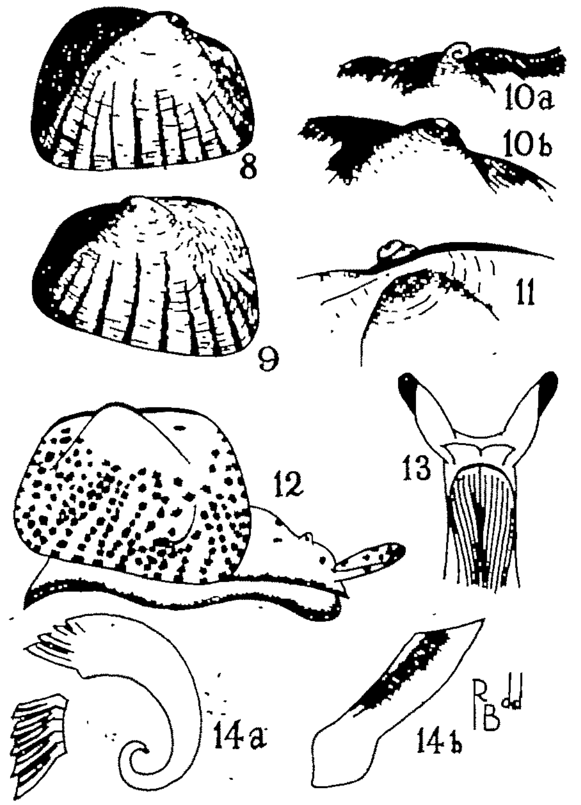


Berthelinia typica (Gatliff and Gabriel).

(1) Left valve of shell. (2) Right valve of shell. (3) Detail of protoconch on umbo of left valve. (4) Detail of hinge line of left valve. (5) Living animal from right side. (6) Dorsal aspect of right rhinophore. (7) Radula: *a*, complete series; *b*, detail of a large tooth

---

* Present address: 24 Autumn Street, Geelong West, Victoria, Australia.



Midorigai australis gen. et sp. nov.

(8) Left valve of shell. (9) Right valve of shell. (10) Detail of protoconch: *a*, dorsal aspect; *b*, lateral aspect. (11) Detail of hinge line of left valve. (12) Living animal from right side. (13) Underside of head and anterior foot. (14) Radula: *a*, complete series; *b*, detail of a large tooth

contains red pigment cells in patches of varying area; in some specimens the whole mantle is thus red pigmented. The adductor muscle shows as a grey-blue circular patch on each valve.

The radula contains 41 or more teeth similar to those of *T. limax* (*loc. cit.*, Fig. 8). The spiral series of teeth is broken into three sections, 6 large teeth in the lower series, 3 similarly sized teeth in the ascending series, and 32 or more evanescent teeth in the descending series.

The shell is as figured by each of the authors cited and I add figures of the present specimens (Figs. 1–4). The protoconch is elevated, erect, of 1¼ whorls in the vertical plane. The valves are smooth with fine growth lines visible. The adductor muscle is firmly attached to the left valve and easily detached from the right, the scar is circular, nacreous inside the valves and visible externally. There are no teeth in the hinge line. There is a strong leathery transparent periostracum over each valve, the thickening and strengthening of which provides the ligament upon which the valves hinge at the umbones. The largest shell measures 5 mm. long, 2·5 mm. high and over the paired valves 1·5 mm. The shell is pale translucent olive-green, the protoconch white, the ligament brown and the periostracum colourless or pale horn colour.

Material examined: 1 specimen, Torquay, February 2, 1960; 3 specimens, Torquay, March 5, 1960.

The species lives on the green alga *Caulerpa scalpelliformis* (R. Brn.) C. Ag. which grows either in isolated colonies of a few leaves in the narrow crevices between rocks or as single stipes some little distance apart among the denser brown algae on the top of rocks, in the channels at the outer edge of the reef where there is strong tidal influence. The small specimens live upon the pale green stalks and roots of the alga; consequently these specimens are paler in colour. The adult specimens feed on the sharp flat sword-like edges of the alga; a minute hole is pierced by the radula and the surface juices are sucked out, leaving a narrow band easily discernible by its yellowish colouring. The animal when irritated exudes great quantities of white viscous fluid from the hyperbranchial ducts opening on the posterio-ventral margins of the mantle. At rest, the species retracts the head within the shell, which takes up a vertical position on the alga, as though attached by a strong byssus; in this attitude it resembles most closely a small green species of Pelecypoda.

Crosse[6], originally described *Berthelinia* from a single juvenile valve; later, together with Fischer[7], he described the complete shell, clearly indicating the position, shape and size of the adductor muscle scar, and most important, the erect protoconch in the vertical plane of the valve. There can be no doubt that this genus is applicable to the present species. The comparison of the Victorian and Japanese species clearly indicates that they are congeneric and, except for a few minor points, conspecific. I have dissected out and examined the radula of each species, and I find that both contain a similar number of teeth, 41 or more, which is more than indicated by Kawaguti and Baba. That the teeth are in three series in both radulae is possibly due to the contraction of the body during preservation, but as *Midorigai australis* preserved in the same manner exhibited only two series, I feel that the three series may be a generic characteristic.

Although the Japanese authors do not mention it, I find that there is a thin transparent periostracum present on each of the valves of *Tamanovalva limax*, and that it is thickened in the same way as in my specimens, thus providing the 'invisible' ligament. It is quite possible that Verco's South Australian specimens are not this species, but instead are some new species with teeth in the hinge line and a large vertical protoconch of about two whorls; the shell is also more attenuated posteriorly, and the adductor muscle scar and the animal are unknown. The South Australian specimens described first by Verco and later by Hedley cannot be traced at the present time.

My specimens and the Japanese topotypes resemble most closely *Edentellina corallensis* Hedley; the topotypes of this species in Mr. Gabriel's collection cannot be separated in any real way from *Berthelinia typica* cotypes in the same collection. Thus I must reduce *E. corallensis* and also *T. limax* to synonyms of *B. typica*. The Californian *Scintilla ? chloris* Dall is larger, length 9 mm., but is still remarkably similar to the present species, and I think should be added to the synonymy of it.

Midorigai gen. nov.

This new genus is proposed for those sacoglossan slugs similar to *Berthelinia*, but with the following differences. The shell is more obese, the shape more square, the protoconch very much smaller and in a nearly horizontal plane across the hinge line of the two valves. There are two adductor muscles; the lower, larger one is horizontally oval, with an anterior flange rising up towards the upper, much smaller, muscle just below the anterior hinge line. The foot is narrower than the neck. The rhinophores are stout and at mid-length swollen; the oral tentacles are large and pointed. The vaginal pore is in front of the lower adductor muscle. Radula is as usual in the Sacoglossa, teeth more coarsely denticulate laterally than in *Berthelinia*. Body-colour is dark green, the mantle within the shell is spotted with large cream spots, the neck and rhinophores with a few paler cream patches.

Midorigai australis sp. nov.

In the type species (Figs. 8–14) the body is stout and the foot is nearly as wide as the neck. The neck is high and rises up towards the shell from immediately behind the eye prominence. The eye prominence is broadly elevated and close to the rhinophore bases. The auriculate rhinophores are stout, swollen at mid-length with the bases constricted; the tips are rounded and not square as in the previous species. The oral tentacles are large, square-lobate with the anterio-lateral corners sharply pointed. The anterior edge of the foot is bilabiate, the upper lip medianly slit, the lower continuous and rounded in shape. The sole is medianly grooved for its whole length; on each side of this groove there are six faint grooves originating near the anterior end of the foot, and these carry the mucus or pedal fluids from the glands within the bilabiation of the anterior part of the foot. The foot is flattened anteriorly and folded along the median groove posteriorly. The penial aperture is behind the right rhinophore base, but in front of the level of the eyes; the vaginal pore is small and in front of the lower adductor muscle. The tail of the foot is very little shorter than the posterior of the shell. The length of the largest animal was 5·5 mm. The anus opens above the posterior ridge of the foot within the shell. The ducts from the hyperbranchial glands open in the margins of the mantle behind the anus. The gill is bluish, larger than in *B. typica*, and situated between the anus and the adductor muscles. The lower larger adductor muscle is placed in the anterior part of the shell, but rather far back from the anterior margin; it is horizontally oval with an anterior flange of muscle running forward and curving upwards to the much smaller elongate-oval adductor muscle near the hinge line. This latter muscle can be observed by careful scrutiny of the living animal.

The radula has as usual two series of teeth in its uniseriate spiral. There are 5 teeth in the ascending series, and about 34 in the descending series; the whole spiral is more tightly coiled than in *B. typica*. The teeth are coarsely denticulate laterally, the tips being sharply angled towards the cutting edge.

The body colour is dark green, the rhinophores have large yellowish patches spread sparsely over them, and patches of the same size extend over the body. The mantle within the valves is densely spotted with large rounded spots of yellow-cream; some of these form wavy series which originate in the squarish yellow patches unequally spread along the mantle edges. The sole is pale green, the anterior edge of the foot whitish. The eye prominence is white, the eyes black.

The shell of the largest specimen measures 4·4 mm. long, 3 mm. umboventrally and 1·75 mm. broad. The left valve is the more convex of the two and is a little higher at the hinge line than the right, which fits under this higher upper edge; the ligament thus takes a vertical position, not a horizontal position as in *B. typica*. The protoconch is small and flatly coiled in its horizontal position on top of the umbo of the left valve; it encroaches upon the right valve for half its diameter. There is a strong translucent periostracum over the thin valves, which is strengthened and is coloured dark brown where it forms the ligament. The ligament extends twice as far in front of the umbo as behind it. There are no teeth in the hinge line. The valves are pale translucent olive-green with darker rays of green radiating out from the umboes. The protoconch is yellowish and thus inconspicuous. The interior of the valves is nacreous, particularly the lower adductor muscle scar.

Material examined: 1 specimen (holotype) Torquay, February 21, 1960; 5 specimens (paratypes) Flinders, Victoria, March 20, 1960; 1 specimen Torquay, April 2, 1960.

At Torquay this species lives upon the green alga *Caulerpa scalpelliformis* along with *Berthelinia typica* and the oxynoid sacoglossan *Oxynoe viridis* (Pease). At Flinders it lives upon the tender tips and needle-like leaves of the 'rat-tail' green algae *Caulerpa brownii* (C. Ag.) Endl. and *C. simpliciuscula* (Turn.) C. Ag. Both these algae grow outwards from the vertical walls of deep rock pools and channels at the extreme edge of the reef at Flinders. The animal exudes copious quantities of white viscous fluid from the posterior gape of the shell. The ventral margin of the closed valves gapes a little to allow the foot to protrude. In motion, the foot is thrust forward and the shell drawn towards the head in two or three jerky movements. The right valve contains none of the viscera.

This species can be separated from *Berthelinia* by the following criteria: (1) the small protoconch placed half on the right valve; (2) the right valve smaller than the left; (3) the foot narrower than the neck; (4) the swollen rhinophores; (5) the two adductor muscles; (6) the two series of teeth in the radula; and (7) the darker colouring and the spotting within the shell. Perhaps the shell both Verco and Hedley called *Edentellina typica* is more closely related to this species than to *Berthelinia*.

That a second genus and species should occur along with one known for fifty years is truly remarkable, but no more so than the plentiful occurrence of *Berthelinia typica* (= *Tamanovalva limax*) in Japanese waters. Wider researches in similar habitats will probably reveal more forms of the same types as those described here.

Note added in proof. Dr. K. Baba, of Osaka (*in litt.*, received May 25, 1960) considers *B. typica* to differ specifically from *B. limax* because of its different shell shape and somewhat differently formed apices of the radular teeth. I regard these two species as the known extremes of zoogeographical variation within a single species, with *B. corallensis* and *B. chloris* as intermediate intergrading forms. Further material of all forms will perhaps allay the present differences of opinion.

---

[1] *Proc. Roy. Soc. Vict.*, N.S., 24, 190, pl. 46, Figs. 5–6 (1911).

[2] *Biol. J. Okayama Univ.*, 5, 177–184 (1959).

[3] *Proc. Malac. Soc. Lond.*, 14, 74–76 (1920).

[4] *Proc. Biol. Soc. Washington*, 31, 5–8 (1918).

[5] *Trans. Roy. Soc. S. Aust.*, 40, 596–597 (1916).

[6] *J. Conchyliol.*, 23, 79–81, pl. 2, Fig. 3 (1875).

[7] *J. Conchyliol.*, 35, 305–311, pl. 10 (1887).

LETTERS TO THE EDITORS

ASTRONOMY

Origin of the Solar System

There is a considerable degree of order in the solar system which current theories seem capable of explaining only in part. The present communication describes a new approach which has led to a proposed model for its formation which seems to be much more successful in explaining the regularities observed.

This model, in common with some others which have been advanced, envisages the passage of a star into the neighbourhood of the Sun. The order of magnitudes under consideration at present envisages a star of one hundred Sun masses moving with a velocity of 100 km./sec. and approaching the Sun to within a distance of ten times the solar radius. The Sun is imagined as initially spinning about an axis not in the plane of the orbit of the star. A tide is raised on the surface of the Sun which increases in height as the star approaches. Eventually a position is reached where a portion at the tip of the tidal bulge facing the Sun is under a greater gravitational pull from the star than from the Sun itself, and this portion then breaks away and, moving under the combined gravitational attractions of the star and the Sun, forms the planet Pluto.

This loss of material at the solar surface sets up waves which will travel around the Sun from the unaffected obverse tidal bulge towards that part of the Sun facing the oncoming star. The wave-crest approaches the oncoming star which eventually draws off another portion of the solar material to form the planet Neptune. A new wave is initiated to give the planet Uranus, and then Saturn and Jupiter are formed in a similar way. At this stage the star is approaching most closely and is able to draw material out from the Sun almost continuously, a great deal of which material it may even capture. Indeed a large planet could have been formed at this stage and captured by the star. The residue of the ejected material forms the belt of asteroids, which lie for the most part between the orbits of Jupiter and Mars. Finally, as the star recedes, the four smaller planets—Mars, Earth, Venus and Mercury—are formed.

Fig. 1 shows the possible scheme of operation. It is hoped that the regular time-intervals between the production of each planet will account for the well-known but hitherto unexplained Bode's law. In support of this idea it may be noted that the same law, with different constants, also applies to the innermost satellites of those planets possessing appreciable satellite systems (Table 1). The proposed mechanism for their formation is similar to that given above, but with the planet itself acting as the parent body. However, the agreement with Bode's law is not so precise because of the perturbing influence of the Sun.

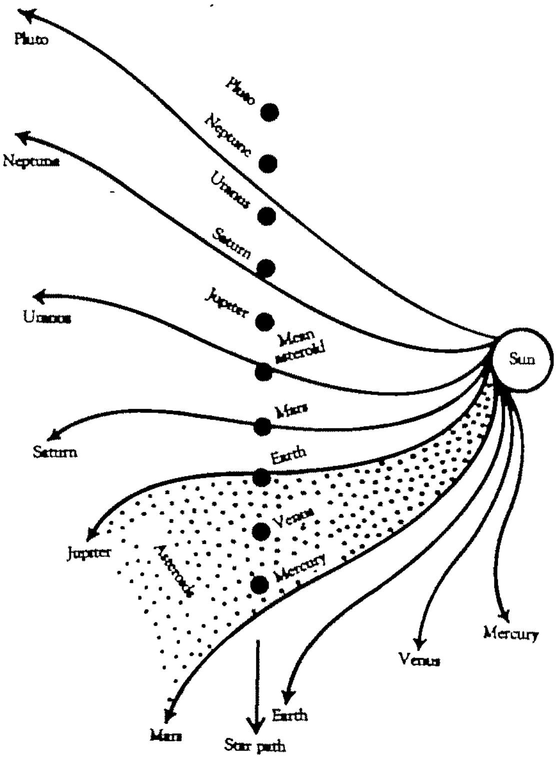


Fig. 1. Suggested scheme for the origin of the solar system. The position of the passing star when each planet leaves the Sun is indicated by ●

An interesting point concerns the time taken by the whole process. If the waves on the surface of the Sun are considered as gravity waves on a deep liquid of wave-length equal to the circumference of the Sun, travelling a distance equal to one half the circumference, it is found that the time for the journey of each wave is about 80 min. Thus the material for the formation of the planets will have been removed from the Sun in a total time of 12 hr. Of course, many hundreds of years will have elapsed after the passage of the star before Pluto, the outermost planet, had completed its first orbit.

Full consideration of the model gives reasonable qualitative explanations for the following observed

Table 1

Jupiter			Saturn			Uranus		
Satellite	Bode-type law	Orbit radius (× 10⁴ km.)	Satellite	Bode-type law	Orbit radius (× 10⁴ km.)	Satellite	Bode-type law	Orbit radius (× 10⁴ km.)
1	19 + 0 = 19	18·1	1 (Mimas)	18·6 + 0 = 18·6	18·6	1 (Miranda)	14 + 0 = 14	13·0
2 (Io)	19 + 22 = 41	42·2	2 (Enceladus)	18·6 + 4·8 = 23·4	23·8	2 (Ariel)	14 + 6 = 20	19·2
3 (Europa)	19 + 44 = 63	67·1	3 (Tethys)	18·6 + 9·6 = 28·2	29·5	3 (Umbriel)	14 + 12 = 26	26·7
4 (Ganymede)	19 + 88 = 107	107·1	4 (Dione)	18·6 + 19·2 = 37·8	37·8	4 (Titania)	14 + 24 = 38	43·9
5 (Callisto)	19 + 176 = 195	188·4	5 (Rhea)	18·6 + 38·4 = 57·0	52·7	5 (Oberon)	14 + 48 = 62	58·7

phenomena and physical properties of the solar system: (i) The occurrence of a law (it is hoped Bode's law) for the radii of the planetary and satellite orbits. This is a result of the regular time-sequence of their production. The departure from the law for the outermost planets is also explained. (ii) The relative masses of the planets (including Mars) and of the satellites in each system. (iii) The large eccentricities of the orbits of Mercury and Pluto. (iv) The inclinations of the planetary orbits to the ecliptic. (v) The periods of rotations of the planets about their axes. (vi) The inclination of the planetary equators to their orbits. (vii) The inclination of the solar equator to the ecliptic and the variation of its period of rotation with latitude. (viii) The retrograde spin of Uranus and the retrograde orbits of its satellites. (ix) The retrograde orbit of Triton, the inner satellite of Neptune, and the large eccentricity of its other satellite, Nereid. (x) The origin of the satellites Titan and the Moon.

It is hoped to carry out calculations on the University of Manchester Mercury computer to see whether the basic ideas behind such a system are feasible, and, if so, to find values of the constants that would give an approximation to the system as it exists at present.

I wish to acknowledge the many helpful discussions I have had with Prof. H. Lipson during the period in which these ideas were being formulated.

Note. After this short communication had been prepared, it was found that a communication on a similar topic had appeared in *Nature* of May 21, p. 621, by Egyed. The theory presented here would seem to have the advantage that it explains the origin of the solar system in terms of readily understood physical principles without invoking rather exotic phenomena, such as the variation of G with time. Other observations, for example, the distribution of angular momentum in the solar system, also seem more readily explained by the mechanism proposed here.

M. M. WOOLFSON

Physics Department,
College of Science and Technology,
Manchester 1.

PHYSICS

Photo-Injection of Charge into Dielectric Liquids

ALTHOUGH many workers have studied the electrical breakdown of pure highly insulating liquids, few have been concerned with the fundamental processes of charge production and movement. This is because of the experimental limitation set by the extremely low natural conductivity. By applying high electric fields or high-energy radiation the conductivity of very pure dielectric liquids may be enhanced; but in both cases it remains difficult to devise experiments to study the mechanism. The difficulties may be partly overcome by a new method of increasing the conductivity. This is by ultra-violet illumination of the electrodes: some preliminary experiments on this effect are reported in this communication.

Dornte[1] was apparently the only early worker to observe a dependence of the current in pure dielectric liquids on ultra-violet radiation. More recently, Le Blanc[2] used the effect to measure the charge mobility in liquid n-hexane, but neither of them investigated it further. It has probably been overlooked by other workers because of their use of glass test cells or of air-saturated liquids. It has recently been found that the ultra-violet photocurrents can be induced in a dielectric liquid only if it is thoroughly degassed, and for the work described here this was achieved by final distillation at a pressure of less than 10^{-6} mm. mercury. Similarly, dissolved oxygen has been shown to be a critical impurity in the electrical breakdown of pure liquids[3].

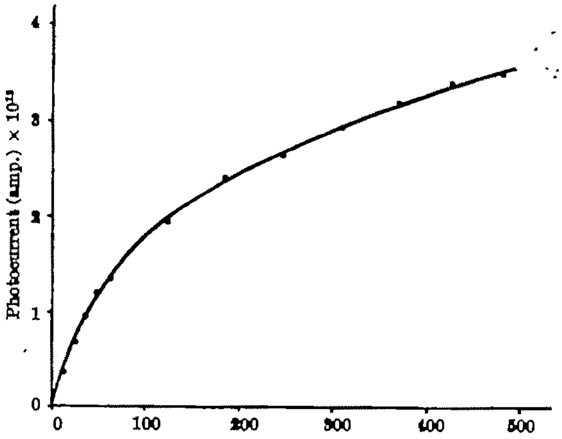


Fig. 1. Typical variation of photocurrent with applied voltage (1-cm. diam. electrodes spaced 7 mm. apart)

The liquid used in the present work was highly purified n-hexane having a residual conductivity of 10^{-16}–10^{-17} mho/cm. With low applied fields the current can be increased by a factor of at least 10^3 by focusing the ultra-violet radiation from a medium-power mercury discharge lamp on to the cathode. The photocurrent varies markedly with voltage as shown by the typical result of Fig. 1. The cell used for this work was completely sealed off at a pressure of 10^{-6} mm. after filling with the degassed liquid. By freezing out the hexane in a side bulb with liquid nitrogen the photoelectric emission from the same cathode could be studied in a good vacuum. As expected, the photocurrent in vacuum shows good saturation with voltage, and with a field of 170 V./cm. the currents are between 200 and 2,000 times greater than in the liquid for the same illumination.

By using optical filters it has been possible to obtain a rough measure of the spectral response for the photocurrent in both cases. For an aluminium cathode in vacuum the photoelectric threshold corresponded to a work function of about 4·1 eV. Approximately the same long-wave threshold was obtained for the photocurrent induced in hexane with a low applied field. There is no doubt that photocurrents are produced in the liquid by radiation of wave-lengths up to 3000 Å., that is, far beyond the absorption limit (~2000 Å.) for the liquid itself. This indicates that the current originates at the cathode, but the lack of saturation, and other features to be described, show that the process is very different from photoelectric emission into a vacuum. For this reason the release of charge from the cathode into the liquid is better described by the term 'photo-injection'.

Further investigation of the spectral response of the liquid photocurrent has indicated that the threshold wave-length increases slightly as the applied voltage is increased, although the effect contributes only very little to the lack of saturation shown in Fig. 1. It has also been found that the form of the dependence upon voltage varies with wave-length. For example, the curve of Fig. 1 was obtained using the unfiltered radiation from a mercury lamp, but a more nearly ohmic characteristic is obtained by isolating wave-lengths near the threshold.

The transient response of the photocurrent on suddenly illuminating the cathode has also been studied, and this can be related to the charge mobility as measured by Le Blanc[2]. With the equipment used so far it has only been possible to record transit times of the order of seconds for the movement of the injected charge between the electrodes. This has indicated a mobility of about 5×10^{-4} cm.^{2}/volt sec. at room temperature, that is, slightly lower than found by Le Blanc. However, it is disturbing to find that with very low applied fields the transit time appears to depend on the wave-length of the ultra-violet illumination. The transients are further complicated by slow variations with time.

From these measurements there appears to be no doubt that photo-injection of charge into a dielectric liquid is possible. The dependence upon voltage shows, however, that it is not justified to assume, as is commonly done[4], that electron emission into a liquid is similar to that into vacuum. The injection of charge through a space charge barrier at the interface of the liquid and the metal seems much more likely[5], but many experiments are required before it is possible to work out the details. The ability to inject charge into a dielectric liquid opens up several interesting possibilities for investigating charge movement. Further work is being carried out and will be reported in more detail elsewhere.

This work was made possible by the award of the Henley Research Fellowship and by the loan of apparatus from the Central Research Fund of the University of London.

M. J. MORANT

Queen Mary College,
Mile End Road,
London, E.1.
May 26.

[1] Dornte, R. W., *Indust. and Eng. Chem.*, 32, 1529 (1940).
[2] Le Blanc, O. H., *J. Chem. Phys.*, 30, 1443 (1959).
[3] Sletten, A. M., *Nature*, 183, 311 (1959).
[4] Lewis, T. J., "Progress in Dielectrics", 1, 99 (London, 1958).
[5] Morant, M. J., *J. Electrochem. Soc.* (in the press).

An Ionization Detector for Permanent Gases

THREE highly sensitive gas ionization methods for the detection of volatile substances have been reported: the hydrogen flame ionization detector[1], the 'argon' detector[2], and the electron affinity ionization detector[3]. These devices are practical and efficient in the measurement of low concentrations of organic vapours; they suffer, however, the disadvantage of a slight or negligible response to most permanent gases. This communication describes a sensitive ionization method of measuring the concentration of all permanent gases, except the noble gases, in an argon carrier-gas stream.

The physical basis of the method is as follows. When argon containing free electrons is exposed to an electrical field, the temperature of the free electrons is rapidly raised to a level far above that of the argon atoms. This is because only a small proportion of the energy gained by the electrons from the field is lost during their elastic collisions with the argon atoms[4]. Collisions between free electrons and the molecules of other gases, except the noble gases, are by contrast non-elastic and result in the loss of a large proportion of the energy of the colliding electron. The addition of a small quantity of some other gas to argon causes, therefore, a reduction of the free-electron temperature at a given field intensity. There are several possible methods for observing variations of the free-electron temperature in argon when it is contaminated with other gases. The quenching of the normal response of an 'argon' detector has been suggested[5]; a more direct method is described here.

An ionization chamber of plane-parallel geometry is filled with argon and contains a source of free electrons. The chamber is connected directly across the input of a d.c. amplifier, and the anode of the chamber fed through a condenser with positive pulses of short duration (between 1 and 10 μsec.). When the chamber contains only pure argon, little or no current is observed to flow; this is because during the short period of the pulse there is insufficient time to permit the deflexion and collection of the fast-moving free electrons. With contaminated argon, however, the electron temperature is lower and they are moving slowly enough to permit their collection during the application of the pulse. The chamber therefore provides a signal current related to the concentration of the contaminant gas.

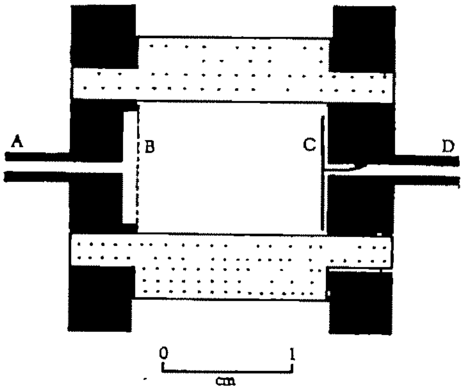


Fig. 1. Construction of the detector. (*A*) Gas inlet and anode connexion; (*B*) gas-flow diffuser made from 100-mesh wire gauze; (*C*) radioactive source; (*D*) gas outlet and cathode connexion. Black, brass; stippled, polytetrafluoroethylene

Fig. 1 shows the construction of a practical detector; its dimensions and the materials of its construction are indicated with the figure. The most convenient shape of electrical pulse to apply to the chamber is a half-wave rectified sine-wave. With a detector of the type illustrated, the frequency of the sine-waves used to generate the pulses should be between 0·2 and 0·7 Mc./s. and the amplitude of the pulses between 50 and 100 volts. Electrons are set free from the argon within the chamber by irradiation with soft β-particles from a sheet of metal foil containing tritium as the active element. The quantity of tritium should be sufficient to provide a d.c. saturation current of between 3 and 10×10^{-9} amp.

Fig. 2 shows the variation of current-flow in the detector with the frequency of the applied pulses. In pure argon no current flows when the frequency is higher than 0·27 Mc./s. When other gases are present at a concentration of 0·1 per cent by volume, there is an extension of the range of frequency over

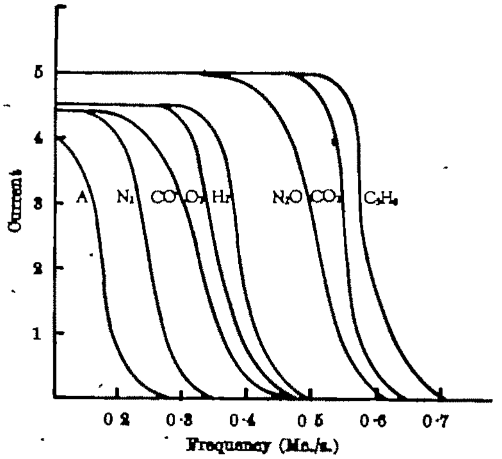


Fig. 2. Response of the detector to pure argon and to 0·1 per cent by volume concentration of various other gases in argon. Abscissa, frequency in Mc./s. of the applied half-wave rectified sine-waves. Ordinate, current drawn from the detector × 10^{8} amp.

which a current flows in the chamber. In general, the more complex the molecule of the contaminant gas the higher the frequency at which a current can still be observed. In practice it is possible to distinguish between such gases as nitrogen, oxygen, carbon dioxide and organic vapours simply by adjusting the frequency of the pulses applied to the detector.

When operated at a frequency of 0·27 Mc./s., the detector illustrated is capable of responding to all but the noble gases. The background current in pure argon is less than 10^{-10} amp. and the noise-level at a total time constant of 1 sec. less than 10^{-13} amp. The least detectable concentration of diatomic and of polyatomic gases in argon is approximately one in 10^7 and one in 10^8 by volume respectively. Helium or nitrogen can replace argon as the carrier gas, but the sensitivity is then greatly reduced.

The response of the detector is linear with gas concentration up to 1 per cent by volume of the diatomic gases. Using the detector illustrated in Fig. 1 the response to polyatomic gases is somewhat non-linear, especially at high frequencies. Recent experiments have shown, however, that the response to the concentration of polyatomic gases is dependent on the dimensions of the chamber and the magnitude of the primary electron current. There is reason for believing that with a modified design a linear response to the concentration of all gases can be achieved.

The device described would appear to have promise as a transducer for the concentration of permanent gases and of vapours such as water vapour which are otherwise difficult to measure.

I am indebted to Dr. S. R. Lipsky, of Yale University, for his advice and suggestions, and to Mr. P. Simmonds for expert technical assistance.

J. E. LOVELOCK

National Institute for Medical Research,
Mill Hill, London, N.W.7.

[1] McWilliam, I. G., and Dewar, R. A., "Gas Chromatography", edit. by Desty, D. H. (Butterworths, London, 1958).

[2] Lovelock, J. E., *J. Chromatography*, 1, 35 (1958).

[3] Lovelock, J. E., and Lipsky, S. R., *J. Amer. Chem. Soc.*, 82, 431 (1960).

[4] Townsend, J. S., "Electrons in Gases" (Hutchinson, London, 1947).

[5] Willis, V., *Nature*, 183, 1754 (1959).

Yield Stress exerted on a Body immersed in a Bingham Fluid

It is well known that finely divided, flocculated, aqueous suspensions of clay behave as Bingham fluids at concentrations less than about 25 per cent by volume. That is, their equation of flow is:

$$S = S_0 + \eta D$$

where S = shear stress applied, S_0 = minimum shear stress which will cause shearing, D = rate of deformation of the suspension, η = plastic viscosity.

Because such suspensions can resist stresses below a maximum value (often called the yield stress) without shearing, they should be able to hold bodies, in a certain range of density and size, stationary within themselves. A body should move only when the difference between its density and that of the suspension is sufficient for it to develop a force greater than that exerted on it through the yield stress of the suspension. The problem is to determine the magnitude of this limiting force, which we will call F_s.

For a cube falling with its faces horizontal and vertical, Yancey, Geer and Sokaski[1] have assumed that the minimum value of F_s would result from the yield stress S_0 acting over the bottom face only of the cube. Meerman[2] suggested that S_0 would act at least over the total vertical area of the cube, and Whitmore[3] that it would act over the whole surface area of the cube. We have so far been unable to find any reference to experimental measurements having been made on bodies, and, in order to test the various ideas, we have made some ourselves.

In our method the body is hung in the suspension by a fine thread attached to the free end of a horizontal wire, the other end being clamped to a bracket which can be raised or lowered on a screw thread. The body is of such a density as to sink in the suspension. When the body is in position in the suspension the free end of the wire is raised slightly then very carefully allowed to fall until the body comes into equilibrium, with F_s acting upwards on it. The bracket is then lowered about 1½ in., and carefully raised to its previous position. F_s is now acting downwards on the body, and the free end of the wire is a distance D_s below its original position. Thus $F_s = c\frac{D_s}{2}$, where c is the proportionality constant of the wire.

If S_0 acts uniformly over a body, the magnitude of F_s should be independent of the orientation of the body. However, measurements on two glass blocks, sized 6·2 × 1·9 × 0·8 cm. and 4·1 × 1·9 × 0·8 cm. in a 20 per cent by weight suspension of 'Supreme' kaolinite clay supplied by English Clays Lovering Pochin and Co., Ltd., showed that the orientation had a big effect on the value of F_s (Table 1). The reproducibility of F_s was in all cases better than ±8 per cent.

Table 1

Block	Horizontal face (cm.²)	F_s (dyne)
A	6·2 × 1·9	3,610
	6·2 × 0·8	2,230
	1·9 × 0·8	1,390
B	4·1 × 1·9	2,690
	4·1 × 0·8	1,420
	1·9 × 0·8	1,120

If it is assumed that different yield stresses prevail on the horizontal and vertical surfaces it can easily be shown that the best values to suit both of the bodies are:

Horizontal-face yield stress 145 ± 15 dyne cm.$^{-2}$
Vertical-face yield stress 29 ± 3 dyne cm.$^{-2}$.

The yield stress as obtained from viscosity measurements made with a Ferranti rotating-cylinder viscometer at 5 rates of shear was 52 dyne cm.$^{-2}$.

Thus it is clear that for suspensions of this type yield stresses obtained from viscometer measurements may not be of much use in predicting instability towards bodies immersed in them. A more detailed examination of this phenomenon is at present being made.

G. Boardman
R. L. Whitmore

Department of Mining and Fuels,
University of Nottingham.
May 30.

---

[1] Yancey, H. F., Geer, M. R., and Sokaski, M., Paper F1, Third International Coal Preparation Conference, Liège (1958).

[2] Meerman, P. G., Second Symposium on Coal Preparation, Leeds, 253 (1957).

[3] Whitmore, R. L., Second Symposium on Coal Preparation, Leeds, 282 (1957).

Effect of Electric Fields on Hydrogen-like Excitons

Some substances such as cadmium sulphide show long-range photo-effects; that is, if light falls on a crystal at some point then photo-conductivity can be observed in regions which may be several millimetres away from this point. There has been some dispute as to whether excitons play any part in this process of energy transfer[1]. Recently, Nikitine and Haken[2] have shown that the change of energy of an exciton in a magnetic field due to its diamagnetism may be appreciable compared with the thermal energy kT, at least if the field is high and the temperature low. They suggest that if exciton migration occurs then an inhomogeneous magnetic field should have a detectable effect on it.

We wish to point out that the interaction of an exciton with an electric field may be more easily observed. Suppose the exciton is describable in terms of a hydrogen-like s-function. Then it can be shown that in an electric field F its energy is decreased to a first approximation by:

$$\Delta E \simeq -\frac{9}{4} \kappa a_e^2 F^2 \qquad (1)$$

where κ is the dielectric constant of the crystal and a_e is the effective exciton radius. Since both these quantities can be large, ΔE can be very large. For example, if κ is 10 and a_e is 50 Å. then in a field of 3×10^4 V./cm. the value of ΔE will be equal to the exciton binding energy of 0·014 eV. This means that the perturbation energy is so large that we are already beyond the limit of validity of equation 1 and field ionization of the exciton can occur. The theory of this process for a hydrogen atom has been given by Oppenheimer[3]. Roughly, ionization occurs when the difference of potential energy across the exciton due to the applied field is equal to the binding energy E_b, or:

$$e a_e F_i \simeq E_b \qquad (2)$$

With the parameters used above the threshold field for ionization F_i is 2×10^4 V./cm.

Fields of such magnitude can be applied to a crystal by using external electrodes, but they also arise naturally within the crystal in the potential barriers at grain boundaries. If the density of centres contributing to the space charge in the barrier is 5×10^{16} cm.$^{-3}$ then a barrier height of only 0·1 V. will produce a field of 2×10^4 V./cm. Clearly much higher fields can be produced by applying an external voltage along a crystal containing a transverse grain boundary. The boundary will then attract excitons through the polarization mechanism described by equation 1 and destroy them by the ionization mechanism of equation 2. It will therefore be opaque to excitons but transparent to light, and we have a means of distinguishing between the two.

As an example, we have observed long-range photo-effects in high-resistivity gallium arsenide and have shown that they are entirely unaffected by the presence of a grain boundary. We conclude that in this material the effects are not due to exciton migration. A full account of these experiments will be published elsewhere.

Acknowledgment is made to the Admiralty for permission to publish this communication.

J. W. Allen

Services Electronics Research Laboratory,
Baldock,
Herts.

---

[1] See, for example, the papers of Broser, I., and Broser-Warminsky, R., Balkanski, M., and Diemer, G., *et al.* in "Proceedings of the Rochester Conference", *J. Phys. Chem. Solids*, 8 (1959).

[2] Nikitine, S., and Haken, H., *C.R. Acad. Sci., Paris*, 250, 697 (1960).

[3] Oppenheimer, J. R., *Phys. Rev.*, 31, 66 (1928).

Electron Microscope Images of Dislocations

Hirsch *et al.*[1] and Bollmann[2] observed dark and white spots in the electron microscopic image of thin metallic film, and suggested that the contrast is caused by the Bragg reflexion due to the distorted lattice around a dislocation. We call this, for convenience, *H.-B.* dislocation contrast. Menter[3] first observed an extra terminating half-line in the electron microscope image of platinum phthalocyanine, and suggested that the extra line is the image of the extra terminating half-plane associated with an edge dislocation in the crystal. We call this Menter's dislocation contrast. In Menter's dislocation, no contrast such as *H.-B.* dislocation can be observed.

A plane grating of 66μ spacing was irradiated by an almost parallel light-beam of wave-length 4900 Å. This corresponds to the electron optical system where a thin crystal is irradiated by electrons. Fig. 1*a* is an image of the grating with an extra terminating half-line near its centre which is photographed by allowing the diffracted beams of the order $n = 0$, ± 1, ± 2 to contribute to the image. This corresponds to Menter's dislocation contrast. The diffraction pattern of the grating is illustrated in Fig. 2. In a metal crystal, the spacing of the lattice is about a tenth of that of platinum phthalocyanine, and the Bragg angle of the diffracted electron beam is about ten times larger than that of phthalocyanine. In the image of a metal crystal, therefore, only one diffracted beam is permitted to contribute to the image by the small aperture in the objective lens. Fig. 1*b* shows an image of the same grating which is imaged under the conditions where only one part of a diffracted beam $n = +1$ contributes to the image. This corresponds to a dark-field image showing *H.-B.* dislocation contrast. Thus we are able to

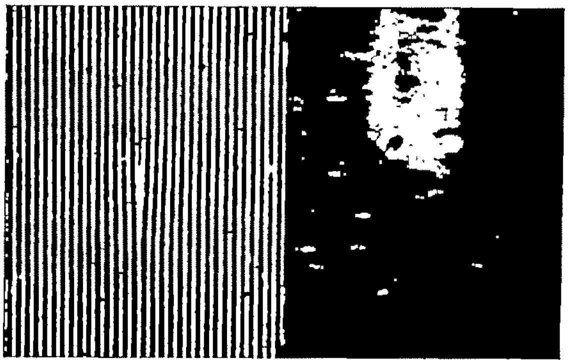

(a) (b)

Fig. 1. a, Amplitude grating with a dislocation near its centre imaged by allowing the diffracted beams of the order $n = 0, \pm 1, \pm 2$, to contribute to the image; b, the same imaged with a stop in back focal plane of lens to permit only a small part of a diffracted beam to pass through to image plane

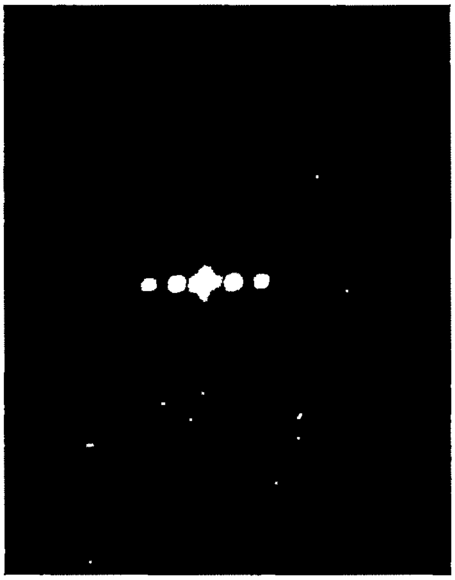


Fig. 2. Diffraction pattern of the grating shown in Fig. 1

produce images similar to those taken by Menter and *H.-B.* from the same grating[4].

In the experiment recorded in Fig. 1*b*, if the whole of a diffracted beam contributes to the image, the contrast shown in Fig. 1*b* will never be observed. However, it may be explained that the contrast of dislocation in plane grating is similar to that of *H.-B.* dislocation contrast of a crystal. The intensity of a diffracted beam from a crystal with sufficient thickness changes by the deviation from the Bragg angle. Therefore, the order of deviation can be detected by the variation of intensity of the diffracted beam, that is, brightness of the electron microscopic image. In a very thin crystal, which may be replaced by a plane grating, deviation from the Bragg angle will not produce the variation of intensity because of uniform intensity cross-section of reciprocal lattice point elongated normal to the crystal surface. In a very thin film, the amount of deviation from the Bragg angle can be detected only by the angular deviation of the diffracted beam from the Bragg angle. Therefore, in order to detect the amount of deviation by the variation of intensity of beam, it is necessary to use the very small aperture so that one part only of the diffracted beam can contribute to the intensity of the image.

In a real crystal the diffracted intensity depends on the crystal lattice potential and crystal thickness in addition to the deviation from the Bragg angle, and for a complete interpretation these quantities must be taken into account. The experiment described here does, however, give a useful qualitative interpretation of how these two types of dislocation contrast arise.

We wish to express our sincere thanks to Prof. K. Tanaka for his kind discussion and to Dr. J. Menter for his helpful discussion and for correcting the English.

HATSUJIRO HASHIMOTO
KAZUO FUJITA

Kyoto Technical University,
Matsugasaki, Sakyo-ku, Kyoto.

[1] Hirsch, P. B., Horne, R. W., and Whelan, M. J., *Phil. Mag.*, 1, 677 (1956).

[2] Bollmann, W., *Phys. Rev.*, 103, 1588 (1956).

[3] Menter, J. W., *Proc. Roy. Soc.*, A, 236, 119 (1956).

[4] Menter, J. W., *Phil. Mag.*, Supp. Adv. Phys., 7, No. 27, Figs. 18 and 62 (1958).

METALLURGY

Work-Hardening and Ductility of Rhenium and their Relation to the Behaviours of Other Metals having a Hexagonal Structure

POLYCRYSTALLINE rhenium work-hardens rapidly when tested in tension at room temperature (the proportional limit is 26,000 p.s.i. and the ultimate tensile strength is 164,000 p.s.i.[1]), and has an elongation of 24 per cent. The fracture is intergranular[2]. In the present communication an extension of the study of the mechanical properties of rhenium to single crystals is reported. The behaviour of rhenium is then compared with other metals having a hexagonal structure.

Crystals grown by the electron bombardment technique[3] were deformed in tension, and the dependence of their behaviour on orientation was studied. Slip occurred on the (0001) basal plane and on the $\{10\bar{1}0\}$ prismatic planes in agreement with earlier work in this laboratory on polycrystals[2]; the slip direction was $<11\bar{2}0>$ as with other close-packed-hexagonal metals which slip on these planes (beryllium, magnesium, titanium and zirconium). For each crystal, the first slip system which became operative was noted; this depends on orientation as shown in Fig. 1. From the position of the boundary *AB* it is seen that the critical resolved shear stress for (0001) slip is about half the critical resolved shear stress for

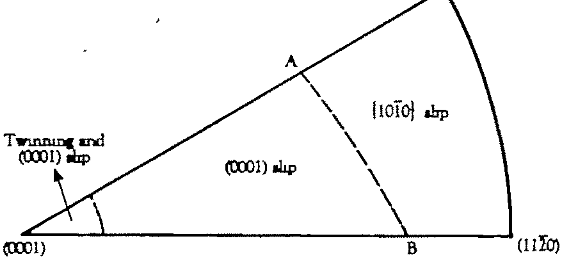


Fig. 1. Initially operative slip system as a function of orientation

$\{10\bar{1}0\}$ slip, the actual values being approximately 1,300 p.s.i. and 2,400 p.s.i. respectively.

All crystals were very ductile with elongations greater than 40 per cent. Specimens oriented with either a $\langle 10\bar{1}0\rangle$ or a $\langle 11\bar{2}0\rangle$ direction parallel to the tensile axis deformed by duplex $\{10\bar{1}0\}$ slip and necked down to a chisel-edge type fracture. In crystals oriented so that slip occurred initially on only one $\{10\bar{1}0\}$ plane the lattice rotated into an orientation which gave duplex $\{10\bar{1}0\}$ slip, leading to a similar fracture. The work-hardening rate was more rapid for slip on a $\{10\bar{1}0\}$ plane than on the (0001) plane, and when duplex $\{10\bar{1}0\}$ slip occurred the rate was greater still.

In contrast with this behaviour of rhenium crystals oriented with a $\langle 11\bar{2}0\rangle$ direction parallel to the tensile axis, similarly oriented beryllium crystals[4] deform by single $\{10\bar{1}0\}$ slip leading to fracture on a $\{11\bar{2}0\}$ plane after elongations of about 10 per cent.

Table 1

Metal	Critical resolved shear stress (p.s.i.)		C.R.S.S. (0001) slip / C.R.S.S. $\{10\bar{1}0\}$ slip	Elongation of polycrystalline metal at room temperature
	(0001) slip	$\{10\bar{1}0\}$ slip		
Beryllium	2,000	9,500	0·21 (ref. 4)	<5 per cent unless of special preferred orientation
Rhenium	1,300	2,400	0·5	25 per cent (ref. 1)
Titanium	9,000	2,000	4·5 (ref. 5)	≏ 50 per cent for iodide titanium (ref. 6)
Zirconium	>4,800	1,300	>3·7 (ref. 7)	≏ 40 per cent for iodide zirconium (ref. 8)

When the behaviours of polycrystalline hexagonal metals which slip on the $\{10\bar{1}0\}$ planes are compared, it appears that the ductility decreases as prism slip becomes more difficult (Table 1). Hauser, Landon and Dorn[9] reached a similar conclusion on comparing magnesium with magnesium base alloys. Such a correlation is compatible with current ideas on fracture; for it is generally believed that for brittle fracture to occur, energy must not be dispersed by plastic flow, and when multiple slip is possible, this dispersion of energy becomes easier.

R. A. JEFFERY
E. SMITH

Research Laboratory,
Associated Electrical Industries,
Aldermaston Court, Aldermaston,
Berkshire.

---

[1] Sims, C. T., Craighead, C. M., and Jaffee, R. I., *J. Metals*, 7, 168 (1955).

[2] Churchman, A. T., (to be published).

[3] Calverley, A., Davis, M., and Lever, R. F., *J. Sci. Instr.*, 34, 142 (1957).

[4] Tuer, G. L., and Kaufmann, A. R., "The Metal Beryllium", 372 (A.S.M., 1955).

[5] Churchman, A. T., *Proc. Roy. Soc.*, A, 226, 216 (1954).

[6] McQuillan, A. D., and McQuillan, M. K., "Titanium" (Butterworths, London, 1956).

[7] Rapperport, E. J., *Acta Met.*, 7, 254 (1959).

[8] Lustman, B., and Kerze, F., "The Metallurgy of Zirconium" (McGraw-Hill, New York, 1955).

[9] Hauser, F. E., Landon, P. R., and Dorn, J. E., *Trans. Amer. Soc. Met.*, 50, 856 (1958).

Borrmann Effect observed in an Aluminium Single Crystal

IN X-ray diffraction studies of a nearly perfect single crystal, Borrmann *et al.*[1] observed anomalous increases in the intensities not only of the diffracted but also of the transmitted ray. This phenomenon was interpreted by Laue[2] from the dynamical theory of X-ray diffraction. Such a dynamical effect on X-ray diffraction, however, has hitherto been observed only on some kinds of natural crystals of good quality. Fortunately, recent techniques are making it possible to obtain substances of high purity, and consequently experimental studies of the dynamical effect are possible without serious difficulty.

In general the crystal structure of a metal single crystal is imperfect, and accordingly the dynamical effect will be negligible. Lately, however, the change in the integrated intensity of X-rays due to cold-working has been examined with aluminium single crystals and a large effect of extinction was observed[3]. This result shows that the aluminium single crystal used was of good quality, and so the abnormal transmission described here might be observable in such cases. Hence the present experiment was carried out to ascertain whether it is possible to see the Borrmann effect in the aluminium single crystal also.

The crystal specimens were made by the following process: aluminium 99·995 per cent in purity, was cold-rolled into strips, approximately 4 mm. in thickness, and after etching and washing, the strips were annealed preliminarily at 500° C. for 2 hr., and after subjecting to 2 per cent elongation they were heated at 600° C. for 150 hr. to produce the single crystals. In the X-ray examination a copper target was used at 15 kV. and 7 m.amp., a nickel filter about 10μ in thickness was inserted, and the beam aperture was of the order of 5°. The irradiated area of the specimen was about 5 mm. in diameter, and the X-ray source was of the order of 1 mm. in diameter. The specimen was mounted on a goniometer and adjusted so as to obtain a (200) reflexion. The glancing angle of the incident ray was about 75° when set at the Bragg angle. An X-ray film, which was masked with a black paper, was placed so as nearly to touch the back surface of the specimen.

In some cases the Borrmann effect could be observed as shown in Fig. 1, from which it will be seen that the image is formed of two irregular intense lines, which are the images of the transmitted and the diffracted rays, respectively. As the X-ray source is, however, comparatively large, the fine structure of the image is obscure. Fig. 2 is a transmission Laue photograph from the region, either surface of which was ground carefully with emery

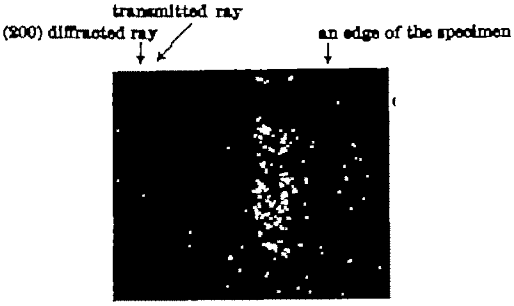


Fig. 1. X-ray image of an aluminium single crystal. (× 10)

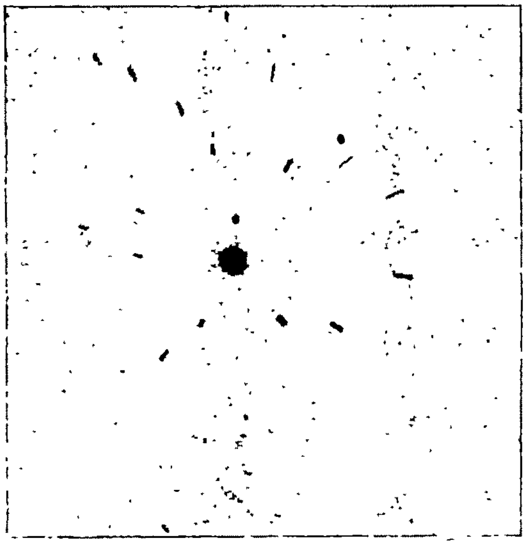


Fig. 2. X-ray photograph of an aluminium single crystal showing double spots

paper. It is clearly seen that each Laue spot is split into two parts. These correspond to an intense reflexion from the thin layer of either surface of the specimen[3]. The observation indicates a large extinction effect. Therefore it may be concluded that the Borrmann effect is also observable in an aluminium crystal of structurally good quality.

We are continuing our studies of the lattice defects of metals by using aluminium single crystals made by zone melting, and are expecting that the internal structure of the crystal will become observable more clearly with such materials of high purity.

KOICHI NAKAJIMA
SHIGEYASU KODA

Research Institute for Iron, Steel and Other Metals,
Tohoku University,
Sendai,
Japan.

---

[1] Borrmann, G., *Phys. Z.*, 42, 157 (1940). Borrmann, G., Hartwig, W., and Irmler, H., *Z. Naturforsch.*, 13, *a*, 423 (1958).

[2] von Laue, M., *Acta Cryst.*, 2, 106 (1949).

[3] Sutoki, T., and Nakajima, K., *Sci. Rep. Res. Inst., Tohoku Univ.*, A, 10, 77 (1958).

CHEMISTRY

The Silicon–Boron System

RECENTLY the synthesis of a compound of the composition SiB_4 has been reported in two articles[1,2]. Concurrent with this work we have been investigating this compound as a part of our programme for studying high-temperature materials.

The compound was prepared in two different ways: (*a*) by sintering in an argon atmosphere a mixture of finely powdered boron (99 per cent purity) with amorphous silicon in an electrical resistance-type furnace; (*b*) by melting a mixture of boron (about 10 per cent) and silicon (about 90 per cent) in a high-frequency induction furnace in an argon atmosphere. The last method usually gives very beautiful crystals of the new silicon boride (SiB_4) embedded in the silicon phase. The excess silicon was dissolved in a nitric acid–fluoric acid mixture.

By the first method of preparing the compound, we were able to study the behaviour of silicon–boron mixtures under various conditions. We have found that at temperatures between 1,200 and 1,380° C., the new compound is formed at first, but is then slowly decomposed into SiB_6 and silicon. At temperatures below 1,200° C. it is stable for long periods. The pure compound, apparently free from SiB_6 and silicon, has been prepared from the stoichiometric mixture heated at 1,200° C. for about three weeks in an argon atmosphere.

Several of our chemical analyses and density measurements indicate the formula SiB_4 (39·3 wt. per cent silicon). Some of our analyses, however, gave higher values of the silicon percentage (up to 48 wt. per cent silicon) and some density measurements also gave considerably higher values (up to 2·55 gm./cm.^{3}) than the one calculated for SiB_4 from our unit cell data: $a = 6{\cdot}319 \pm 0{\cdot}005$ Å. $b = 12{\cdot}713 \pm 0{\cdot}010$ Å. (2·43 gm./cm.^{3}). (Compare the result of Moissan's investigation[3] of apparently the same compound: formula SiB_3, density 2·52.) This suggests a fairly broad homogeneity range, which is also in accordance with the structural arrangements proposed by us. As a further support of this, we have noticed a small variation in relative line intensities from different samples.

From Weissenberg data a two-dimensional Patterson projection along the hexagonal *c*-axis was carried out. The result bears a close resemblance to the corresponding Patterson synthesis for CB_4 (ref. 4), and it would be reasonable to believe that the two compounds are isostructural. However, there are certain discrepancies, and therefore a three-dimensional Patterson synthesis was carried out. It shows that in the 0,0,*z*-position only two atoms are situated, about 2·4 Å. apart. The other atomic positions form icosahedrons in approximately the same manner as in CB_4. The atoms of an icosahedron are of two different sizes, the atoms forming the top and bottom of the icosahedron having higher electron density than the others.

A reasonable way to interpret these facts is the following. Consider the space group $R\bar{3}m$, formula SiB_4 with 9 molecules in the hexagonal cell. 6 of the 9 silicon atoms are placed in a 6*c* position, the other 3 silicon atoms and 15 boron atoms are statistically distributed over an $18h_1$ position ($x \approx 0{\cdot}11$, $z \approx 0{\cdot}87$), and 18 boron atoms are placed in an $18h_2$ position ($x = 1/6$, $z \approx 0{\cdot}02$). The remaining three boron atoms may be placed in interstitial positions or the composition may not be SiB_4. The presumed substitution of boron atoms by silicon atoms in $18h_1$ naturally gives room for a large variation of the composition.

In addition to the work on SiB_4, we have made some preliminary measurements on a part of the liquidus curve of the silicon–boron system. The result is given in Table 1. It is evident that there is a eutectic at about 3 per cent boron.

Table 1. LIQUIDUS TEMPERATURES OF SILICON–BORON MIXTURES

Weight per cent boron	Temperature of final disappearance of the solid phase (° C.)
0	1,420
1	1,415
2	1,406
3	1,403
4	1,411
5	1,414
6	1,420
7	1,422
8	1,431
9	1,421
10	1,431

The work on this liquidus curve and on the structure of SiB_4 will be continued. A three-dimensional Fourier synthesis is being carried out at the moment and the exact parameters will be published later.

CYRILL BROSSET
BENGT MAGNUSSON

Institution of Inorganic Chemistry,
Chalmers University of Technology,
Gothenburg.

---

[1] Colton, R., *J. Amer. Chem. Soc.*, 82, 1002 (1960).

[2] Cline, C. F., and Sands, D. E., *Nature*, 185, 456 (1960).

[3] Moissan, H., and Stock, A., *C.R. Acad. Sci., Paris*, 131, 139 (1900).

[4] Zhdanov, G. S., and Sevast'yanov, N. G., *C.R. Acad. Sci., U.R.S.S.*, 32, 432 (1941). Note that the parameter values given in this work refer to an old convention (equivalent positions: 0,0,0; 1/3,2/3,1/3; 2/3,1/3,2/3 instead of 0,0,0; 1/3,2/3,2/3; 2/3,1/3,1/3).

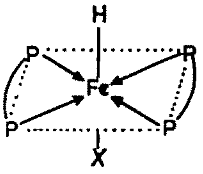
Some New Hydrides of Iron and Osmium

STABLE hydrido-complexes of the type *trans*-[MHX(phosphine)$_2$] (X = halogen or similar anionic ligand, phosphine = tertiary phosphine or chelate di-tertiary phosphine) containing the heavier transition metals ruthenium[1], osmium[1], palladium[2] and platinum[2] have been reported and a very unstable nickel derivative is also known[3]. Here we report the first stable derivatives containing a metal (iron) from the first transition series. These are interesting because the halo-hydrides (II) and (IV) show enormous chemical shifts in the proton resonance spectrum and because the hydride (I) was prepared from the metal and gaseous hydrogen. They have the *trans*-octahedral structure shown below and their properties are summarized in Table 1.

Table 1. PROPERTIES OF THE COMPLEX IRON HYDRIDES

Compound	m.p. (vacuum)	$\nu_{\text{Fe—H}}$	$\delta_{\text{Fe—H}}$ ('Nujol' mulls)	$\nu_{\text{Fe—D}}$	$\delta_{\text{Fe—D}}$	Chemical shift (p.p.m., water standard)
(I)	248–252° dec.	1,726(*s*)	716(*m*)	1,259(*s*)	525(*m*)	+18·4 (C_6H_6)
(II)	154·5–155·5° dec.	1,849(*s*)	—	1,336(*s*)	—	+39·1 (C_6H_6)
(III)	180° dec.	1,810(*s*)	—	—	—	—
(IV)	dec. *c.* 220°	1,870(*s*)	—	—	—	+36·0 (C_6H_6)

Trans-[$FeH_2\{o\text{-}C_6H_4(PEt_2)_2\}_2$] (I) is prepared by dissolving finely divided iron in the diphosphine, $o\text{-}C_6H_4(PEt_2)_2$, at 190° under hydrogen at atmospheric pressure, or by reducing *trans*-[$FeCl_2\{o\text{-}C_6H_4(PEt_2)_2\}_2$] or [$FeCl_2\{o\text{-}C_6H_4(PEt_2)_2\}_2$][$FeCl_4$] with excess lithium aluminium hydride. It is an orange crystalline substance, easily soluble in organic solvents, monomeric in boiling benzene, and thermally remarkably stable but very sensitive to air. The red crystalline hydrido-chlorides (II) and (III) are obtained by lithium aluminium hydride reduction of *trans*-[$FeCl_2$(diphosphine)$_2$], while (IV) is made by the reaction of *trans*-[$FeH_2\{o\text{-}C_6H_4(PEt_2)_2\}_2$] with one equivalent of hydrochloric acid in dry ether.



(I) X = H, P—P = $o\text{-}C_6H_4(PEt_2)_2$
(II) X = Cl, P—P = $C_6H_4(PEt_2)_2$
(III) X = Cl, P—P = $C_6H_4(PMe_2)_2$
(IV) X = Cl, P—P = $o\text{-}C_6H_4(PEt_2)_2$

Trans-[$OsHCl\{C_6H_4(PEt_2)_2\}_2$], which completes the first eutropic series of phosphino-hydrides, has also been prepared, and a comparison of properties is made in Table 2.

Table 2. SOME PROPERTIES OF *trans*-[$MHCl\{C_6H_4(PEt_2)_2\}_2$] ($M$ = Fe, Ru, Os)

M	m.p. (vacuum)	Colour	Dipole moment (±0·2 D)	$\nu_{M\text{—H}}$ ('Nujol' mull)	Chemical shift (p.p.m., water standard)
Fe	154·5–155·5 dec.	red	4·25	1,849	+39·1 (C_6H_6)
Ru	174·5–176	colourless	4·9	1,944	+27·1 ($CHCl_3$) +26·1 (C_6H_6)
Os	170·5–171·5	colourless	4·6	2,051	+31·3 ($CHCl_3$)

It will be noted that $\nu_{M\text{-H}}$ increases by 202 cm.$^{-1}$ on passing from M = iron to M = osmium, corresponding to about 24 per cent increase in bond-strength (force constant) on ascending the series. This is also the sequence of increasing thermal stabilities.

The chemical shift of the proton resonance in compound (II) is the largest ever recorded. It is even greater than the shift of the proton resonance in water relative to the unshielded proton (27 p.p.m.).

We are indebted to Dr. N. Sheppard of the University of Cambridge for the nuclear magnetic resonance spectra, to Dr. D. M. Adams for the infra-red spectra and to Miss L. Bates for the dipole moment determinations.

J. CHATT
F. A. HART
R. G. HAYTER

Imperial Chemical Industries, Ltd.,
Akers Research Laboratories,
The Frythe,
Welwyn, Herts.

---

[1] Chatt and Hayter, *Proc. Chem. Soc.*, 153 (1959).

[2] Chatt, Duncanson and Shaw, *Proc. Chem. Soc.*, 343 (1957); *Chem. and Indust.*, 859 (1958).

[3] Green, Street and Wilkinson, *Z. Naturforsch.*, 738 (1959).

Gas Liquid Chromatography of Conjugated Fatty Acids

THE heating of polyunsaturated fatty acids in strong alkali is known to cause re-arrangement of the double bonds to form a conjugated system[1]. The effect of this isomerization on the behaviour of polyunsaturated fatty acids in gas liquid chromatography has been studied in relation to linoleic and linolenic acids as found in wheat flour oil.

Oil was extracted by shaking the flour continuously for 2 hr. with carbon tetrachloride under nitrogen. The extract was filtered to remove flour particles and the solvent removed under vacuum in a rotary evaporator. Unconjugated fatty acids were prepared by saponification of the oil under nitrogen with 0·5 N methanolic potassium hydroxide, refluxing for 2 hr. Following acidification and ether extraction, the free fatty acids were methylated by reaction with diazomethane[2].

Conjugated fatty acids were prepared by an adaptation of the alkaline isomerization method[3] for analysis of unsaturated fatty acids. The oil was heated in a solution of 6·6 per cent potassium hydroxide in ethylene glycol at 180° C. for 25 min. under a stream of oxygen-free nitrogen. The mixture was cooled, diluted with water and acidified, when the isomerized free fatty acids were extracted with ether. The fatty acids were methylated as before by reaction with diazomethane.

The mixed methyl esters were analysed with a Pye argon chromatograph using a column packed with 2·3 per cent poly(ethyleneglycol adipate) as stationary phase on 60–100 mesh diatomaceous earth (M. and B. 'Embacel'). The chromatograms of the

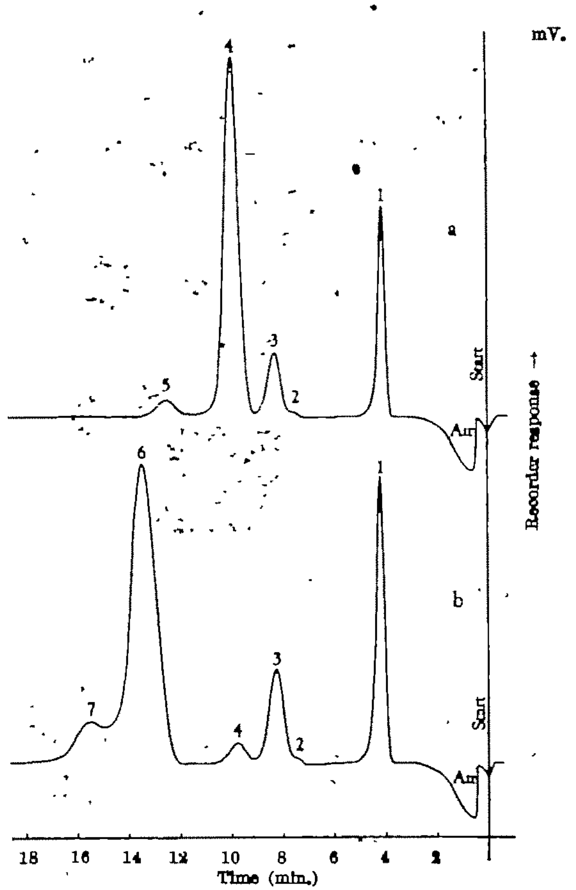


Fig. 1. Gas liquid chromatograms of fatty acid methyl esters from (*a*) unisomerized and (*b*) isomerized wheat flour oil. Column: 120 cm. × 0·4 cm. with argon flow of 20 ml. per min. at 177° C. Peak identification: (1) methyl palmitate; (2) methyl stearate; (3) methyl oleate; (4) methyl linoleate; (5) methyl linolenate; (6) methyl linoleate, conjugated isomer; (7) methyl linolenate, conjugated isomer

methyl esters of the unisomerized and isomerized fatty acids (Figs. 1*a* and *b*) show that following isomerization there is a change in the position occupied by the esters of linoleic and linolenic acids, the conjugated isomers being retained by the stationary phase to a greater extent than the unconjugated acids.

The retention volumes for individual esters, and the percentage composition of the two mixtures are given in Table 1. These results show that isomerization increased the retention of methyl linoleate by 36 per cent, and of methyl linolenate by 24 per cent. The excessive broadening of the conjugated fatty acid ester peaks in Fig. 1*b* may be due to the presence of *cis*- *trans*-isomerism in the conjugated systems. Such isomerism in a conjugated system has been shown by Hoffmann and Keppler[4] to affect the position of 2,4 decadienals in gas liquid chromatography on a silicone-oil column.

Table 1. Gas Liquid Chromatography Analysis of Isomerized and Unisomerized Flour Oil

Fatty acids (as methyl esters)	Retention vol. (ml.)	Relative retention time (oleic = 1·00)	Percentage composition	
			Unisomerized	Isomerized
Palmitic acid	81	0·60	17·5	19·3
Stearic ,,	149	0·91	0·3	0·5
Oleic ,,	163	1·00	11·3	11·6
Linoleic ,,	195	1·20	65·9	2·9
Linolenic ,,	247	1·51	5·0	—
Conjugated linoleic ,,	266	1·63	—	60·1
Conjugated linolenic ,,	306	1·88	—	6·5

The presence of 2·9 per cent of unconjugated methyl linoleate in the isomerized sample indicated incomplete isomerization of the oil by the method[3] used. This was reflected in the low figure of 60·1 per cent for conjugated methyl linoleate as compared with the presence of 65·9 per cent methyl linoleate in the unisomerized sample. However, the total percentage of polyunsaturated acids in the two samples agreed well (unisomerized 70·9 per cent, isomerized 69·5 per cent) and was within the expected error of a single-run determination.

The effect of isomerization on the position of these unsaturated acids when analysed on a column having 5·9 per cent 'Apeizon *L*' grease as stationary phase was also examined. With this type of column the order of elution of saturated and unsaturated fatty acid esters is the reverse of that found using the polar polymer stationary phase mentioned above; that is, increasing unsaturation shortens the retention time of acids having equal carbon chain-lengths.

As previously found[6], the retention time of the polyunsaturated acids was increased after isomerization. The retention time for methyl linoleate increased by 27 per cent, and for methyl linolenate by 58 per cent. This change was particularly striking since before isomerization the unsaturated acids were not separated by this column, whereas after isomerization methyl linoleate was completely separated from methyl oleate, although its position was now coincident with that occupied by methyl stearate.

The marked change in retention time of polyunsaturated acids following isomerization demonstrates the importance of using mild conditions for the saponification of lipids containing such acids during the preparation of the free fatty acid esters for gas liquid chromatography. Thus, inadvertent formation of conjugated acids during the saponification procedure is likely to give rise to anomalous peaks on the chromatograms which will affect both the qualitative and quantitative analyses of the acids present.

In view of this possibility when using the saponification procedure, an alternative method of preparing lipid material for gas liquid chromatography analysis is perhaps to be preferred. Inter-esterification with dry methanol in the presence of an acid, followed by extraction and high-vacuum distillation of the methyl esters formed[5], is one such method, and is now being used exclusively in this laboratory.

We wish to thank Mr. R. J. Davies for technical assistance in this work.

N. W. R. Daniels
J. Wendy Richmond

Spillers Limited,
Technological Research Station,
Station Road,
Cambridge.
Feb. 22.

[1] Pitt, G. A. J., and Morton, R. A., "Progress in the Chemistry of Fats and Other Lipids", 4, 243, edit. by Holman, R. T., Lundberg, W. O., and Malkin, T. (Pergamon Press, 1957).

[2] De Boer, Th. J., and Backer, H. J., *Rec. Trav. Chim.*, 73, 229 (1954).

[3] "Official and Tentative Methods", Cd. 7–58 (American Oil Chemists' Society, Chicago, 1958).

[4] Hoffmann, G., and Keppler, J. G., *Nature*, 185, 310 (1960).

[5] Stoffel, W., Chu, F., and Ahrens, jun., E. H., *Anal. Chem.*, 31, 307 (1959).

[6] Beerthuis, R. K., Dijkstra, G., Keppler, J. G., and Recourt, J. H., *Ann. N.Y. Acad. Sci.*, 72, 616 (1959).

RADIOCHEMISTRY

Radiolysis of Highly Enriched Oxygen-18 Water Solutions containing Hydrogen Peroxide-16,16

The use of the isotope oxygen-18 opens new possibilities to gain information regarding the primary processes in irradiated aqueous solutions. Using ordinary water in the presence of oxygen-16,18, Hart, Gordon and Hutchison[1] were able to obtain information regarding some of the reactions of molecular oxygen. Backhurst, Johnson, Scholes and Weiss[2], using water enriched 1·5 mol. per cent in oxygen-18 at pH 1·2, were able to investigate the incorporation of oxygen-18 into the hydrogen peroxide formed. Recently, highly enriched (92–95 atom per cent oxygen-18) water became available prepared in the Isotope Distillation Plant of the Weizmann Institute and contained practically 100 per cent deuterium), which enables one to investigate the fundamental processes involved, and high concentrations of hydrogen peroxide-16,16 itself may be used to protect the hydrogen peroxide formed by various mechanisms, while serving as a scavenger of radicals at the same time.

We investigated the action of 200-kVp. X-rays and 2·9-MeV. protons on solutions of approximately 1 M hydrogen peroxide-16,16 in water, which contained 92–95 atom per cent oxygen-18.

Reactions were carried out in the presence and absence of initially added oxygen-16,16 or oxygen-18,18 (94 per cent) and in the presence or absence of added 1 M bromide. The reaction products investigated were oxygen-16,16, oxygen-16,18 and oxygen-18,18 formed during radiolysis as well as the same species formed from the decomposition of the hydrogen peroxide after irradiation was completed. Hydrogen peroxide was decomposed by platinum-black, which has been shown (Anbar, M., unpublished work) not to produce during decomposition any induced exchange between the various isotopic species of hydrogen peroxide. Hydrogen peroxide also does not appreciably exchange its oxygen with water. The presence of a high concentration of hydrogen peroxide protects the hydrogen peroxide formed during irradiation, the isotopic composition of which remains intact, and enables its total yield and mode of formation to be investigated.

It was found that in the case of X-rays the yield of hydrogen peroxide-18,18 is relatively unaffected by added bromide ions; the yield is proportional to dose up to total doses of 2 Mrads, the G value being approximately 0·4. On the other hand, in the case of proton irradiation, the yield of hydrogen peroxide-18,18 is reduced by a factor of nearly 10 when bromide is present during irradiation.

The yield of hydrogen peroxide-16,18 in a solution irradiated with X-rays is reduced to half in the presence of bromide, and to one-tenth when proton irradiation is used. For X-rays, the yield of hydrogen peroxide-16,18 remains approximately constant in the pH range 0·3–11. That of hydrogen peroxide-18,18 decreases very significantly above pH 8. These results point to different mechanisms for the formation of hydrogen peroxide-18,18 and hydrogen peroxide-16,18. Tracer experiments using originally added oxygen-18,18 proved that hydrogen peroxide-18,18 does not originate to any large extent from this source. In addition to the radical intermediates H and OH formed from the water by the radiations[3], it is assumed that molecular products, H_2 and H_2O_2, may be produced directly from water[4].

Our results show that hydrogen peroxide-18,18 can indeed be formed through a distinct 'molecular' mechanism from water alone, whereas 'scrambled' hydrogen peroxide-16,18 results from reactions of $H^{18}O$ radicals or their equivalent with hydrogen peroxide-16,16, according to:

$$^{18}OH + H^{16}O - {}^{16}OH \rightarrow H^{18}O - {}^{16}OH + {}^{16}OH$$

Full details of this work are being prepared for publication.

MICHAEL ANBAR
SHMUEL GUTTMANN

Isotope Department,
Weizmann Institute of Science,
Rehovoth.

GABRIEL STEIN

Department of Physical Chemistry,
Hebrew University,
Jerusalem, Israel.

---

[1] Hart, E., Gordon, S., and Hutchison, D. A., *J. Chim. Phys.*, 52, 570 (1955).

[2] Backhurst, J. D., Johnson, G. R. A., Scholes, G., and Weiss, J., *Nature*, 183, 176 (1959).

[3] Weiss, J., *Nature*, 153, 748 (1944).

[4] Allen, A. O., and Schwarz, H. A., Proc. Second Int. Conf. Peaceful Uses of Atomic Energy, 29, 30 (1958).

Non-destructive Analysis of Microgram Quantities of Silver by Radioactivation

A non-destructive method of determining μgm. quantities of silver by use of the nuclear reactor *JRR*-1 and an *RCL*-256-channel pulse-height analyser has been investigated.

In the present work, a sample (0·1–10 gm.) is placed in the reactor for 30 sec. to be irradiated with neutrons at a flux of 3×10^{11} neutrons per sq.cm./sec., cooled for 10 sec., counted for 20 sec., further cooled for 10 sec., and counted for 20 sec. The scintillator used is a 2-in. thick, well-type sodium iodide crystal. An aluminium vessel (2·5-mm. thick) is inserted in the well as an absorber for β-rays. At the first counting 128 channels in the analyser are used, and in the second counting the rest are used. The resultant γ-spectrum shown on the monitor (Braun tube) is photographed and the height of photopeak due to 0·66 MeV. γ-rays with silver-110 ($T_{1/2}$ = 24·2 sec.) is measured. By the comparative method the amount of silver is determined.

An example of the coefficient of variation of single analyses has been obtained by the use of six standard samples which include 1·25 μgm. of silver each. The coefficient estimated from six values is only 2·8 per cent, the average area under photopeak being $3 \cdot 4 \times 10^3$ counts. Results of analysis are shown in Table 1.

In the case of lead, interference is negligible. In the case of bismuth, slight interference due to *Bremsstrahlung* is found. In the case of zinc sulphide, though two

Table 1. RESULTS OF ANALYSES

Sample	Silver found (p.p.m.)
Lead	1·09
Bismuth I	7·6
Bismuth II	< 0·02
Zinc sulphide (silver added)	23·2

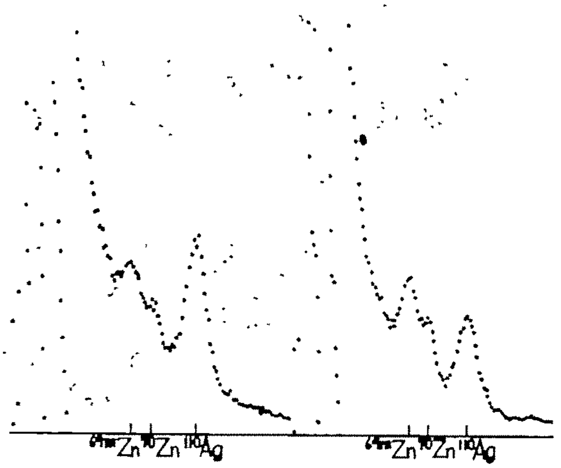


Fig. 1. γ-Spectrum. Sample: 0·35 gm. of silver-added zinc sulphide

photopeaks due to 0·438 MeV. γ-ray with zinc-69 *m* and 0·513 MeV. γ-ray with zinc-71, respectively, are found, the extent of interference is small (Fig. 1). From this the lower limit of the detection of silver in zinc sulphide is estimated at about 1 p.p.m. Further, it can be deduced that, if the matrix of a sample is made of an element which is less activated than zinc under the conditions described above, the detection limit of silver is less than 1 p.p.m. Such elements have been found in the literature on the basis of activation cross-section, half-life of nuclide formed, abundance of unconverted γ-photons of nuclide formed, and of neutron absorption cross-section, and are shown in Table 2.

Table 2. ELEMENTS IN WHICH THE DETECTION LIMIT OF SILVER IS LESS THAN 1 P.P.M.

(Arranged by increasing γ-activity to be induced under conditions in this work)

H	He	Be	C	N	Pb	Bi
Ne	O	Zr	S	Tl	Y	Ce

I hope to publish a full account of this work in the *Nippon Kagaku Zasshi* (*Journal of the Chemical Society of Japan*).

I am indebted to Prof. Shoji Makishima for encouragement, and to Dr. Toshio Nakai for permission to use laboratory facilities. My thanks are also due to Dr. Seishi Yajima, Dr. Yuichiro Kamemoto, Mr. Koreyuki Shiba and Mr. Terutomi Moki for their help with the γ-spectra.

MINORU OKADA

Government Chemical Industrial
Research Institute, Tokyo,
Shibuya-ku, Tokyo.

Jan. 26.

Radiolytic Oxidation of Ferrous Solutions with Standardized Internal Sources of Phosphorus-32

THE 'Fricke' solution is the most common chemical dosimeter in use at present, but the *G*-value of the oxidation is still not universally accepted. We have redetermined this value by radiolysis with 100–250 mc. phosphorus-32 dissolved in air-saturated 0·8 *N* sulphuric acid containing 10^{-3} *M* ferrous ions (as ferrous ammonium sulphate) and 10^{-3} *M* chloride (as sodium chloride). The energy dissipated by the radioactive decay was determined from standardization of the radioactivity by 4π-proportional counting as well as 4π-liquid scintillation counting, and an acceptance of the calculated value[1] of 0·69 MeV. for the average energy per disintegration of phosphorus-32.

The standardization values as obtained by the 4π-liquid scintillation method are about 1·1 per cent higher than those from 4π-proportional counting. This discrepancy is consistent and quite reproducible[2]. For some years now it has been believed that the proportional counting method was very nearly 100 per cent efficient for high-energy beta emitters such as phosphorus-32[3], but recent work[4] using sodium-24 and phosphorus-32 incorporated in the same compound, $^{24}\mathrm{NaH}_2{}^{32}\mathrm{PO}_4$, in which each radionuclide was separately standardized, the former by β–γ coincidence and the latter by 4π-proportional counting, showed that the self-absorption correction for phosphorus-32 amounted to about 1 per cent. It is thus possible that the newer 4π-liquid scintillation method may be more accurate than 4π-proportional counting.

Carrier-free phosphorus-32, produced by neutron irradiation of sulphur, contains some phosphorus-33. The relative amounts of the two isotopes were determined by measuring the radioactivities of the lines corresponding to mass-charge ratios between 47 and 51 as obtained by the isotope separator of the National Physical Research Laboratory, Pretoria. The phosphorus-33 content was 1·6 ± 0·16 per cent of the total activity.

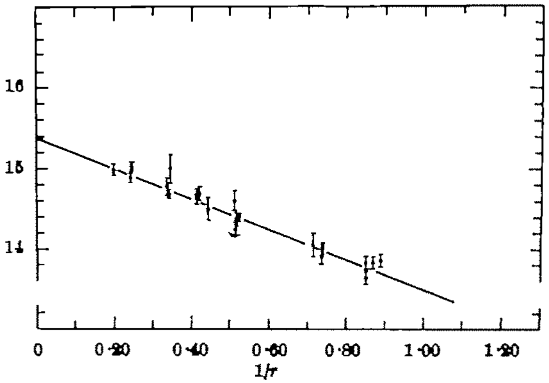


Fig. 1. Variation of apparent *G*-value with radius^{-1}

Corrections for the loss of energy through the walls of the containers were made by measuring the apparent yield, G_r, for each of 22 spherical glass containers of radius *r* and extrapolating the plot of G_r against $1/r$ to zero. Fig. 1 shows the results obtained (standardization by proportional counting). The errors marked are standard errors for each flask, and the straight line is that calculated by the method of least squares, each point being given a statistical weight in accordance with the number of replicate determinations made with the corresponding flask. The same data were used to determine the '95 per cent error' of the *G*-value at infinite radius. The results obtained were:

for 4π-proportional counting	15·39 ± 0·04 ions/100 eV.
for 4π-liquid scintillation counting	15·21 ± 0·04 ions/100 eV.

The assumption of linearity of G_r with $1/r$ is justified by the fact that the discrepancies between values obtained from the straight line and those calculated from data published by Hine and Brownell[1] lie within the experimental errors.

M. PEISACH

Radiochemistry Section,
National Chemical Research Laboratory,

J. STEYN

Radioactivity Division,
National Physical Research Laboratory,
South African Council for
Scientific and Industrial Research,
Pretoria.

---

[1] Hine, G. J., and Brownell, G. L., "Radiation Dosimetry" (Academic Press, New York, 1956).

[2] Steyn, J., Proc. Symp. Metrology Radionuclides, Vienna, 1959 (in the press).

[3] Pate, B. D., and Yaffe, L., *Canad. J. Chem.*, **33**, 15, 925, 1656 (1955).

[4] Campion, P. J., Taylor, J. G. V., and Merritt, J. S., Proc. Symp. Metrology Radionuclides, Vienna, 1959 (in the press).

BIOCHEMISTRY

Oxidative Phosphorylation: Synthesis of Adenosine Diphosphate by the Oxidation of Quinol Phosphates

THE importance of oxidative phosphorylation in the respiratory chain of living organisms has led to intensive research into the possible *in vivo* and *in vitro* mechanisms of phosphorylation[1], and several theories have been advanced which postulate quinol phosphates[2-4] (or analogous nitrogenous systems derived from riboflavin[5,6]) as the active intermediates in phosphate transfer.

An earlier communication from this Laboratory[4] reported the formation of inorganic pyrophosphate during the oxidation of 2-methyl naphtha-1 : 4-quinol diphosphate in aqueous solution in the presence of orthophosphate, and this work has now been extended to the synthesis of adenosine diphosphate. Two routes have been successfully followed, in one of which phosphate has been transferred to adenylic acid as substrate, and in the other the nucleotide has been transferred to inorganic phosphate as substrate.

In the first of these two syntheses of adenosine diphosphate, 2 : 3-dimethyl naphtha-1 : 4-quinol monophosphate was oxidized by bromine in the presence of the tetra *n*-butyl ammonium salt of adenosine-5′-phosphate under rigorously anhydrous conditions in N,N-dimethyl formamide. After removal of excess bromine by *cyclo*hexene and evaporation of the solvent, the residue was dissolved in water and passed down a cation-exchange column ('Amberlite *IR*-120', H^+ form). The eluate and washings were freeze-dried, the residual gum dissolved in ethanol, and the nucleotide fraction precipitated with ether[7]. Repetition of this procedure removed ortho- and pyrophosphate. The nucleotide fraction was chromatographed on an anion-exchange column ('Dowex-1', Cl^- form) and the adenosine diphosphate isolated as the free acid (yield estimated spectrophotometrically, 25 per cent). The product had the correct analysis, a phosphorus to nitrogen ratio of 1 : 2·51, and ran as a single spot during paper chromatography and paper electrophoresis. An enzymic estimation (on a sample which had been kept for a week) using phospho-enol pyruvate-pyruvate kinase and myokinase showed the sample to contain 72 per cent adenosine diphosphate and 28 per cent adenylic acid. A parallel assay on the sodium salt of adenosine diphosphate supplied by the Sigma Chemical Co., St. Louis, Missouri, gave values of 87 per cent adenosine diphosphate and 13 per cent adenylic acid.

In the second synthesis, a naphtha-1 : 4 quinol ester of adenylic acid was oxidized in the presence of inorganic phosphate. Adenosine diphosphate was again isolated as the free acid and assayed as before. The results obtained in the two syntheses were virtually identical.

Further details of this work will appear elsewhere. We are indebted to Dr. K. J. M. Andrews (Roche Products, Ltd.) for helpful discussion and the provision of certain materials, and to Dr. J. B. Chappell (Department of Biochemistry, Cambridge) for the enzymic assays.

V. M. CLARK
D. W. HUTCHINSON
ALEXANDER TODD

University Chemical Laboratory,
Cambridge.

---

[1] Slater, E. C., *Rev. Pure and App. Chem. (Australia)*, **8**, 221 (1958).

[2] Wessels, J. S. C., *Rec. trav. chim. Pays-Bas*, **73**, 529 (1954).

[3] Harrison, K., *Nature*, **181**, 1131 (1958).

[4] Clark, V. M., Kirby, G. W., and Todd, Sir Alexander, *Nature*, **181**, 1650 (1958).

[5] Glahn, P. E., and Nielsen, S. O., *Nature*, **183**, 1578 (1959).

[6] Grabe, B., *Arkiv för Kemi*, **15**, 323 (1960).

[7] Hall, R. H., and Khorana, H. G., *J. Amer. Chem. Soc.*, **77**, 5057 (1955).

N-Terminal Amino-Acids of Bovine Antibody

BOVINE γ-globulin has been shown to be a mixture of molecules having N-terminal amino-acids, aspartic acid, glutamic acid, serine, alanine and valine with a total of less than 1 mole/mole of γ-globulin[1]. A partial fractionation was achieved by partition chromatography of γ-globulin; the molecules with N-terminal aspartic acid, serine and alanine were concentrated in the faster running fractions, but valine, the principal N-terminal acid, was present in all the fractions[2]. Glutamic acid was present in only trace amounts in all the fractions.

In view of these results, we suggested that there were two types of γ-globulin: (1) with N-terminal aspartic acid, serine and alanine; (2) with N-terminal valine, and that a partial fractionation of these two types had been obtained. McFadden and Smith[1] analysed γ-globulin from a cow which had been strongly immunized with mixed antigens and found a much higher content of N-terminal valine and only traces of other amino-acids.

This led us to suggest that antibody γ-globulin had only N-terminal valine, and that the molecules with the other N-terminal amino-acids were really β-type globulins which have an electrophoretic mobility similar to that of antibody. We also found that true β-globulin had N-terminal aspartic acid, glutamic acid, serine, alanine, threonine, but no N-terminal valine.

The gift of bovine antibody to a well-characterized antigen (rabbit serum albumin) by Drs. F. J. Dixon and W. O. Weigle enabled us to test our suggestion. The bovine antibody was received as a freeze-dried specific precipitate prepared from the colostrum of an immune cow. It contained 19 per cent of rabbit serum albumin. Rabbit albumin was found to have glutamic acid as N-terminal amino-acid, present in 0·6 mole/mole albumin. The N-terminal amino-acids of the specific precipitate, after allowance for

Table 1. N-TERMINAL AMINO-ACIDS IN BOVINE γ-GLOBULIN

	Amount of N-terminal amino-acid mole/mole protein	
	Commercial preparation	Antibody
Aspartic acid	0·12	0·04
Glutamic acid	0·03	0·00
Serine	0·12	0·10
Alanine	0·11	0·10
Valine	0·42	0·25
Total	0·81	0·49

the N-terminal glutamic acid present in the antigen, are given in Table 1 together with a parallel determination of the N-terminal acids of bovine γ-globulin (Armour Laboratories preparation).

The results for the commercial preparation of bovine γ-globulin agree well with previous results[2] and it can be seen that the N-terminal amino-acid content of the antibody is almost equally complex. Glutamic acid is apparently absent, after allowing for the contribution of the rabbit albumin present in the specific precipitate, but the other four terminal acids are present, all in somewhat lower amounts.

These results do not support the previous suggestion that the complexity of N-terminal amino-acids of bovine γ-globulin arise from contamination with biologically unrelated β-type globulin. The low total yield suggests that in half the molecules the peptide chains are cyclic, or that certain structural features prevent the reaction of the fluor-dinitrobenzene with the terminal amino-group.

We wish to thank Drs. Dixon and Weigle for their generous gift of bovine antibody, and Mr. M. C. Scrutton for his valuable assistance.

ELIZABETH M. PRESS*
R. R. PORTER*

National Institute for Medical Research,
The Ridgeway, Mill Hill, N.W.7.

* Present address: Wright Fleming Institute, St. Mary's Hospital Medical School, London, W.2.

[1] McFadden, M. L., and Smith, E. L., *J. Amer. Chem. Soc.*, 75, 2784 (1953).

[2] Porter, R. R., and Press, E. M., *Biochem. J.*, 66, 600 (1957).

Action of Nucleic Acids on the Inhibition of Growth by Actinomycin of *Neurospora crassa*

ACTINOMYCIN is well known to possess cytostatic properties in mammalian tissues[1]. Foley *et al.*[2] have shown the inhibitory effect of actinomycin on the cell-growth of 12 microbiological systems under various experimental conditions. In our work on the mode of action of actinomycin, *Neurospora crassa* was used as test organism.

Recently, Beers[3] has shown the inhibitory effect of dyestuffs on the synthesis of polyadenylic acid in *M. lysodeikticus*. The mechanism of inhibition is supposed to be due to the formation of dye–polymer complexes. Steiner and Beers[4] were able to demonstrate formation of dye–polymer complexes between dyestuff, polynucleotides and yeast ribonucleic acid and deoxyribonucleic acid. An interaction between dyestuff and deoxyribonucleic acid was also shown by Lawley[5]. These findings suggest that actinomycin may act in the same way. It therefore seemed to be of interest to us to study the action of deoxyribonucleic acid, ribonucleic acid and polynucleotides on the growth inhibitory effect of actinomycin on *N. crassa*.

The materials used were: actinomycin *C* from Bayer, Leverkusen; actinomycin *D* from Merck, Sharp and Dohme; deoxyribonucleic acid of low molecular weight from Th. Schuchardt, Munich = deoxyribonucleic acid I; deoxyribonucleic acid of low molecular weight from C. Roth, Karlsruhe = deoxyribonucleic acid II; deoxyribonucleic acid of high molecular weight from C. Roth, Karlsruhe = deoxyribonucleic acid III; ribonucleic acid from C. Roth, Karlsruhe, Th. Schuchardt, Munich, and C. F. Boehringer, Mannheim.

Growth of *N. crassa* was followed in horizontal tubes according to Ryan, Beadle and Tatum[6] (for further details see Rauen[7]). The test-medium was: Fries minimal, pH 6·3; concentration of actinomycin 5 μgm. ~ 0·0025 μmol./ml.; growth inhibition at 96 hr. 90 per cent hydrolysis of deoxyribonucleic acid and ribonucleic acid was performed as described by Schmidt[8].

Table 1. REVERSAL OF INHIBITION OF ACTINOMYCIN BY DEOXYRIBONUCLEIC ACID (DNA), RIBONUCLEIC ACID (RNA) AND SOME OF THEIR DEGRADATION PRODUCTS

Treatment	Substance	Reversal of inhibition (μgm./ml.) 50 per cent	100 per cent
None	DNA I DNA II DNA III	50 30 25	200 80 60
0·1 *N* hydrochloric acid 20° 4 hr. = intermediaries between DNA and apurinic acid	DNA I DNA II DNA III	50 30 25	200 100 60
1 *N* sodium hydroxide 20° 18 hr. = acid insoluble polynucleotides	DNA II	25	60
0·1 *N* hydrochloric acid 37° 27 hr. = apurinic acid	DNA II		no effect
Deoxyribonuclease = 5′-oligonucleotides + 5′-mononucleotides	DNA II	60	200
1·5 *N* hydrochloric acid 100° 1 hr. = purines, pyridine-nucleotide diphosphate, pyrimidine-mononucleotides	DNA I DNA II DNA III		no effect
None	RNA	600	
1 *N* sodium hydroxide 20° 18 hr. = (2)3-mononucleotides	RNA	1,200	
0·1 *N* hydrochloric acid 37° 18 hr. = pyrimidine nucleotides	RNA	1,400	
1·5 *N* hydrochloric acid 100° 1 hr. = purines + pyrimidine + (2)3-mononucleotides	RNA		no effect

As shown in Table 1, deoxyribonucleic acid and ribonucleic acid and some of their degradation products, presumably oligonucleotides, counteract the growth-inhibitory action of actinomycin on *N. crassa*. There are some differences between deoxyribonucleic acid of various origins and of various molecular weights. Obviously ribonucleic acid is far less effective than deoxyribonucleic acid. The degradation products of deoxyribonucleic acid and ribonucleic acid, after alkaline and weak acid hydrolysis, are of about the same activity as deoxyribonucleic acid and ribonucleic acid themselves. Degradation products of nucleic acids of low molecular weights, as are found by extensive hydrolysis, are ineffective. It is, however, of interest to note that commercially available purines and pyrimidines in high concentrations (referring to actinomycin) abolish more or less the cytostatic properties of actinomycin. Adenine, adenosine and adenosine mono-, di- and tri-phosphates at concentrations of 1 μmol./ml. reverse the effect of actinomycin to about 50 per cent, 4–5 μmol./ml. to about 100 per cent. Guanine, xanthine and hypoxanthine could not be tested quantitatively on account of their weak solubility. Guanosine and inosine were as effective as adenosine. At a concentration of 4–5 µmol./ml., certain unphysiological purine derivatives, for example, 8-azaxanthine and 8-chloroxanthine, also counteract the actinomycin effect in this organism to an extent of 50 per cent. The pyrimidines were found to be not very effective. With 10 µmol./ml. of thymine, cytosine and uracil each, only 30 per cent release of actinomycin inhibition was attained. It was further observed, strangely enough, that some unphysiological pyrimidine derivatives, for example, 5-bromuracil and 2-amino-4-methylpyrimidine, which themselves have cytostatic properties, counteract the actinomycin inhibition to a greater or lesser degree.

These experimental results apparently lead to the suggestion that actinomycin reacts directly with deoxyribonucleic acid, oligonucleotides of deoxyribonucleic acid and to a much lesser extent with ribonucleic acid perhaps by formation of dye–polymer complexes. The effect of purines and pyrimidines is supposed to be a kind of displacement of actinomycin from its site of action in the living cell. The high concentrations required of these substances is evidence in favour of this view.

How far this interpretation of experimental results is relevant must be established by further investigation.

W. Kersten
H. Kersten
H. M. Rauen

Physiologisch-chemisches Institut
der Universität,
Münster, Westfalen.

[1] Robinson, H. J., and Waksman, S. A., *J. Pharm. Exp. Therap.*, 74, 25 (1942).

[2] Foley, G. E., McCarthy, R. E., Binns, V. M., Snell, E. E., Guirard, B. M., Kidder, G. W., Dewey, V. C., and Thayer, P. S., *Ann. N.Y. Acad. Sci.*, 76, 413 (1958).

[3] Beers, R. F., Fourth Int. Congr. Biochem., Vienna, Sect. 3–7 (1958).

[4] Steiner, R. F., and Beers, R. F., Fourth Int. Congr. Biochem., Vienna, Sect. 3/28 (1958).

[5] Lawley, P. D., *Biochim. Biophys. Acta*, 19, 160 (1956).

[6] Ryan, F. D., Beadle, G. W., and Tatum, E. L., *Amer. J. Bot.*, 30, 784 (1943).

[7] Rauen, H. M., Hess, G., and Mechery, J., *Z. physiol. Chem.*, 315, 46 (1959).

[8] Schmidt, G., in Colowick–Kaplan "Methods in Enzymology", 3 (Academic Press, New York, 1957).

Biogenesis of Ascorbigen, 3-Indolylacetonitrile and Indole-3-carboxylic Acid from D,L-Tryptophan-3-^{14}C in *Brassica oleracea* L.

During earlier work we found that ascorbigen (the bound form of ascorbic acid) is an indole derivative[1–4]. In view of the fact that the indole moiety of ascorbigen possesses a carbon skeleton identical with that of tryptophan, the hypothesis was put forward that this amino-acid[5], as well as 3-indolylpyruvic acid[6], may be the precursor of the synthesis *in vivo* of ascorbigen. In preliminary experiments we found that the level of ascorbigen in kohlrabi was raised after the injection of tryptophan into the bulb[7].

Jones and co-workers[8] have advanced the theory that 3-indolylacetonitrile, the plant growth stimulator (auxin) in the genus *Brassica*, may also be synthesized *in vivo* from tryptophan.

In order to verify these hypotheses and preliminary observations, we introduced 5·1 mgm. of labelled D,L-tryptophan-3-^{14}C (specific activity, 25·6 µc./mgm.) to the over-ground parts (50 gm.) of young plants of *Brassica oleracea* L., var. *sabauda* (Savoy cabbage). Tryptophan was administered in the form of a concentrated aqueous solution, which was taken up by the plants in the course of 3 hr. The plants were then transferred to a container with distilled water, where they were left for 48 hr. in light, and at a temperature of 25°. The plant juice (20 ml.) was extracted with 10 ml. of light petroleum, in order to eliminate paraffins and waxes[8], and four times with 10 ml. of ethyl acetate. The ethyl acetate extract was evaporated to dryness *in vacuo* and chromatographed on Whatman No. 1 paper with the butyl acetate/water system[1]. The measurement of the chromatogram on a flow counter with automatic registration showed that the R_F-value of the most active zone corresponded to the R_F-value of ascorbigen (0·5). Another zone of activity was found in the range of R_F-values from 0·7 to 1·0 (Fig. 1).

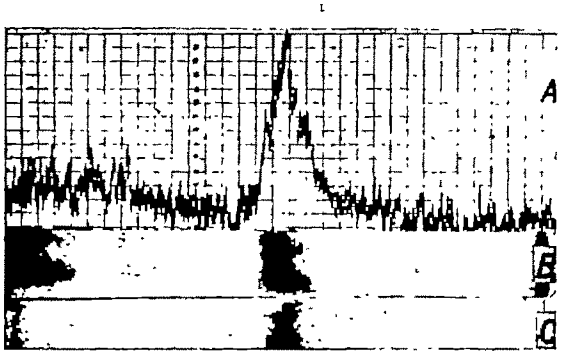


Fig. 1. (*A*) Distribution of the radioactivity on chromatogram *B* as measured with an automatic recording and scanning device (methane flow counter). (*B*) Chromatogram of ethyl acetate extract. (*C*) Chromatogram of a sample of pure ascorbigen

The zone of maximum radioactivity (R_F 0·5) was eluted, and the eluate treated with 1 per cent sodium hydroxide solution. The solution was re-chromatographed in the same solvent system as before. It was found that the eluted active substance behaved in the same way as ascorbigen[9,10], that is, it decomposed into a number of degradation products. The activity in the 0·5 R_F-zone (ascorbigen) disappeared, but reappeared again in the zones of the following R_F-values: 0·9, 0·15 (substance *C*, see refs. 5, 9, 10) and on the starting-line (substance *S*, refs. 10, 12).

The eluate of the zone R_F 0·7–1·0 from the first chromatogram was re-chromatographed in the system carbon tetrachloride/acetic acid/water[8,9,11] and *iso*-propylether/water[11]. Comparison with synthetic specimens showed that the eluate contained radioactive 3-indolylacetonitrile, indole-3-carboxylic acid and a substance corresponding to 3-indolylpyruvic acid. Some other non-identified active products were found in the extract as well.

From these experiments, the conclusion may be drawn that tryptophan can be utilized in the genus *Brassica oleracea* L. for the synthesis of a series of physiologically important indole derivatives, namely: ascorbigen, 3-indolylacetonitrile, indole-3-carboxylic acid and other derivatives.

Our results point to the possibility of a biosynthetic approach to the preparation of labelled ascorbigen that could be of considerable use in the study of its fate and role in plant and animal organisms.

Experimental details will be described in the *Collection of Czechoslovak Chemical Communications*.

We are greatly indebted to Academician F. Šorm for his support and interest during this work.

M. Kutáček
Ž. Procházka
D. Grünberger
Plant Production Research Institute,
Czechoslovak Academy of Agricultural
Sciences, Prague, and
Institute of Chemistry,
Czechoslovak Academy of Sciences, Prague.

[1] Procházka, Ž., *Chem. Listy*, **47**, 1637 (1953).

[2] Procházka, Ž., *Chem. Listy*, **47**, 1643 (1953); *Coll. Czech. Chem. Comm.*, **19**, 581 (1954).

[3] Procházka, Ž., Šanda, V., and Šorm, F., *Chem. Listy*, **50**, 167 (1956); *Coll. Czech. Chem. Comm.*, **22**, 333 (1957).

[4] Procházka, Ž., and Šanda, V., *Chem. Listy*, **52**, 2378 (1958).

[5] Procházka, Ž., Šanda, V., and Šorm, F., *Coll. Czech. Chem. Comm.*, **22**, 654 (1957); *Chem. Listy*, **51**, 1197 (1957).

[6] Constantinas, N., Procházka, Ž., and Jindra, A., *Coll. Czech. Chem. Comm.*, **24**, 1702 (1959).

[7] Kutáček, M., Valenta, M., and Icha, F., *Experientia*, **13**, 284 (1957).

[8] Jones, E. R. H., Henbest, H. B., Smith, G. F., and Bentley, J. A., *Nature*, **169**, 485 (1952).

[9] Kutáček, M., Icha, F., Valenta, M., Tupý, J., and Holková, L., *Chem. Listy*, **52**, 531 (1958); *Coll. Czech. Chem. Coll.*, **24**, 817 (1959).

[10] Šanda, V., Constantinas, N., and Procházka, Ž., *Coll. Czech. Chem. Comm.* (in the press).

[11] Procházka, Ž., Šanda, V., and Macek, K., *Coll. Czech. Chem. Comm.*, **24**, 2928 (1959).

[12] Kutáček, M., Valenta, M., and Nováková, J., *Coll. Czech. Chem. Comm.* (in the press).

Electrophoretic Pattern during Amphibian Development

Paper electrophoresis became a suitable technique for embryological purposes when Kohn[1] proposed the use of pure cellulose acetate as a supporting medium instead of filter paper. This method enables us to separate much smaller amounts of protein than hitherto: one single amphibian embryo yields enough protein to give a clear electrophoretic pattern.

Individual embryos of *Triturus alpestris* of every stage from the uncleaved egg to stage Glässner 26 were sucked up into a capillary tube, frozen, thawed and centrifuged at 7,000*g* for 20 min. The clear supernatant minus the fat layer was applied as a thin line across a cellulose acetate strip (10 cm. × 5 cm.). The same veronal buffer pH 8·6 (0·05 M) was used for the extraction of the proteins and for the electrophoresis itself. A potential gradient of 10 V./cm. was applied for 45–90 min. After the run, the proteins were stained with very dilute (1/10,000) nigrosine in 3 per cent trichloroacetic acid.

The uncleaved egg yields eleven distinct nigrosine-positive bands. Five of them are on the positive side of the pattern and six on the negative side. This distribution is, however, artificial because of the electro-endosmosis which shifts the starting line towards the negative pole. After correction, it is found that only one band migrates towards the negative and nine towards the positive pole. In cleaving eggs, two new fast electropositive bands appear. These fade away at the blastula stage. During gastrulation and neurulation, the electrophoretic pattern is practically the same as in the uncleaved egg. At the tail-bud stage, two of the strongest bands (the third and the fourth from the positive pole) become progressively reduced and finally disappear. At the same place, two very narrow bands make their appearance and remain to the last stage examined (stage 26). These results are summarized in Fig. 1, which shows the fate of the different protein bands during development.

Spiegel[2], using paper electrophoresis followed by staining with bromphenol blue, could detect six cathodic and one or two anodic bands in *Rana pipiens* embryos. All the fractions were detectable from the unfertilized egg to stage 17 and no new band appears during development. The discrepancy with our results may be explained by the superiority of cellulose acetate over filter paper as a supporting medium.

Chemical tests have been made to determine the nature of the proteins separated by electrophoresis. The periodic acid–Schiff reaction of Köiw and Gronwall[3] as modified by Sohar, Bossak and Adlersberg[4] stains red the second, third, fourth and fifth band (Fig. 1, *b*, *c*, *d* and *e*) of the pattern. Furthermore, there is another strong red band on the positive side of the pattern (between *j* and *k*), but this one does not correspond to any protein band. It consists of polysaccharide (very likely glycogen) shifted towards the negative pole by the endosmotic flow. The first, second, third and fourth bands (Fig. 1, *a*, *b*, *c* and *d*) are strongly basophilic: methylene blue stains them dark blue at pH 3.

Attempts are now being made to characterize the chemical nature of all the bands of the embryonic pattern more precisely and to study the distribution of the proteins within different tissues. I wish to thank the Fonds National de la Recherche Scientifique (Belgium) for financial support of this work. I am grateful to Prof. C. H. Waddington for advice and guidance.

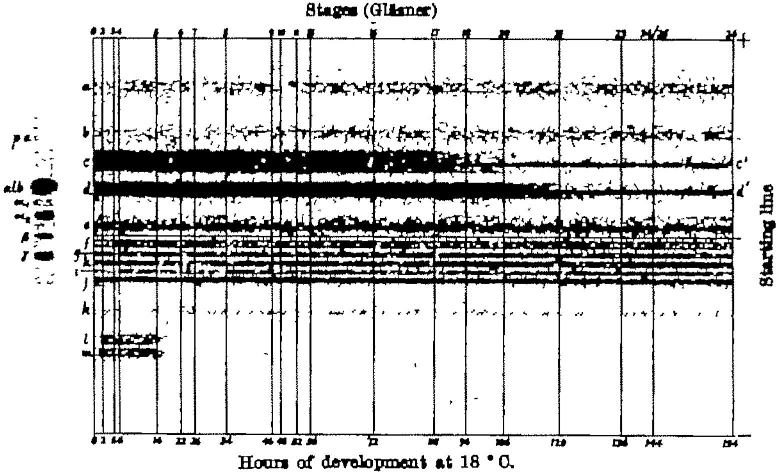


Fig. 1. Electrophoretic changes during embryogenesis. Embryonic proteins subjected to electrophoresis in veronal buffer pH 8·6 for 1 hr. at 10 V./cm. Length between electrodes, 8 cm. The starting line is shifted towards the negative pole by the electro-endosmosis. Real neutral point between *j* and *k*. Control of mouse serum in parallel

H. Denis*
Institute of Animal Genetics, Edinburgh.

* Present address: Institut de Zoologie Ed. Van Beneden, Liège, Belgium.

[1] Kohn, J., *Clin. Chim. Acta*, **2**, 297 (1957).

[2] Spiegel, M., *Anat. Rec.*, **131**, 602 (1958).

[3] Köiw, E., and Gronwall, A., *Scand. J. Clin. and Lab. Invest.*, **4**, 244 (1952).

[4] Sohar, E., Bossak, E. T., and Adlersberg, D., *Proc. Soc. Exp. Med.*, **90**, 305 (1955).

PHYSIOLOGY

Electrophysiological Observations on a Sound-producing Fish

SIMULTANEOUS sound and action potential records have been made from a New Zealand marine teleost, *Congiopodus leucopaecilus* (Perciformes), the pigfish, which produces noises in the water by resonance of the swimbladder. The muscles responsible for the sound are a pair of delta-shaped intracostal striated muscles running obliquely between the vertebral intercentra and back border of the pectoral girdle of either side of the body, and lying against the side walls of the swimbladder. In a fish 24 cm. long the swimbladder is 4·5 cm. and the muscles 3 cm.

The records were made on the two beams of a double-beam oscilloscope, the top beam recording the action potentials from a platinum electrode touching the surface of the exposed muscle, and the bottom beam recording the wave form of the sounds in air from a crystal microphone (of the type used in hearing aids) placed against the opposite side of the body. The fish was mounted on a block of wood and perfused through the mouth with aerated seawater.

The records show the expected correlation between the moment of muscle contraction and the onset of the sound produced. They were obtained without artificial electrical stimulation of any kind, and from behaviour observations and tape recordings of the fish in aquarium tanks can be taken as representing the normal pattern of sound production in this fish. Each sound may be thought of as a single drum beat, and they occur singly or at intervals of more than a second, or as a train of beats at rates of 4–10 per sec. when their function probably includes that of threat. These repetitive sounds are accompanied by raising of the dorsal fin armed with stout spines, and dissection reveals that the occipitospinal nerve supplying the drumming muscle also has fibres running dorsally to the spine-raising trunk musculature.

The muscle spike is of extremely short duration and consists of a number of summed muscle action potentials. Fig. 1 shows the recruitment of fibres during the first 6 beats in a train; the synchrony of firing of the different motor units is such that the total duration of the summed spike is increased by less than 25 per cent of the initial one.

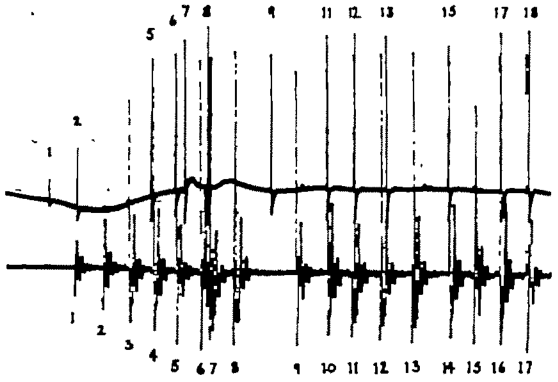


Fig. 1. Muscle action potentials (top trace) and sound vibrations (lower trace) recorded by moving-film camera during the start of a train of sounds at an average of 8/sec. The two beams were staggered in position: the first sound corresponds to the first muscle spike, etc.

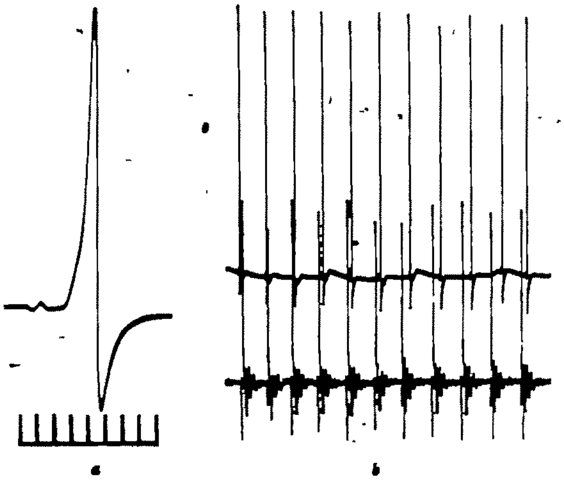


Fig. 2. *a*, Typical summed muscle action potential preceded by the incoming nerve volley (scale in msec.): *b*, record similar to Fig. 1 (but with altered gains) made during a prolonged burst of drumming

The electrical events associated with each contraction (Fig. 2*a*) last 9 msec. The initial deflexion in Fig. 2*a* is the incoming motor nerve volley recorded in volume. The muscle spike, arising after a neuromuscular delay of 1·4 msec., has the following characteristics: rising phase, 2·1 msec.; rapid downward phase, 0·5 msec., and relatively slow (6 msec.) return to resting level from the positive side of the base-line. The end-plate potential appears as a shallow slope (1·1 msec.) at the beginning of the rising phase. Recorded summed spike values are of the order of 6 mV.

There is synchrony of contraction between the drumming muscles of either side. Occasionally during recording one of the two muscles would fail to contract; when this occurred with the exposed muscle, the action potential of the other could still be seen on the recording side and the sound was still maintained (in Fig. 1, the third, fourth, tenth, fourteenth and sixteenth drum-beats are of this kind); in these instances the sound vibrations showed a less-complicated and more-consistent wave-form than when the muscles of both sides contracted. Analysis of the wave-form of the sounds indicates that a 25-cm. fish produces a frequency of about 200 cycles per sec.

It has thus been possible to investigate an overt piece of fish behaviour at a basic physiological level, and it is to be hoped that further features of the behaviour on one hand and its nervous basis on the other will be studied in this preparation. The intracostal muscles of *Congiopodus* and the pattern of impulses they receive from the central nervous system are highly specialized for sound production. The rapidity and constancy of the twitch contraction ensure the production of a specific sound of fairly regular wave-form, though the constancy and loudness of the signal must be limited by the restricted properties of the swimbladder as a resonator. Within these limitations it would seem, both from the steady maximum recruitment-level recorded (Fig. 2*b*) and the fact that the observed rate of drumming is many times slower than the refractory period of the muscle, that the system achieves a near optimal and consistent signal relatively free from interference by a preceding drum-beat. In each of the drum-beats illustrated, except the sixth in Fig. 1, the vibrations of the swimbladder recorded in air have almost completely disappeared from the lower trace before the onset of the next beat. Interference is clearly seen in the seventh drum-beat.

Finally, the cerebellum is notably much larger proportionately in *Congiopodus* than in *Trigla*—a related fish the sounds of which are restricted to the breeding season—and in the absence of information about the role of fish sounds in orientation and communication it is worth speculating that the cerebellum is being used in the integration of the drumming response possibly in relation to reception of its own sounds or those of other members of the school.

This work was done while at the Portobello Marine Biological Station, supported by the Nuffield Foundation. I am indebted to Dr. G. H. Satchell for assistance with the recording, which was carried out in the Department of Physiology, University of Otago Medical School, New Zealand.

A. PACKARD

Zoological Station,
Naples,
Italy.

Immunoelectrophoretic Studies on Purified Human Growth Hormone

THE antigenicity of purified preparations of human growth hormone have been demonstrated by means of a modified tanned cell hæmagglutination method[1], precipitin ring tests[1,2], gel-diffusion studies[2,3] and by immunoelectrophoresis[4].

In immunoelectrophoresis the growth hormone appears as a β-globulin and evidence has been presented for its purity by this technique[4].

In the following experiment, five rabbits (*A–E*) were immunized with 2 mgm. human growth hormone purified according to the technique of Li and Papkoff[5] and mixed with Freund's adjuvant[6]. The injections were given once a week for three weeks, each rabbit obtaining 2 mgm. subcutaneously each time, and one month later 1 mgm. of growth hormone without adjuvant intravenously. One week later the animals were bled and the sera tested in hæmagglutination experiments and immunoelectrophoresis. The hæmagglutination titres of these sera were 1 : 30,000–1 : 80,000.

The immune sera were tested in immunoelectrophoresis against the purified growth hormone preparation in a concentration of 1 mgm./ml. and against undiluted human serum from an evidently normal blood donor.

All immune sera gave a single precipitate in the slow α-globulin region against the growth hormone preparation. This precipitate presented an extended slightly asymmetric shape against four of the immune sera, and when immune serum *D* was used to develop the pattern a two-peaked symmetrical precipitate was obtained (Fig. 1).

The shape of the precipitate is among other factors depending on the relative distribution of serologically identical molecule populations in the electrophoretic field, and a two-peaked symmetrical precipitate is obtained if two electrophoretically different although serologically identical molecule populations are mixed in the same amounts and subjected to immunoelectrophoresis provided the difference in electrophoretic position between those molecule populations is not too pronounced[7].

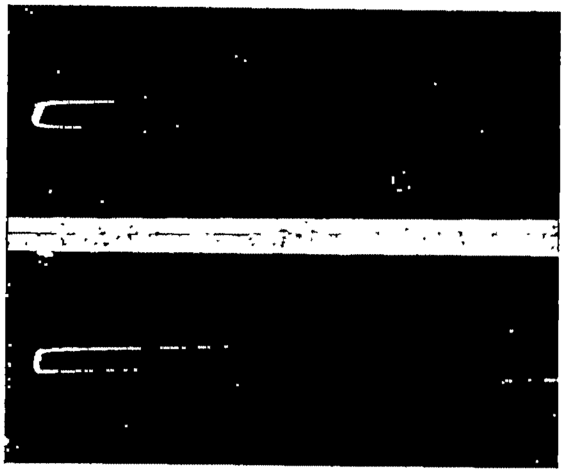


Fig. 1. Immunoelectrophoretic pattern of purified growth hormone (upper beam) and a normal serum (lower basin) as revealed by anti-growth hormone immune serum *C* (upper plate) and *D* (lower plate). To the far left the albumin precipitate is seen in the lower basins

Against one of the immune sera (immune serum *B*) a further precipitate was obtained in the fast α-globulin region.

In conclusion the purified growth hormone preparation appeared immunologically homogeneous when tested against four immune sera prepared on different rabbits. The fifth immune serum (*B*) revealed evidence of another serologically and electrophoretically different component. The single precipitate presumed to represent the growth hormone precipitate was found to be asymmetrical or two-peaked, indicating that it consists of two electrophoretically different although serologically identical molecule populations.

All immune sera against the purified growth hormone preparation also reacted with albumin and γ-globulin in an evidently normal serum. Some of the immune sera also reacted with other components as, for example, the α_1-glykoprotein (*TBP*)[8] and 1–2 α_2-globulins. The γ-globulin precipitate in all instances appeared more extended than when developed with a homologous immune serum.

In the normal serum, no precipitate was found which agreed with the presumed growth hormone precipitate as regards electrophoretic position, site between diffusion centres or shape of the precipitate.

An anti-human immune serum did not give any precipitate formation against the growth hormone preparation, although giving at least 18 different precipitates with a normal human serum (Fig. 2). It might therefore be suspected that impurities mainly of albumin and γ-globulin are present in the purified growth hormone preparation in amounts

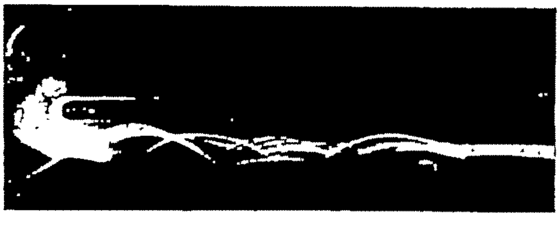


Fig. 2. Immunoelectrophoretic pattern of same material as in Fig. 1 developed with an antihuman immune serum. (Upper basin: purified growth hormone 1 mgm./ml.; lower basin, a normal serum.) No precipitates are seen in the upper basin

sufficient to elicit antibody formation although not sufficient to give precipitate formation in the present experimental circumstances. As another possibility, the antibodies against the growth hormone itself might be suspected of also reacting with certain normal serum constituents. Absorption of one immune serum against the growth hormone preparation with a normal human serum by means of intra-basin gel-absorption[9] did not, however, absorb the antibodies against the growth hormone preparation.

JAN HIRSCHFELD

Department of Bacteriology,
Karolinska Institutet,
Stockholm, 60.

CARL-AXEL GEMZELL
LEIF WIDE

Konung Gustav V : s Forskningsinstitut,
Stockholm, 60.

[1] Hayashida, T., and Li, C. H., *Science*, 128, 1276 (1958).

[2] Cruickshank, B., and Currie, A. R., *Immunol.*, 1, 13 (1958).

[3] Hayashida, T., and Li, C.H., *Endocrinol.*, 65, 944 (1959).

[4] Grumbach, M. M., Kaplan, S. L., and Solomon, S., *Nature*, 185, 170 (1960).

[5] Li, C. H., and Papkoff, H., *Science*, 124, 1293 (1956).

[6] Ramon, G., Lemetayer, E., and Richou, R., *Rev. d'Immunol.*, 1, 199 (1935).

[7] Hirschfeld, J., *Nature*, 185, 164 (1960).

[8] Hirschfeld, J., and Söderberg, U., *Experientia*, 16, 198 (1960).

[9] Hirschfeld, J., *Nature* (submitted for publication).

Increase of Esterase Activity during Intracellular Digestion in a Histophagous Ciliate

THE macrophages of vertebrates and invertebrates[1] as well as some Protozoa[2] exhibit strong esterase and lipase activity demonstrable by histochemical and biochemical methods. Considering the prominent position of the hydrolytic enzymes in digestive processes, it seems probable that they have also some significance in the intracellular breakdown of particles, a common characteristic of both cell-types in question. In the course of our recent work on the problems of feeding and digestion in a histophagous ciliate, *Tetrahymena corlissi* Thompson, strain *W*, we obtained some results that may confirm this assumption.

Cells of *T. corlissi*, grown axenically on a tryptone (1 per cent) and yeast extract (0·05 per cent) broth, were washed twice in Prescott solution and kept during the experiments in the same solution. Fresh frozen sections of rat spleen served as food. The animals readily ingested the spleen cells. Smears of unfed and fed (for 1 hr.) animals, and those of animals starved (2–24 hr.) in Prescott solution after feeding, were fixed in cold 10 per cent formalin (1 hr.). The 'Tween' procedure of Gomori[3] and the azo-dye procedure of Nachlas and Seligman[4] were used for the demonstration of esterases. The slides were mounted in glycerine-jelly.

Unfed animals exhibited a slight or moderate activity on the substrates α-naphthyl acetate, 'Tween 60' and '80'. Parallel with the formation of food vacuoles a great increase in esterase activity has been observed. Using α-naphthyl acetate, which gives a distinctly localized reaction product, the food vacuoles could be demonstrated as the site of the increased activity (Fig. 1). The 'Tween' procedure revealed only a general increase in the activity, but did not show its intracellular localization. In animals starved after feeding there is a drop in the activity to the initial level within 24 hr. The digestion is already completed at this time and the animals contain only empty vacuoles as revealed by the control slides stained with hæmatoxylin.

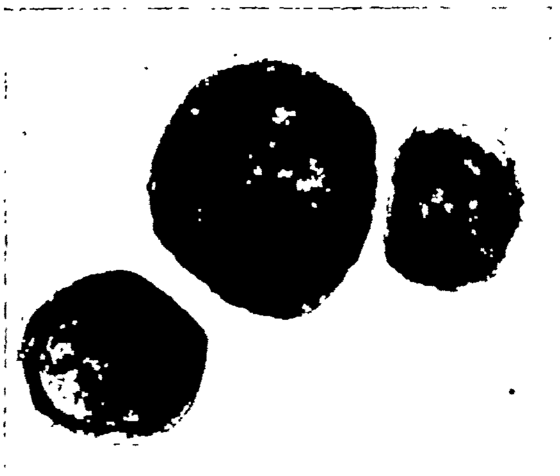


Fig. 1. One fed and two unfed cells of *T. corlissi*. The food vacuoles of the fed individual exhibit a strong esterase activity. Azo-dye method

These changes are probably due to an activation of the enzymes and may indicate an intimate correlation of the esterases with the intracellular digestion. Our recent findings do not enable us to determine the type of the enzymes responsible for the increase observed. The splitting of both substrates, α-naphthyl acetate and the unsaturated 'Tween 80', seems to indicate that at least a non-specific esterase and a lipase may be at work. Further studies aiming at a more detailed characterization of the enzymes are in progress.

We wish to thank Dr. J. O. Corliss for the strain of *T. corlissi* and the Difco Co., Ltd., for supplying us with a sample of tryptone and yeast extract.

MIKLÓS MÜLLER
JÓZSEF TÓTH
IMRE TORÓ

Department of Histology,
Medical University,
Budapest, IX.

[1] Wells, G. C., *J. Invest. Dermatol.*, 31, 83 (1958).

[2] Fennell, R. A., and Pastor, E. P., *J. Morphol.*, 103, 187 (1958). Guthwin, H., and Kopac, M. J., *Ann. New York Acad. Sci.*, 78, 538 (1959).

[3] Gomori, G., *Proc. Soc. Exp. Biol. Med.*, 58, 362 (1945).

[4] Nachlas, M. M., and Seligman, A. M., *J. Nat. Cancer Inst.*, 9, 415 (1949).

A High-Energy Phosphate Requirement for Succinate Oxidation in Uncoupled Rat Liver Mitochondria

IT has been reported by Borst and Slater[1,2] that rat liver mitochondria, depleted of endogenous phosphate by pre-incubation with hexokinase and glucose, showed a marked phosphate requirement for the oxidation of glutamate in the presence of 2,4-dinitrophenol. This phosphate requirement was attributed to the substrate-level phosphorylation linked to the oxidation of α-ketoglutarate which is not uncoupled by dinitrophenol. Evidence has been given that other Krebs-cycle metabolites, such as succinate, citrate, and malate, did not show the same phosphate requirement in uncoupled systems as that observed with glutamate and α-ketoglutarate. Recent work in this Laboratory[2] has shown that when mitochondria were pretreated for 2 min. at 30° C. with 10^{-4} *M* dinitrophenol or with 10^{-4} *M* dinitrophenol + 10^{-3} *M* adenosine-5′-phosphate, in both cases in 0·25 *M* sucrose, and afterwards washed twice with sucrose, other Krebs-cycle metabolites showed a phosphate requirement very similar to that observed by Borst and Slater in the case of glutamate and α-ketoglutarate. In such systems succinate was the only Krebs-cycle substrate the aerobic oxidation of which proceeded without any apparent phosphate requirement when the respiration was measured using the conventional Warburg technique.

However, a more detailed analysis of the succinate oxidation in mitochondria pretreated with dinitrophenol, performed by measuring the initial phase of oxygen uptake with the oxygen electrode, has shown that the requirement for phosphate in this system is even more striking than that observed with other Krebs-cycle metabolites. Moreover, succinate not only required inorganic phosphate for maximum oxidation but also the inorganic phosphate had to be added to the mitochondria together with the succinate, prior to the addition of the uncoupler, since inorganic phosphate added after the addition of dinitrophenol or of dicoumarol was no longer able to stimulate succinate oxidation. Evidence for this effect is demonstrated in Fig. 1 by showing the different rates of succinate oxidation in mitochondria pretreated with dinitrophenol according to the different order of addition of succinate, inorganic phosphate and dicoumarol. The above effect suggested that the presence of both inorganic phosphate and succinate, prior to the addition of the uncoupler, was needed for synthesizing high-energy phosphate. It therefore seemed that the dinitrophenol pretreatment had brought the mitochondria into a condition where high-energy phosphate was required for oxidizing succinate at maximum rate.

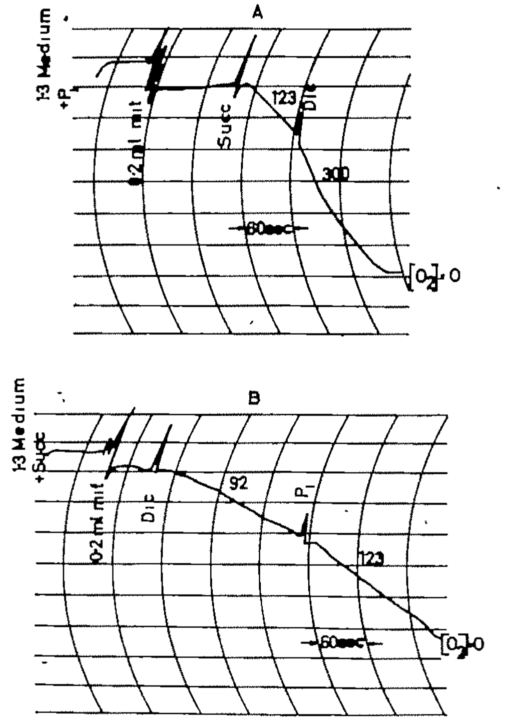


Fig. 1. Inorganic phosphate requirement for oxidation of succinate in 2,4-dinitrophenol-pretreated rat liver mitochondria. The inorganic phosphate is able to stimulate respiration only if added before the uncoupler (*A*), and not if added after the uncoupler (*B*). Concentrations of the reagents in a final volume of 1·5 ml. were as follows: 0·05 *M* potassium chloride, 0·033 *M* *tris* buffer, pH 7·5, 0·008 *M* magnesium chloride, 0·05 *M* sucrose, 0·013 *M* succinate (*Succ*), 0·003 *M* inorganic phosphate (*Pi*), 0·00006 *M* dicoumarol (*Dic*). Mitochondria from 400 mgm. rat liver wet weight (about 8 mgm. protein). The substances were added at the points indicated. '1·3 Medium' stands for potassium chloride, *tris* and magnesium chloride, added in a volume of 1·3 ml. Oxidation-rate of succinate is given in mμ atoms oxygen per min.

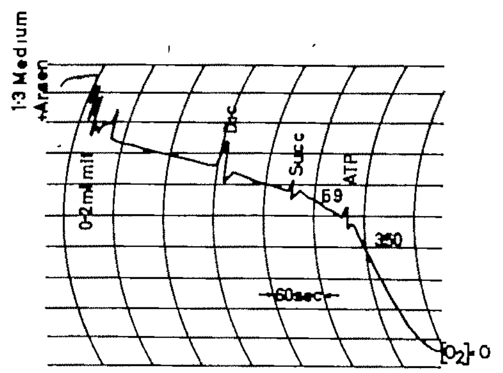


Fig. 2. Stimulation of succinate oxidation by adenosine triphosphate in an arsenate–dicoumarol-inhibited system. Concentrations of reagents were as given in Fig. 1. 0·002 *M* arsenate (*Arsen*) and 0·0013 *M* adenosine triphosphate (*ATP*) were added at the points indicated. Oxidation-rate of succinate is given in mμ atoms oxygen per min.

The validity of this hypothesis was tested with rat liver mitochondria depleted of phosphate by preincubation in the presence of arsenate and dicoumarol, since it has been observed[3] that incubation with arsenate is the most efficient means tried to deplete the mitochondria of both inorganic and high-energy endogenous phosphate. As shown in Fig. 2, the addition of succinate to normal rat liver mitochondria pre-incubated for 3 min. in the presence of 2 m*M* arsenate and 6×10^{-5} *M* dicoumarol resulted in a very low respiration. The addition of 1·m*M* adenosine triphosphate to this inhibited system was able to stimulate the respiration 4–6-fold, bringing the oxidation rate of succinate to about 50–60 per cent of the level obtainable by the addition of dicoumarol to rat liver mitochondria in the presence of succinate.

The possible interference of oxaloacetate as inhibitor of the succinate oxidation in our system, although very improbable because of the fact that succinate was added last to the arsenate–dicoumarol-inhibited system, was ruled out by the addition of cysteine-sulphinic acid, which was not able to stimulate the inhibited respiration although it was able to remove oxaloacetate by way of a transaminase reaction[4]. Moreover, the oxidation of succinate with phenazine metosulphate as electron acceptor was not inhibited in this system.

Another aspect of the inhibition of the succinate oxidation, described above, was obtained by testing the effect of amytal. As shown in Fig. 3, addition of 2 m*M* amytal to mitochondria prior to, or simultaneously with, the addition of arsenate and dicoumarol resulted in a complete prevention of the respiratory inhibition. This effect of amytal was probably due to bringing the mitochondrial diphosphopyridine nucleotide into the reduced state (by way of endogenous mitochondrial substrates)

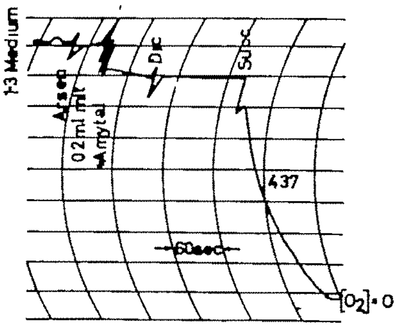


Fig. 3. Protection by amytal of succinate oxidation in an arsenate–dicoumarol-inhibited system. Concentrations of reagents as given in Figs. 1 and 2. 0·002 *M* amytal was added, together with the mitochondria at the point indicated. Oxidation-rate of succinate given in mμ atoms oxygen per min.

since it failed to occur when the amytal was added after the arsenate and dicoumarol, or when it was tested in mitochondria pretreated with dinitrophenol plus adenosine-5′-phosphate; addition of glutamate and inorganic phosphate to the latter system restored the amytal effect.

The results presented here strongly indicate that the oxidation of succinate in phosphate-depleted, uncoupled mitochondria is influenced by the redox status of one or more carriers in the amytal-sensitive region of the respiratory chain. The conditions required for succinate oxidation may be fulfilled either by an extensive reduction of the mitochondrial diphosphopyridine nucleotide or by the addition of high-energy phosphate, the latter possibly acting by a 'reversal of the oxidative phosphorylation'. This hypothesis is in line with the observations reported from different laboratories[5,6] that the oxidation of succinate in intact mitochondria is accompanied by a high degree of reduction of diphosphopyridine nucleotide, even higher than that observed with substrates linked with diphosphopyridine nucleotide. The interest of the present findings may lie in the fact that adenosine triphosphate apparently can influence the respiratory chain in spite of the presence of phosphorylation-uncouplers, or in other words, that dinitrophenol (and other uncouplers) apparently only inhibit the forward, but not the backward, reaction of respiratory chain phosphorylation. This concept is in agreement with the postulated mechanisms of phosphate–adenosine triphosphate exchange and dinitrophenol-induced adenosine triphosphatase reactions previously formulated at this Institute[7].

This work has been aided by a grant from the Swedish Medical Research Council.

GIOVANNI FELICE AZZONE*
LARS ERNSTER

Wenner-Grens Institute,
University of Stockholm,
Stockholm.
Feb. 17.

---

* Postdoctoral Fellow of the Consiglio Nazionale delle Ricerche. Permanent address: Istituto di Patologia Generale, Università di Padova, Italy.

[1] Borst, P., and Slater, E. C., *Nature*, 184, 1396 (1959).

[2] Borst, P., and Slater, E. C., *Nature*, 185, 537 (1960).

[3] Azzone, G. F., and Ernster, L. (in preparation).

[4] Singer, T. P., and Kearney, E. B., *Arch. Biochem. Biophys.*, 61, 397 (1956).

[5] Chance, B., and Hollunger, G., *Fed. Proc.*, 16, 163 (1957); *Nature*, 185, 666 (1960).

[6] Klingenberg, M., and Slenczka, W., *Biochem. Z.*, 331, 486 (1959).

[7] Löw, H., Siekevitz, P., Ernster, L., and Lindberg, O., *Biochim. Biophys. Acta*, 29, 392 (1958).

Total and l(+) Tartaric Acid Inhibited Rat Serum Acid Phosphatase

THE activity of the total acid phosphatase has been determined in many of the rat's tissues, but data on the activity of this enzyme in rat serum are scant[1,2]. We did not find any report dealing with l(+) tartaric acid inhibited acid phosphatase in rat serum.

The purpose of the present investigation was to determine the activities of the total and l(+) tartaric acid inhibited acid phosphatase in the serum of rats of both sexes. The results of our work are shown in Table 1. It is evident that the activity of both serum total and l(+) tartaric acid inhibited acid phosphatase is much higher in the rat than in the human serum in which the mean activity is 2·5 King–Armstrong units in adults and 5 King–Armstrong units in children[3]. Although the mean activity of the serum total acid phosphatase in small rats is slightly higher than the mean activity in bigger rats of the same sex, and the mean activity in big male rats higher than in big female rats, the differences are statistically not significant.

Table 1. SERUM TOTAL AND l(+) TARTARIC ACID INHIBITED ACID PHOSPHATASE IN RATS

Group No.	Sex	Weight (gm.)	No. of rats	Serum total acid phosphatase in King–Armstrong units; mean ± *S.D.*	Serum l(+) tartaric acid inhibited acid phosphatase in King–Armstrong units; mean ± *S.D.*
I	Male	40–50	12	18·5 ± 2·98	6·79 ± 2·3
II	Male	140–180	19	17·2 ± 4 92	8·86 ± 3·4
III	Female	40–50	8	17·3 ± 2·1	7 3 ± 2·93
IV	Female	120–160	10	14 9 ± 3·17	6·7 ± 1 26

White rats were anæsthetized with 'Nembutal'. Blood was drawn from the abdominal aorta, twice centrifuged and the enzyme activities determined immediately thereafter according to the methods of King (ref. 5) and Fishman (ref. 6).

The proportion of the l(+) tartaric acid inhibited to the non-inhibited serum acid phosphatase ranges from 1 : 2 to 1 : 1, a higher proportion than that found in humans. The mean activity of the l(+) tartaric acid inhibited phosphatase in the serum of big male rats is higher than in the serum of female rats of the same age and weight-range ($P < 0·05$; *t* test). This may be due to prostatic activity.

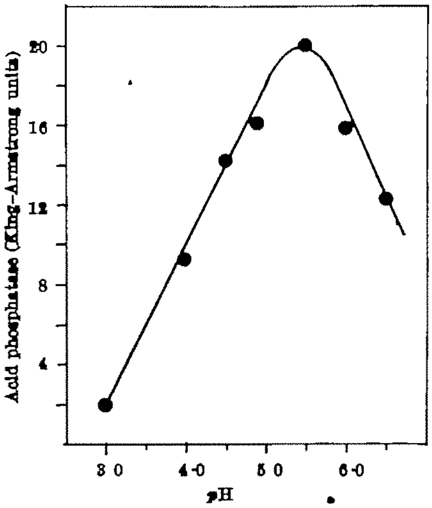


Fig. 1. pH enzyme activity curve for total serum acid phosphatase (citrate buffer)

The pH optimum of total acid phosphatase was found to be pH 5·5 (Fig. 1). Dialysis against citrate buffer pH 4·9 at 4° C. for 24 hr. did not change the activity.

It is not clear which tissues contribute to the high activity of the total and $l(+)$ tartaric acid inhibited acid phosphatase in the rat serum. The optimum pH of 5·5 points to the red cells as a possible source of the uninhibited acid phosphatase[4]. (The pH optimum of the inhibited enzyme could not be detected over the range of pH 3–6.) The high activity of the $l(+)$ tartaric acid inhibited enzyme in female rats shows that there exist major sources for it other than the prostate.

From this work it seems that younger rats do not have statistically higher serum acid phosphatase activity than older ones such as in humans[5], but without serial determinations at many ages starting in very young animals this question cannot be definitely answered.

Rat serum with a high activity of total and $l(+)$ tartaric acid inhibited acid phosphatase presents a valuable tool for the study of the properties of the above enzyme.

This investigation was supported by grants from the General Federation of Labour in Israel and the Upjohn Co.

Z. Laron
B. Epstein Halberstadt

Department of Pediatrics and
Rogoff Medical Research Institute,
Beilinson Hospital,
Petah Tikva, Israel.

[1] Melay, A., and Firminger, H. J., *J. Nat. Cancer Inst.*, 13, 917 (1952).
[2] Vranic, M., Allegretti, N., and Rabadija, L., *Hoppe-Seyler's Z. physiol. Chemie*, 314, 147 (1959).
[3] Laron, Z., and Epstein-Halberstadt, B., *Pediatrics* (in the press).
[4] Tsubol, K. K., and Hudson, P. B., *Arch. Biochem. Biophys.*, 43, 339 (1953).
[5] King, E. J., and Wooton, I. D. P., "Micro-analysis in Medical Biochemistry", Third ed., 90 (J. and A. Churchill, Ltd., London, 1956).
[6] Fishman, W. H., and Lerner, F., *J. Biol. Chem.*, 200, 89 (1953).

Physiological Media for Tissues of *Helix*

During the course of recent work in this School, it became necessary to find a physiological saline suitable for the tissues of *Helix aspersa* Müller. The saline was required for a series of experiments on oxygen-uptake by certain tissues of *Helix*, using the Warburg method.

Two solutions suggested themselves for consideration: that of Bernard and Bonnet[1] and that of Hédon–Fleig[2]. The former solution contains the chlorides of sodium, potassium, calcium and magnesium; no buffer is required and no sugar is provided. It was devised for experiments on the heart of *Helix pomatia*, and is capable of supporting heart-beat for periods of up to four days. A factor in favour of this solution is the ease with which it can be prepared. The Hédon–Fleig solution is more complex: it contains a phosphate buffer, is provided with a sugar, and requires adjustment to a pH of 8·4. Moreover, it requires special measures for sterilization, since the use of heat causes liberation of carbon dioxide and a consequent rise in alkalinity.

The Bernard and Bonnet solution was used in the first of the series of experiments referred to above. The tissues investigated were: (*a*) slices of liver and ovotestis (no effort made to separate the two tissues) —two flasks; (*b*) slices of the common duct of the reproductive tract—two flasks. All the flasks registered a rapid and progressive decline in oxygen-uptake commencing within 30 min. of the start of the experiment (that is, from the first manometer reading) (Fig. 1). In all cases oxygen consumption ceased within 1 hr.

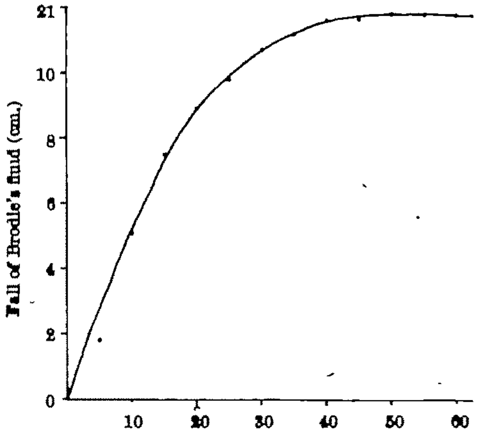


Fig. 1. Oxygen uptake, measured as a fall of the Brodie's fluid in the manometer, plotted against time. Slices of liver and ovotestis in Bernard and Bonnet saline

In the second and subsequent experiments Hédon–Fleig saline was used. Tissue slices were taken from: (*a*) liver and ovotestis; (*b*) common duct; (*c*) albumen gland; (*d*) penis; (*e*) gonad (no liver tissue attached); (*f*) crop with salivary glands attached. Several 'runs' were performed with tissues (*a*), (*b*) and (*c*). In contrast with the earlier results, the rates of oxygen-uptake usually remained constant throughout the experiments, which lasted from 1¼ to 1¾ hr. (Fig. 2). This observation indicates that the saline was not at fault in the few cases where the rate of oxygen uptake tended to decline. Moreover, when a decline occurred it was invariably small, and in no case did oxygen-consumption cease within the period of the experiment.

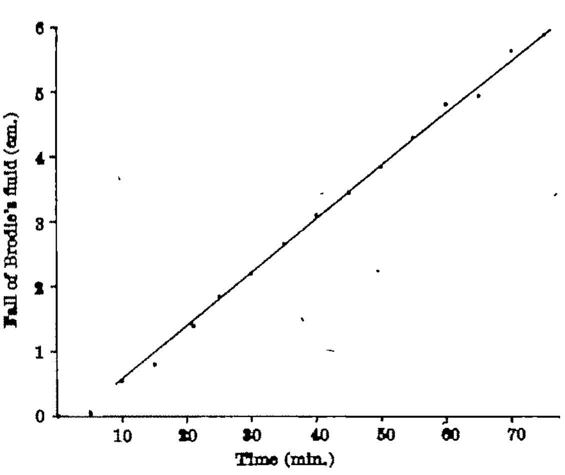


Fig. 2. Oxygen uptake, measured as a fall of the Brodie's fluid in the manometer, plotted against time. Slices of liver and ovotestis in Hédon–Fleig saline

Although the first experiment (Bernard and Bonnet saline) was not repeated, the results are regarded as reliable. It is concluded that, whatever the merits of the Bernard and Bonnet saline where the snail heart is concerned, for most tissues of *Helix* the Hédon–Fleig solution is a more suitable physiological medium.

It is of interest to note that Prosser[3] gives a formula for a physiological solution for *Helix* and attributes the formula to Bernard and Bonnet[1]. However, the formula given by Prosser bears no resemblance to that of Bernard and Bonnet. Moreover, it yields a considerable amount of precipitate which persists at all temperatures from about 20° C. to boiling point. Prosser's formula was therefore regarded as an error and was not used in these experiments.

C. K. GODDARD

School of Biological Sciences,
University of New South Wales,
Sydney.

---

[1] Bernard, A., and Bonnet, V., *C.R. Soc. Biol., Paris*, 103, 1119 (1930).

[2] Bolles Lee, "The Microtomist's Vade Mecum", edit. by Gatenby and Beams, eleventh ed., 247 (Churchill, Ltd., London, 1950).

[3] Prosser *et al.*, "Comparative Animal Physiology" (Saunders Co., Philadelphia and London, 1950; reprint 1952).

'Water Rigour' as an Aid when Operating on Marine Gastropoda

WHILE investigating the physiological aspects of the distribution of two species of the marine gastropod *Bullia*, one of us (A. C. B.) discovered that these snails can crawl only between certain limits of salinity. As the salinity of the sea-water is decreased by the addition of distilled water, movements become more and more restricted, eventually resulting in the total loss of locomotory powers while the animal becomes distended due to the osmotic inflow of water. Providing that dilution is accomplished reasonably slowly (taking 60 min. or more) the foot is not retracted at any stage, while the excitability of the muscles is greatly reduced or disappears completely. The animal remains motionless with stiff, swollen tissues. For *Bullia digitalis* Meuschen, this critical salinity lies in the region of 1·8 per cent, while in the case of *B. laevissima* (Gmelin) it is about 2·35 per cent. Loss of locomotory powers due to decreased salinity has previously been noted for some rocky-shore gastropods by Broekhuysen[1] and Brown[2]. The phenomenon resembles the loss of contractility in vertebrate skeletal muscle subjected to 'water rigour'. However, in *Bullia* the process is completely reversible. The snails can be kept for some hours at these reduced salinities without apparent ill-effect; when returned to fresh, undiluted sea-water they soon recover and behave normally.

A fuller account of this work is soon to be published.

It is well known that most operations for experimental purposes on Gastropoda are extremely difficult, because of the powerful contractions of the animal's muscles. Anaesthetics, to which the snails are rather insensitive, do not prevent contractions satisfactorily, even if the animals are so heavily drugged that they do not recover. In connexion with research on the function of the osphradium in *Bullia*, we were interested in severing the osphradial nerve of the living snail. At first we were at a loss for a successful method of performing such a delicate operation, but then it occurred to us that animals subjected to 'water rigour' might prove to be suitable subjects. A number of snails were therefore brought into this condition. As expected, the snails could then be operated on without any difficulties arising from muscular contractions. A window was cut in the shell, over the osphradium and dorsal pallial artery, and the osphradial nerve was then severed with a small eye-surgeon's scalpel. When returned to undiluted sea-water, more than half the snails operated on recovered and were used for experiments on sensory perception. None of these showed any abnormal behaviour[2] which could be attributed to previous 'water rigour'.

Those snails which did not recover were later dissected in order to discover the cause of death. In all of them it was found that structures other than the osphradial nerve had been injured during the operation; in most cases the pallium had been damaged. In no snail was there any evidence that the reduced salinity conditions to which they had been subjected had produced ill-effects.

Other work in our Department (unpublished experiments by G. Noble) has confirmed that 'water rigour' is a very effective aid when operating on *Bullia*, not only for the operation described above but also in removal or cauterization of organs possibly connected with sensory perception, such as the inhalant siphon, tentacles, etc. It seems likely that the 'water rigour' technique might find wider application in the field of gastropod physiology.

B. J. KRIJGSMAN
A. C. BROWN

Zoology Department,
University of Cape Town,
Rondebosch, Cape Town.

---

[1] Broekhuysen, G. J., *Trans. Roy. Soc. S. Afr.*, 28, 255 (1940).

[2] Brown, A. C., *Portugal Acta Biol.* (in the press).

IMMUNOLOGY

Natural Occurrence of Delayed-type Iso-hypersensitiveness

EVIDENCE has been obtained for the existence, in certain normal guinea pigs, of a state of delayed iso-hypersensitiveness to a heritable factor present in the serum of other normal guinea pigs. This condition, which arises at about 2 months of age, appears analogous to the long known[1] natural existence of circulating iso-antibodies to heritable blood group antigens in other species. Delayed-type hypersensitivity to isophile antigens may, of course, be experimentally induced (*cf.* ref. 2), but its spontaneous occurrence seems not to have been suspected.

The occurrence of delayed skin reactions among guinea pigs inoculated for the first time with the sera of others is illustrated by a typical experiment. The sera of 12 adult albino guinea pigs (bred from Rockefeller Institute stock) were injected separately into the skin of the back of each of the animals; thus, every animal received 0·1 ml. of 1 : 3 dilution in saline of its own as well as of the 11 other sera. As shown in Table 1, certain of the guinea pigs (Nos. 1–3) responded to the sera of most of the other animals, though not to their own, with erythematous skin

Table 1. DELAYED SKIN REACTIONS GIVEN BY CERTAIN NORMAL GUINEA PIGS TO THE SERA OF OTHER NORMAL GUINEA PIGS

Test of serum from guinea pig No.:	Reaction of guinea pig No.: 1	2	3	4	5–12
1, 2, 3	0	0	0	0	0
4	±	0	0	0	0
5, 6, 7	+	+	+	0	0
8, 9	+	+	±	0	0
10	+	±	+	0	0
11, 12	+	±	±	0	0

0, ±, + = erythema 0–4, 5–9, 10–14 mm. in diameter, at 18–24 hr.

Table 2. INHERITANCE OF THE SERUM FACTOR(S) IN GUINEA PIGS ELICITING DELAYED SKIN REACTIONS IN OTHER NORMAL GUINEA PIGS

No. of pairs	Parental pairs: Serum factor* ♀	× ♂	Live offspring: Serum factor* +	−	Foetal death-rate†
15	+	+	79	1	0·9
8	+	−	14	19	2·1
8	−	+	23	18	2·4
12	−	−	0	85	2·8

* Determined by skin tests in which 0·1 ml. of undiluted serum, from animals at least 2 months old, was injected intradermally into each of 2–4 animals known to be dermally reactive. Sera were judged positive if they evoked reactions of at least 10 mm. in diameter.

† Stillborn and neonatal deaths per 10 live births.

reactions that first were noticeable in 8–10 hr., were maximal at 18–24 hr., and lasted several days. The remaining 9 animals showed insignificant reactions; instead, each (except No. 4) possessed serum capable of evoking a definite response in one or more of the first group.

Comparable experiments, in which guinea pigs of Rockland Farms stock were tested with each others' undiluted sera, likewise differentiated (*a*) dermally reactive animals the sera of which did not evoke skin reactions, (*b*) dermally non-reactive animals possessing sera capable of evoking reactions in others, and (*c*) individuals with neither positive attribute. On the other hand, no dermal reactor was found in a limited test (18 animals) of a third guinea pig stock.

What is doubtless the generalized counterpart of the local skin reaction has been observed in non-immunized animals corresponding to Nos. 1–3 of Table 1. Such animals displayed delayed erythema of the skin of the entire body following intravenous inoculation of 3–4 ml. of a pooled serum which had, one day earlier, elicited local delayed skin reactions in them. The characteristics of these local and general reactions clearly set them apart from the immediate-type cutaneous reactions, related to permeability substances[3], seen in virtually all guinea pigs inoculated with unselected homologous sera.

The factor in serum that evokes the delayed skin response is inactivated by boiling, but not by heating the serum at 56° C. for 30 min. It migrates electrophoretically with the β-globulins[4]. When present, serum factor is detectable from birth and appears to increase as the animal matures. That it is inherited is evident from mating experiments (Table 2). Thus, when present in both parents, serum factor (*SF*) appeared in 79 of 80 live offspring; when present in one parent, about half the offspring possessed it; and when absent in both parents, it was not detected in the young (85 live animals examined). In matings in which the male possessed and the female lacked serum factor and, hence, could not transmit it preformed to her young, serum factor was found in 23 of 41 offspring. The inheritance mechanism is under investigation, as is the question of whether parental (possibly maternal) lack of serum factor is associated with increased foetal mortality, as suggested by the data in Table 2.

The delayed reactivity of certain guinea pigs to the serum of others is not in response to an inherently toxic substance, as originally believed[5], but rests on an immunological basis. Passive transfer of the reactive capacity has been achieved by transplanting lymphoid cells from dermally reactive animals to adult recipients pretreated by neonatal injection of small numbers of donor leucocytes[6], or by total-body X-irradiation. For reasons not yet clear, efforts to transfer dermal reactivity to normal animals have failed.

Table 3 illustrates the results of a set of transfer experiments in which individual donors were either dermally reactive (exp. *A–D*) or non-reactive (*E*, *F*). To assess the reactivity of donor and recipient animals a single pool of 3 individual guinea pig sera positive for serum factor was used, with a pool of 3 sera lacking serum factor as control. Preparations prior to each transfer were as follows. After determining the dermal reactivity of the donor animal, washed leucocytes from 2 ml. of its blood were injected intravenously into each of several guinea pigs (less than 24 hr. old) born of parents lacking both serum factor and dermal reactivity. (About 75 per cent of such offspring would also lack both attributes.) When about two months of age, the presumed chimeras of each particular donor were skin-tested, along with the donor. On the following day, one of the young—provided it was found to lack dermal reactivity to serum factor—was injected with the donor's washed spleen and lymph node cells (the equivalent of 0·15 ml. and 0·10 ml. packed cells) intraperitoneally as well as intravenously. When available, a second recipient was given the donor's serum (2–3 ml. daily for 3 days) by the same routes. Tests for dermal reactivity were made on the third day following transfer and on two or three further occasions during the intervals shown in Table 3.

Dermal reactivity was conferred upon normally non-reactive animals by the lymphoid cells of reactive donors (exp. *A–D*) in a time sequence typical of passive transfer of delayed-type hypersensitivity[7,8]. The transferred reactivity appears specific for serum factor as no recipient reacted significantly to the pool of sera lacking serum factor. In control experiments *E–F*, lymphoid cells from two non-reactive donors failed to confer reactivity upon comparably pretreated recipients.

Table 3. CELLULAR TRANSFER OF DELAYED SKIN REACTIVITY FROM NATURALLY REACTIVE TO NON-REACTIVE GUINEA PIGS (PRECONDITIONED BY DONOR LEUCOCYTES)

Animal skin tested	Time of skin test, pre- or post-transfer	Reactions to sera containing or lacking serum factor*											
		A		*B*		*C*		*D*		*E*		*F*	
		SF+	*SF*−	*SF*+	*SF*−	*SF*+	*SF*−	*SF*+	*SF*−	*SF*+	*SF*−	*SF*+	*SF*−
Donor of cells, serum	1 day pre-	++	0	++	±	+±	0	++	±	0	0	±	±
Recipient of lymph node and spleen cells	1 day pre-	0	0	±	0	0	0	0	0	0	0	0	0
	3 days post-	++	0	±	0	0	0	0	0	±	±	0	0
	6–8 days post-			+±	±	+	0	±	0	0	0	±	±
	10–12 days post-	++	±	+±	0	+	±	+±	±			±	±
	18–22 days post-	±	±	±	±	±	±	++	0	0	0	±	±
Recipient of serum	1 day pre-	0	0					0	0	0	0		
	3–22 days post-	0	0					±	±	0	0		

* Reactions to intradermal inoculations of 0·1 ml. of undiluted pooled sera containing serum factor (*SF*+) or lacking it (*SF*−). 0, ±, +, +±, ++ = erythema 0–4, 5–9, 10–14, 15–19, 20–24 mm. in diameter at 18–24 hr.

The grouping of guinea pigs on the basis of presence or absence of heritable serum factor appears fundamentally similar to the differentiations made within other species based on the occurrence of heritable substances in the sera of some but not all individuals. That is, guinea pig serum factor may be likened to the haptoglobins, transferrins, caeruloplasmins, etc., visualized by starch-gel electrophoresis in the sera of cattle and man[9], or to the gamma-globulin allotypes of rabbits[10]. Indeed, serum factor appears most closely analogous to the Lewis antigens of man[11] and the *J* substance of cattle[12], since natural iso-antibodies (though of circulating type) occur against these substances. Work is in progress to determine whether guinea pig serum factor may be associated with circulating iso-antibodies, may be visualized electrophoretically, or has a discernible biological function. The existence in the guinea pig of what is evidently a new type of 'iso-immune' state, namely, delayed iso-hypersensitivity, suggests the possibility that a similar state may occur in other species, especially those cited above, and may have escaped detection perhaps because of low frequency.

I am grateful to Dr. Edward J. Hehre for guidance, for help with this manuscript, and for the term 'iso-hypersensitivity'. Thanks also are due Miss Janet F. Parks and Miss Rita Hixon for technical assistance.

The work was supported by grants *E*-1264 and *E*-2003 from the National Institutes of Allergy and Infectious Diseases, U.S. Public Health Service.

JACK R. BATTISTO

Department of Microbiology and Immunology,
Albert Einstein College of Medicine,
New York 61, N.Y.

[1] Landsteiner, K., *Zentralbl. Bakt.* (1 Abt. Orig.), 27, 357 (1900).
[2] Medawar, P. B., in "Cellular and Humoral Aspects of the Hypersensitive States", 604 (Hoeber–Harper, 1959).
[3] Miles, A. A., and Wilhelm, D. L., *Brit. J. Exp. Path.*, 36, 71 (1955).
[4] Battisto, J. R., *Bact. Proc.*, *M*, 84 (1957).
[5] Battisto, J. R., *Fed. Proc.*, 16, 1738 (1957).
[6] Paterson, P. Y., *Fed. Proc.*, 18, 2320 (1959).
[7] Landsteiner, K., and Chase, M. W., *Proc. Soc. Exp. Biol. and Med.*, 49, 688 (1942).
[8] Lawrence, H. S., in "Cellular and Humoral Aspects of the Hypersensitive States", 299 (Hoeber–Harper, 1959).
[9] Smithies, O., and Walker, N. F., *Nature*, 178, 694 (1956).
[10] Oudin, J., *C.R. Acad. Sci., Paris*, 242, 2606, 2489 (1956).
[11] Mourant, A. E., *Nature*, 158, 237 (1946).
[12] Ferguson, L. C., Stormont, C., and Irwin, M. R., *J. Immunol.*, 44, 147 (1942).

PATHOLOGY

Bone Marrow Depression in Murine Leukæmia

On occasions the appearance of leukæmia in humans is preceded by a period of bone marrow depression and evidence of aplastic anæmia[1]. Such findings may persist for some time and may result in confusion in diagnosis or the leukæmia is regarded as an aleukæmic form of the disease. In a group of *A* strain mice at present being studied for the effects of intermittent X-radiation, it was noted that while, as expected, the mice developed lymphocytic neoplasms and leukæmia in response to the irradiation, a significant proportion of animals with these diseases also showed aplastic or hypoplastic changes in their marrows when examined at autopsy. This hypoplasia initially affected the erythropoietic cells (Fig. 1), but as it became more severe appeared to affect all elements of the bone marrow (Fig. 2). The incidence of lymphoid leukæmia and the various forms of that disease in this group of mice have been considered elsewhere[2]; this communication presents some of the features of the marrow depression which is seen in the mice with lymphoma and lymphoid leukæmia. Table 1 shows the distribution of marrow hypoplasia or aplasia in the different groups of mice. A fuller discussion of the incidence of this condition, its time of appearance and relationship to radiation dose will be presented elsewhere. However, it is obvious that two factors, apart from radiation, appear to increase the incidence of bone marrow depression; they are femaleness and the absence of a thymic tumour or enlargement.

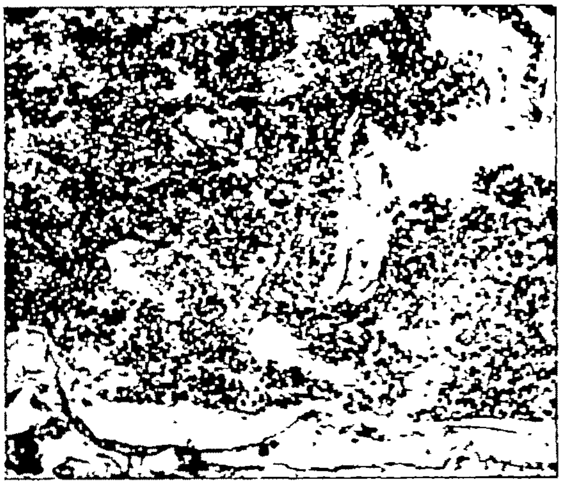


Fig. 1. Hypoplastic bone marrow from vertebra. Diminution mainly in erythropoietic cells. Female mouse with non-thymic lymphoid leukæmia. Received 1,000 r. total body intermittent X-radiation. Age, 335 days at death. Hæmatoxylin and eosin. (× 200)

It is known that a number of endocrine secretions, for example, adrenal steroids, sex hormones, may influence lymphoid tumour production in the mouse and, in general, hormones which appear to diminish the size of the thymus appear to inhibit the genesis of

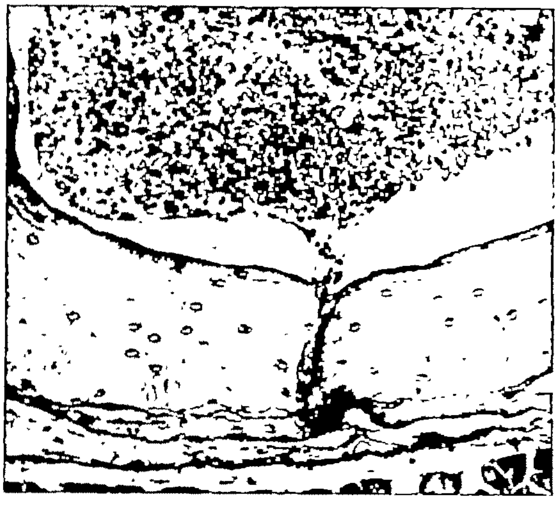


Fig. 2. Aplastic bone marrow—right mid-femur. Female mouse with non-thymic lymphoid leukæmia. Received 1,000 r. total body intermittent X-radiation. Age, 318 days at death. Hæmatoxylin and eosin. (× 200)

TABLE 1

	Radiated mice Male	Radiated mice Female	Control mice Male	Control mice Female
a Total numbers of experimental mice				
With leukæmia	108	121	20	17
Without leukæmia	495	455	89	102
b Animals with bone marrow depression in relation to total numbers				
With leukæmia	24 (22·2%)	44 (36·3%)	1 (5·0%)	2 (11·7%)
Without leukæmia	59 (11·9%)	60 (13·1%)	2 (2·2%)	6 (5·8%)
c Total numbers of animals with different forms of leukæmia				
Thymic	73	62	2	2
Non-thymic	35	59	18	15
d Animals with bone marrow depression in relation to different forms of leukæmia				
Thymic	7 (9·5%)	16 (25·8%)	0 (0%)	1 (50%)
Non-thymic	17 (48·5%)	28 (47·5%)	1 (5·5%)	2 (15·5%)

Leukæmia here signifies a generalized neoplastic disease, with or without thymic enlargement, in which the tumour cells are almost all immature lymphocytes. Radiation was given as 100 r. weekly total body X-radiation to totals of 500 r., 1,000 r. and 1,500 r.

lymphoma[3]. The influence of œstrogen is a little obscure, and appears to depend on the time of administration of the hormone in relation to radiation[4]. Recently, Metcalf[5] has claimed that the thymus secretes a hormone-like substance, lymphocytosis-stimulating factor, the levels of which are raised in mice with a high incidence of spontaneous leukæmia and in mice following radiation. Throughout the life of mice unaffected by infectious disease, the commonest circulating leucocyte is the lymphocyte, and it must be assumed that such cells probably bear the brunt of the immunological defences in that species. Consequently, interference with the mechanisms of control of lymphocyte production and function probably have serious consequences for the mouse. We know that œstrogens may cause marrow aplasia in dogs and in spayed rats—abnormalities which may be corrected by testosterone[6]. We also know that testosterone may produce a rise in red-cell numbers in women who have carcinoma of the breast and who are treated with this hormone[7], and recently testosterone has been used in the treatment of aplastic anæmia in children with success[8].

The present findings indicate further the complexity of the pathogenesis of lymphoid leukæmia in the mouse. At least two hormone systems, the sex hormones and, if it can be shown to be a distinct hormone, lymphocytosis-stimulating factor, appear to be directly implicated. While it is not permissible to transfer directly findings in the mouse to humans, it would seem reasonable to try testosterone administration in those patients with aplastic crises in leukæmia and also in those patients who present with aplastic or hypoplastic bone marrow pictures. Some of these latter may ultimately develop frank leukæmia, and attempts at marrow regeneration may allow earlier recognition of the disease.

This work was done under U.S. Atomic Energy Commission Contract *AT*(30–1)–901 with the New England Deaconess Hospital.

JAMES T. DUHIG

Cancer Research Institute,
New England Deaconess Hospital,
Boston 15, Massachusetts.

---

[1] Wintrobe, M. M., "Clinical Hematology", 957 (Lea and Febiger, 1956).

[2] Duhig, J. T., *Amer. J. Path.*, 35, 697 (1959).

[3] Kaplan, H. S., *Cancer Res.*, 14, 535 (1954).

[4] Kaplan, H. S., "Radiation Biology and Cancer", 289 (Univ. of Texas Press, 1959).

[5] Metcalf, D., *Ann. New York Acad. Sci.*, 73, 113 (1958).

[6] Tyslowitz, R., and Dingemanse, E., *Endocrinol.*, 29, 349 (1941). Vollmer, E. P., and Gordon, A. S., *ibid.*, 29, 828 (1941).

[7] Kennedy, B. J., and Nathanson, I. T., *J. Amer. Med. Assoc.*, 152, 1135 (1953).

[8] Shahidi, N. T., and Diamond, L. K., *J. Dis. Child.*, 98, 293 (1959).

VIROLOGY

Isolation of a Non-pathogenic Tumour-destroying Virus from Mouse Ascites

ANOMALIES of growth of an ascites tumour, consisting of aggregation of tumour cells and other changes, first reported in 1957[1], led to the belief that the tumour was reverting to a solid habit of growth, and selective transplantation was undertaken with the object of segregating solid and fluid variants. As this investigation proceeded, the aggregation effect showed signs of evolving into a more advanced pathological state, with increasing indications of destruction of tumour cells. Many sublines were lost as the incidence of no-takes after massive counted implants increased. Many such no-take animals survived for long periods with no signs of illness or delayed tumour development.

Evidence was obtained that the phenomenon is due to an antigenic tumour-destroying agent, and after excluding a bacterial causation, a virus-like agent was looked for. Vaccinia was thought to be implicated but this was not confirmed, though it seems likely that it was in some way associated with the development of destructive effect on tumours[2].

Early attempts to transmit infectivity by means of filtrates were unsuccessful, probably on account of high losses on filtration; but samples from one 'abnormal tumour' subline which had been stored at −50° C. provided a bacteriologically sterile filtrate that had a potent destructive effect on the Krebs 2 ascites and the Ehrlich ascites tumours obtained from the Chester Beatty Institute and maintained in isolation. Preliminary results show that the sarcoma 37, the Landschutz, the *BP*/8, and the Crocker ascites tumours are also destroyed.

That the agent multiplies is shown by its recovery after serial transmission five times in sterile filtrates obtained from washed Ehrlich cells after infection *in vivo*. The filtrates have been prepared from centrifuged supernatants of infected, washed Ehrlich cells, homogenized in distilled water and filtered through sintered glass of porosity 5. For the transmission of infectivity *in vivo*, the starting filtrate was found to have unchanged potency up to a dilution of 1 : 100, with all-or-none tumour destruction occurring at higher dilutions. At 1 : 1,000, about 30 per cent of the tumours were destroyed, the remaining 70 per cent growing normally to a full yield. The potency of the final, 5th-passage filtrate was qualitatively unchanged, though it had undergone a dilution of the order of $1 : 5 \times 10^6$ during five serial transfers. Control filtrates from 'normal', isolated tumours (Ehrlich and Krebs), prepared in the same way, have never given rise to destruction of tumours or even modified the final yield of tumour cells as compared with untreated and saline controls.

Destruction of tumour cells begins after a latent period following infection. Transmissible infectivity has been extracted from washed cells throughout the latent period. Undiluted filtrates destroy the tumour cells after 3–5 days, but unfiltered extracts are more potent (titre of 10^{-7}), the first signs of cell damage occurring 15–20 hr. after infection. The Ehrlich and Krebs tumours are destroyed when treated with the virus at any stage of ascites growth. Destruction is quantitative in many cases when the agent is given shortly after the implantation of several million tumour cells. In many instances the ascites tumour is effectively destroyed, but a solid tumour develops later at the site of implantation. The earliest result of infection is the sudden aggregation of tumour cells and the deposition of fibrin from the exudate which coagulates in the peritoneal cavity. Increasingly marked nuclear abnormalities leading to total nuclear disruption are seen during the ensuing three days.

The destruction of an established tumour results in the production of a substantial quantity of intraperitoneal debris, and adhesions are formed that give rise to intestinal obstruction, producing various degrees of illness. When a tumour implant is totally destroyed as a result of early treatment with the virus, little or no intraperitoneal disturbance occurs and the animals are indistinguishable from controls not bearing tumours.

A small group of normal mice without tumours, which received 10^6 times the tumour-destroying dose of a filtrate, have been observed for two months and have shown no sign of illness.

Infected cells taken during the phase of cell destruction have been examined under the electron microscope by Dr. R. Dourmashkin, through the courtesy of Dr. R. J. C. Harris, at the Imperial Cancer Research Fund Laboratories at Mill Hill. Large numbers of uniform particles, 75 mμ in diameter, have been found in the cytoplasm. Work is in progress to correlate the presence of these particles with the cytopathogenic effect. The appearance and other known properties of the agent suggest that it may be a new virus.

I thank Prof. Wilson Smith for his encouragement and advice during the latter part of this work.

J. G. BENNETTE

Courtauld Institute of Biochemistry,
Middlesex Hospital Medical School,
London, W.1.

---

[1] Bennette, J. G., Brit. Emp. Cancer Camp. Ann. Rep., p. 20 (1957).

[2] Bennette, J. G., Brit. Emp. Cancer Camp. Ann. Rep., p. 139 (1958).

An Interferon-like Substance released from Tick-borne Encephalitis Virus-infected Chick Embryo Fibroblast Cells

AN interference phenomenon between tick-borne encephalitis and Western equine encephalomyelitis viruses in chick embryo fibroblast monolayers has been described[1]. When chick embryo tissue cultures are inoculated with tick-borne encephalitis virus, the virus multiplies readily, but no cytopathic effect appears until the sixth or seventh day of cultivation. If cultures thus infected had been superinfected with a convenient dose of Western equine encephalomyelitis virus, which normally completely destroys the cells within 48–72 hr., the following events could be observed: (1) complete degeneration of cells caused by this virus and, hence, no interference if tick-borne encephalitis virus-infected cultures were challenged with Western equine encephalomyelitis immediately or 24 hr. after primary inoculation; (2) partial interference if cultures were challenged 48 hr. after inoculating them with tick-borne encephalitis virus; (3) complete suppression of the cytopathic effect caused by Western equine encephalomyelitis virus if challenged 72 hr. after primary inoculation. No interference was established if interfering virus previously neutralized by immune serum was added to cultures.

If, however, the culture fluid infected with tick-borne encephalitis was harvested and transferred to fresh non-infected chick embryo fibroblast monolayers, from which the original fluid had been removed, and immediately challenged with Western equine encephalomyelitis virus, no cytopathic effect caused by Western equine encephalomyelitis virus was present at the time of reading. Treatment of the transferred medium by immune γ-globulin against tick-borne encephalitis virus did not alter its ability to inhibit the cytopathic effect of Western equine encephalomyelitis virus. This phenomenon resembled interferon production in other cell-virus systems, first described by Isaacs and Lindenmann[2]. Results of some experiments analysing this observation are presented.

20 per cent mouse brain suspension of the *Hypr* strain (Czechoslovak tick-borne encephalitis) and the prototype strain of Western equine encephalomyelitis virus propagated in a chick embryo fibroblast bottle-culture were used throughout all experiments. Trypsinized chick embryo cells[3] were cultivated in a medium consisting of 5 per cent inactivated horse serum and 0·5 per cent lactalbumin hydrolysate in Hanks's solution with antibiotics and phenol red. Tube-cultures were seeded with 0·9 ml. of cell suspension containing 3 × 10^5 cells, 1,000-ml. Roux bottle-cultures with 3 × 10^7 cells in 50 ml. of medium. One-day old tube cultures were inoculated with 0·1 ml. of tick-borne encephalitis virus suspension diluted to contain 10^4 *LD*50, bottle-cultures with 0·5 ml. of virus suspension containing 10^3 *LD*50/0·1 ml. The culture fluid was harvested at various intervals, as given with the results. For testing the inhibiting activity of the media harvested, 1–3-day old tube-cultures were used. The Western equine encephalomyelitis virus used as challenge was diluted to contain 10^2–10^3 *TCD*50/0·1 ml. Results were read 3 days after adding the Western equine encephalomyelitis virus. Absence of cytopathic effect caused by Western equine encephalomyelitis virus was considered as positive inhibition.

Table 1 demonstrates the time of appearance of the inhibiting agent in tick-borne encephalitis virus-infected cultures.

For testing the ability of the agent to inhibit the plaque formation of Western equine encephalomyelitis virus a procedure adopted in this Institute for the screening of virus-inhibiting substances (Rada and

Table 1. ABILITY OF CULTURE FLUIDS FROM TICK-BORNE ENCEPHALITIS (TE) VIRUS-INFECTED CULTURES, HARVESTED AT VARIOUS INTERVALS AFTER INOCULATION, TRANSFERRED TO FRESH NON-INFECTED CULTURES, TO INHIBIT THE CYTOPATHIC EFFECT OF WESTERN EQUINE ENCEPHALOMYELITIS (WEE) VIRUS

Time of harvest after inoculation with TE virus	Ability to inhibit the cytopathic effect of WEE virus					
	of untreated fluids			of fluids after contact with immune γ-globulin*		
	Undiluted	Diluted 1:10	Diluted 1:100	Undiluted	Diluted 1:10	Diluted 1.100
24 hr.	0	0	0	0	0	0
48 hr.	+	0	0	+	0	0
72 hr.	+	+	0	+	+	0
120 hr.	+	+	±	*NT*	*NT*	*NT*

* Each dilution of the fluid was mixed in the ratio 10:1 with a 1 per cent solution of immune horse γ-globulin against tick-borne encephalitis virus and incubated 90 min. at 37° C.

+, Positive inhibition (no signs of cytopathic effect); ±, partial inhibition (part of the cells degenerated); 0, no inhibition (all the cells degenerated); *NT*, not tested.

Tube cultures were challenged with 0·1 ml. suspension containing 3·2 × 10^4 *TCD*50 of Western equine encephalomyelitis virus at the same time with the transfer of 0·9 ml. of each sample.

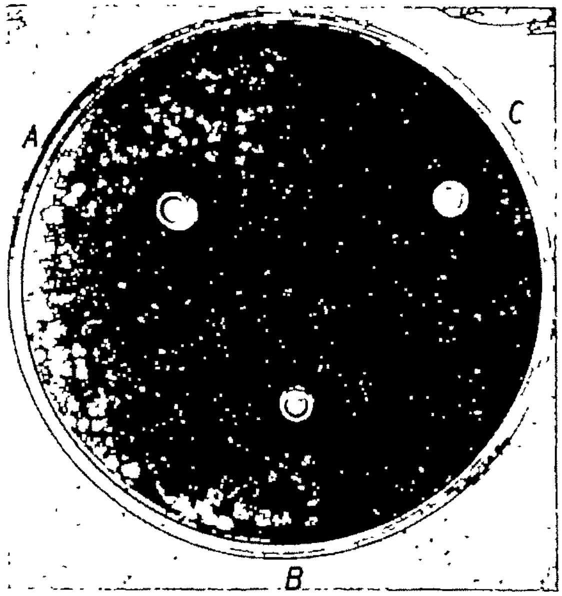


Fig. 1. Western equine encephalomyelitis virus plaque inhibition by the inhibiting agent placed in glass cylinders after adsorption of the virus. *A*, Undiluted fluid; *B*, fluid diluted 1 : 10; *C*, fluid diluted 1 : 100

Závada, personal communication) was used. After adsorption of Western equine encephalomyelitis virus diluted to contain about 5×10^{2} plaque-forming units in 1·9 ml., chick embryo cell monolayers in 10-cm. Petri dishes were overlayed with agar into which small glass cylinders were placed. Two drops of the medium harvested from tick-borne encephalitis virus-infected cultures 72 hr. after inoculation and then treated with immune γ-globulin were placed in each cylinder, using the same dilutions as in the previous experiment. Otherwise the technique described by Dulbecco[3] was employed. Small but definite zones of plaque inhibition could be noticed around cylinders into which undiluted fluids were dropped (Fig. 1). A similar effect was noticed by Porterfield when testing interferon against a variety of plaque-producing viruses[4].

Table 2. STUDIES ON THE MODE OF ACTION OF THE INHIBITING AGENT IN CULTURE FLUID HARVESTED FROM A TICK-BORNE ENCEPHALITIS (TE) VIRUS-INFECTED BOTTLE-CULTURE 72 HR. AFTER INOCULATION

Group No.	Inhibiting fluid	Procedure used	Titre of transferred fluid*
1	Untreated medium†	WEE virus applied along with the transfer to cultures	1 . 80
2	Medium treated with immune γ-globulin‡	WEE virus applied along with the transfer to cultures	1 · 80
3	,, ,,	WEE virus left to adsorb 1 hr. at 37° C., then fluid removed and inhibiting agent added	1 80
4	,, ,,	Inhibiting agent left to adsorb 1 hr. at 37° C., then removed and WEE added	1 : 5
5	,, ,,	Inhibiting agent left to adsorb 24 hr. at 37° C., then removed and WEE added	1 · 80
6	,, ,,	Inhibiting agent mixed with WEE, incubated 1 hr. at 37° C., then transferred into cultures	1 . 80

* Highest dilution to which complete inhibition of the cytopathic effect was established with fluids transferred undiluted and twofold diluted from 1 : 5 to 1 : 160.

† Contained $10^{4\cdot 3}$ i.c. mouse *LD*50 of tick-borne encephalitis virus.

‡ Contained $10^{3\cdot 3}$ i.c. mouse *LD*50 of tick-borne encephalitis virus.

Some work on the mode of action of the agent is summarized in Table 2.

The same dilutions of the fluid which were effective in cultures, mixed with the same dilution of Western equine encephalomyelitis virus and immediately inoculated intracerebrally into mice, did not prevent death caused by Western equine encephalomyelitis virus; all the mice died within the normal incubation period of this virus (72 hr.).

Further evidence has shown that the virus-inhibiting agent released from tick-borne encephalitis virus-infected cells differs from the virus. The agent is adsorbed by cells in culture and seems to have no direct action on extracellular virus. It does not prevent death caused by Western equine encephalomyelitis virus in mice if tested by the same way as in cultures.

J. VILČEK

Institute of Virology,
Czechoslovak Academy of Sciences,
Bratislava 9.

---

[1] Vilček, J., *Acta Virologica*, 4 (in the press).

[2] Isaacs, A., and Lindenmann, J., *Proc. Roy. Soc.*, B, 147, 258 (1957).

[3] Dulbecco, R., *Proc. U.S. Nat. Acad. Sci.*, 38, 747 (1952).

[4] Porterfield, J. S., *Lancet*, ii, 326 (1959).

Mode of Action of Micrococcal Phosphodiesterase

IT was recently reported that phosphodiesterase isolated from *Micrococcus pyogenes* var. *aureus* hydrolyses tobacco mosaic virus nucleic acid giving rise to di- and mono-nucleotides[1,2]. On the basis of its action on this acid and synthetic polymers, polycytidylic acid and polyuridylic acid, it was postulated that the enzyme first cleaves the large nucleic acid molecule into several polynucleotides, which are further broken down by stepwise cleavage of mononucleoside 3′-phosphates starting from one end, until they are reduced to the size of dinucleotides, which are resistant to further action of the enzyme. Thus the enzyme appears to have both endo- and exo-actions. From the amounts of dinucleotides present in the final digest of tobacco mosaic virus nucleic acid, one can calculate the number of intramolecular breaks that are produced in the acid by the endo-action of the enzyme, by assuming that the dinucleotides are at one end of the resultant polynucleotide fragment. In these calculations the data used for the purine and pyrimidine composition of tobacco mosaic virus nucleic acid are those published earlier[3], and the molecular weight of nucleic acid was taken as 2×10^{6} (ref. 4). From the calculations it appears that tobacco mosaic virus nucleic acid has been degraded to approximately 1,240 polynucleotide fragments, having an average weight of 1,600 or an average length of approximately 5 nucleotides.

However, the results presented earlier[3] do not show whether the polynucleotide fragments that are first formed as a result of the endo-action of the enzyme are further degraded starting from the 5′-hydroxyl end of the chain or from the 3′-phosphate end. Experimental evidence has now been obtained on this point, and as will be described, it appears that the enzyme degrades polynucleotide fragments from the 3′-phosphate end.

The polypurine nucleotide fragments, terminated by pyrimidine nucleotides used as substrate in the present work, were prepared as follows: 26·8 mgm.

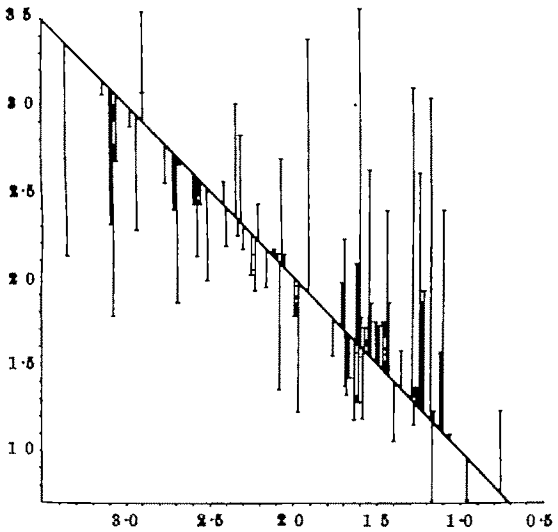


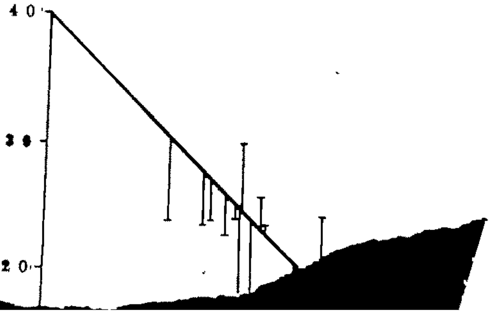
Fig. 1. Oxygen consumption in rats during irradiation

100 male rats (Wistar strain), average weight 190 gm., were divided into four experimental and one control groups, of 20 rats each. The rats were placed in the test chamber and the initial value of oxygen consumption in every rat was measured for 10 min., then the rats were put back in their cage. After a period of 45 min. the second estimation of oxygen consumption was made, and the rats were exposed to X-rays (180 kV., 15 m.amp., 1 mm. aluminium, 0 5 mm. copper, focal distance changed according to the dose-rate. Dose-rates were 100, 50, 20 and 10 r./min. Dose 1,000, 500, 200 and 100 r.).

The oxygen consumption of irradiated and control rats was measured individually by methods described in a previous paper[1].

I did not find any differences in average oxygen consumption in experimental groups during irradiation depending on the dose-rate; but I found that differences depend on the individual level of oxygen consumption before irradiation.

A comparison of oxygen consumption of experimental and control animals in dependence on the initial level of oxygen consumption is given in Figs. 1 and 2.



All experimental animals could be divided in three groups according to the value of initial consumption before irradiation: in the first group are animals with average values, in the second group are animals with extremely high values and in the third animals with an extremely low initial level of oxygen consumption. In the first group rats with an increased oxygen consumption and with a decreased oxygen consumption were observed, the average value of changes being at their initial level. In the second group, the rats have decreased their oxygen consumption and the average values of these changes are lower than their initial level. In the third group, the oxygen consumption is increased during irradiation and the average values are higher than their initial level.

The differences in oxygen consumption in groups of highest and lowest initial oxygen consumption during irradiation is statistically significant ($P = 0{\cdot}005$).

In the control group, I have not observed any changes in oxygen consumption during the second measurement when compared with their initial values.

I have not found in the literature any reports on the relation of the individual level of respiratory metabolism before X-irradiation to the changes in oxygen consumption during irradiation in the conditions described here. Other authors claim that initial oxygen consumption values in rabbits have the same importance for rabbits during daily periods after irradiation[2]. In my experiments, I have observed that rats irradiated under conditions used in radiobiological experiments changed their oxygen consumption during irradiation in a manner dependent on their initial value of oxygen consumption.

It has been shown[3] that irradiation has changed the vegetative balance, and I presume this may be important in connexion with the changes of oxygen consumption.

These results have shown that for work on the metabolic changes in rats during X-irradiation und the described conditions it is more impor know the initial oxygen consumption va experimental animal than the aver whole experimental group of anim

Institute of Biophysics,
Czechoslovak Academy of Scie
Brno.

---

[1] Vacek, A., *Med. Radiol.*,

[2] Pospišil, M., and No

[3] Narinov, Y

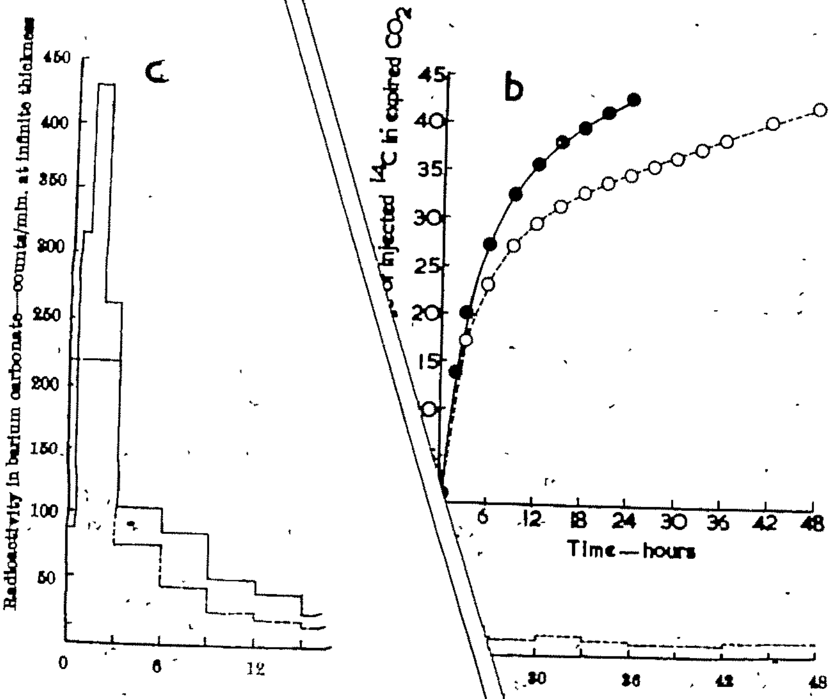


Fig. 1. Elimination of radioactive ca… …nositol as expired carbon dioxide.
a, Radioactivity present in barium … at infinite thickness and thus proportional to specific ac… …at A; ———, rat B.
b, Cumulative percentage of the injec… …l eliminated as carbon dioxide.
O – – – – O, rat … B

Two male albino rats of 356 gm.
(B) were given respectively 10 a
^{14}C-meso-inositol intraperitoneally a
placed inside metabolism chambers
and water, and in which urine and
collected. The inspired air was fr
dioxide, and the carbon dioxide in the e
ollected by drawing the air through
…ion towers containing 5 N sodiu
…f 300 ml./min. The absorptio
…vals up to 48 hr. and 24
…ly. Barium carbonate p
…e technique of Calvi
…d Yankwich[1], and th
…entional thin-windov
…nditions of infinite th
…tal period the
…inositol dete

m.
he
y
d

dioxide with time is approximately exponential and represents an average turnover of free inositol with a half-life of the order of 6 hr. However, the cumulative percentage of injected carbon-14 appearing in the expired air differed in the two rats. In rat A, approximately 42 per cent of the administered activity had been eliminated in the expired carbon dioxide 48 hr. after the injection, while in rat B, a similar elimination was achieved in 24 hr. (Fig. 1b). These figures should be increased by approximately 5 per cent to allow for some loss of carbon dioxide at the end of each collection period necessitated by the removal and replenishing of the absorbant. The discrepancy in the percentage eliminated in the two animals is difficult to ascribe to any definite cause. Similar observations of a rapid degradation of inositol to carbon dioxide have recently been reported by Moscatelli and Larner[3], under different experimental conditions.

The specific activity of inositol in the urine of rat A reached a maximum of 142×10^3 counts/min./mgm. inositol in the sample collected 9–15 hr. following the injection. In rat B, the specific activity in pooled urine samples obtained over the experimental period was $106 \cdot 4 \times 10^3$ counts/min./mgm. inositol. Total loss of radioactivity by renal excretion amounted to 0·33 and 0·58 per cent of the injected carbon-14 inositol in rats A and B respectively.

In rat A, the specific activity in the voided faeces was 107 counts/min./mgm. inositol, and the total loss f radioactivity by this route amounted to 0·014 per nt of the injected material, while in rat B, the ecific activity was 155 counts/min./mgm. inositol d the total loss of radioactivity 0·024 per cent.

lood samples taken from rat B under light ether sthesia by cardiac puncture 9, 16 and 24 hr. after injection gave specific activities in the free ol of 315×10^3, 50×10^3 and 26×10^3 counts/ ngm. inositol respectively.

le 1 shows the radioactivity present in the …amined. It will be seen that the specific …he free and the combined inositol …t in the case of the seminal …ined in both rats, 10·6

Table 1. TISSUE AND SPECIFIC ACTIVITIES FOUND IN RATS KILLED 24 AND 48 HR. AFTER AN INTRAPERITONEAL INJECTION OF ¹⁴C-MESO-INOSITOL

	Inositol fraction	Tissue activity (counts/min./gm. wet weight × 10⁻³)		Specific activity (counts/min./mgm. inositol × 10⁻³)	
		24 hr.	48 hr.	24 hr.	48 hr.
Brain	free	0·75	0·76	0·88	0·78
	combined	1·3	1·4	4·5	2·2
Heart	free	1·1	0·60	15·0	8·6
	combined	—	0·89	—	3·1
Liver	free	2·7	0·79	27·0	6·1
	combined	7·1	1·0	9·8	1·1
Kidney	free	32·0	14·0	40·0	34·0
	combined	6·1	—	27·0	—
Lung	free	2·4	2·3	14·0	9·0
	combined	5·3	—	11·0	—
Seminal vesicle plus secretion	free	34·0	2·7	8·8	0·56
	combined	2·0	2·7	0·76	4·7
Testis	total	1·2	0·31	0·42	0·49
Skin	free	—	0·04	—	0·50
	combined	—	0·76	—	5·4
Skeletal muscle	free	—	0·16	—	5·4
Bone	free	—	1·2	—	6·8
Sciatic nerve	total	—	0·18	—	0·15
Gut	total	—	1·6	—	2·9

components undergoing very rapid turnover in a large non-radioactive metabolic pool would have too few counts to be detected.

The relatively rapid degradation of inositol to carbon dioxide demonstrated in these experiments is of interest and is probably accounted for by the conversion of inositol to glucose. An interconversion involving D-glucuronic acid and the pentose phosphate pathway has recently been suggested by Burns, Trousof, Evans, Papadopoulos and Agranoff[4]. Of interest also is the high specific activity present in the kidney. Charalampous[5] has recently described a renal enzyme capable of converting inositol to glucuronic acid, while Richardson and Axelrod[6] have observed the overall degradation of inositol to carbon dioxide by rat kidney homogenates.

The results reported here suggest that in the rat at least there is an active participation of inositol in intermediate carbohydrate metabolism.

D. A. NIXON

Physiology Department,
St. Mary's Hospital Medical School,
London, W.2.

---

[1] Calvin, M., Heidelberger, C., Reid, J. C., Tolbert, B. M., and Yankwich, R. E., "Isotopic Carbon" (John Wiley and Sons, New York, 1949).

[2] Nixon, D. A., *J. Physiol.*, 133, 4P (1956).

[3] Moscatelli, E. A., and Larner, J., *Arch. Biochem. Biophys.*, 80, 26 (1959).

[4] Burns, J. J., Trousof, N., Evans, C., Papadopoulos, N., and Agranoff, B. W., *Biochim. Biophys. Acta*, 33, 215 (1959).

[5] Charalampous, F. C., *J. Biol. Chem.*, 234, 220 (1959).

[6] Richardson, K. E., and Axelrod, B., *Biochim. Biophys. Acta*, 32, 265 (1959).

BIOLOGY

Copper and Cobalt in Nitrogen Fixation

THE hæmoglobin found in the nodules of leguminous plants, first demonstrated by Kubo, has been since shown to vary in quantity with the condition of the nodules, and both Virtanen *et al.*[1] and Jordan and Garrard[2] have reported a relationship between the quantity of hæmoglobin present and the efficiency of fixation.

The role of hæmoglobin is at present not understood; but its presence implies the possibility that copper and perhaps cobalt would be associated with its synthesis in the nodule. This is supported by the finding that vitamin B_{12} is present in the nodules, and that its concentration in the pink nodules of lucerne is four times as great as in white ones[3].

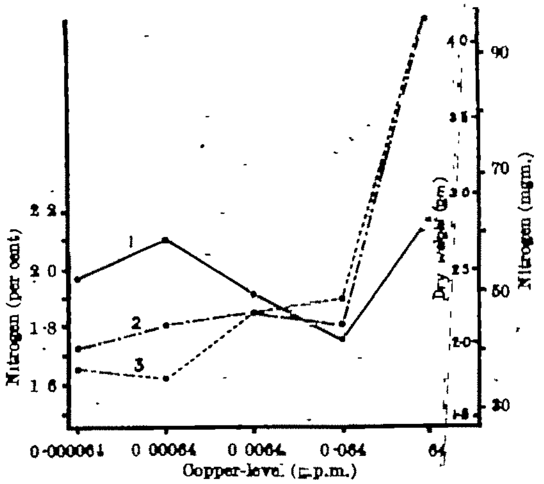


Fig. 1. (1) Per cent nitrogen; (2) mgm. nitrogen; (3) dry weight

On this premise attempts have been made in this Department to investigate the effect of variation in the level of both copper and cobalt on the growth and ability to fix nitrogen of Mount Barker subterranean clover.

In the first case a comparison has been made of the growth in sand culture (after Hewitt[4]), using a modified Long Ashton nutrient medium containing 14 p.p.m. of nitrate nitrogen, on six levels of copper supply ranging from 0·000064 p.p.m. by tenfold steps to 6·4 p.p.m. The highest level was lethal, but the results of the other levels are given below.

As the yield and total nitrogen rose with increased copper supply, the percentage nitrogen fell from the low copper treatments to the Long Ashton level (0·064). Over this range the variation in nitrogen content appears to have been a function of yield only. Between 0·064 and 0·64 p.p.m. copper, however, there was a significant increase both in percentage nitrogen and in total nitrogen content.

Analogous results have now been obtained over three seasons with another strain (Bacchus Marsh), although the level of supply at which stimulation of nitrogen fixation occurred varied from one year to the next. We have not so far been able to demonstrate any change in the haem content of the nodules between these levels of copper supply.

With cobalt, using the same technique as above, subterranean clover was planted out in the glasshouse on May 22, 1959, harvested 152 days later on October 21, 1959. The results for the plants receiving no added nitrogen are given in Table .

From this it is clear that although the highest concentration of cobalt used was restricting growth,

Table 1

	Dry weight (gm.)	Total nitrogen (mgm.)	Dry weight of nodules (gm.)
No added cobalt	5·543	154·7	0·407
0·0006 p.p.m.	5·420	154·9	0·526
0·006 p.p.m.	6·152	178·3	0·511
0·06 p.p.m.	6·365	189·3	0·341
0·6 p.p.m.	4·698	129·8	0·435

(Each seed contained about 0·41 mgm. nitrogen)

additior e rate of 0·008 and 0·08 p.p.m.
had sti gen fixation. (The effect on
the gro ant was demonstrated to the
British Science at a meeting at the
School c n September 1959.)

One cc re of our results has been that
on the g added cobalt, the nodules
increase e to those not receiving this
addition lds even in those plants on a
relatively nitrogen supply (70 p.p.m.).

Our res her that while the total hæm
produced is increased by addition of
cobalt, it n per gm. of nodular tissue
remains This, however, is markedly
depressed the nitrate nitrogen supply,
as can be ble 2.

Table 2

Nitrate nitr in nutrie medium	added to nutrient medium 006	0 006	0·06	0·6 p.p.m.
	gm./gm. dry weight of nodules)			
0	89	619	879	612
7	72	565	527	345
70	35	286	380	409

From th would appear that there is a
clear-cut e copper and cobalt on the
fixation of legume–*Rhizobium* system.
This would at has already been demon-
strated for

One other rest is that the addition of
cobalt up t showed in the early stages
of growth ulation in the number of
leaves proc hen 7 p.p.m. of nitrate
nitrogen wa in the nutrient.

E. G. HALLSWORTH
S. B. WILSON
E. A. N. GREENWOOD

Departme ral Sciences,
Sc ture,
S on,
l.

---

[1] Virtanen, A. I. na, J., and Linnasalmi, A., *Acta Chem. Scand.* Virtanen, A. I., Erkama, J., and Linkola, H.,

[2] Jordan, D. C., a , *Canad. J. Bot*, 29, 360 (1951).

[3] Levin, A. P., F endler, M. D., *Science*, 120, 284 (1954).

[4] Hewitt, E. J., Plant Crops Tech. Comm. No. 22 (1952).

[5] Holm-Hansen, O nd Skoog, F., *Physiologia Plantarum*, 7, 665

Transmiss Disease of Cocoa

THE disease bed as 'buba' or 'cushion
gall' was first ombia in 1938[1]. It was
found afterwar r countries in South and
Central Ameri n Ceylon[2]. The disease
causes hyperpl y of floral cushions, and
is causing con of western Colombia,
Nicaragua and ere it has become wide-
spread. Galls se of the 'green-point'
type in the wes re have been known in
Ghana since 19 Following reports of the
rapid spread o disease in Costa Rica
investigations h in Ghana to assess the
distribution an of the West African
disease, and to The purpose of this
communication he transmission of the
West African d ethods which may be of immediate value to workers concerned with the American 'cushion gall' problem.

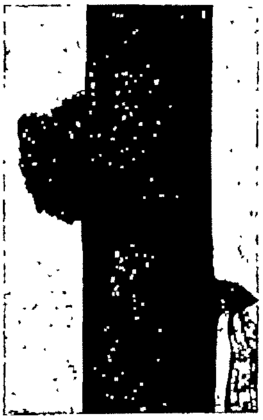


Fig. 1. Gall on mature tree. (× 2/9)

The disease has been transmitted from galls on mature trees, as well as those produced on artificially infected seedlings, by nymphs and adults of the mealy-bug species *Pseudococcus njalensis* Laing and *Ferrisiana virgata* Ckll. and also by various methods of mechanical inoculation. The first transmissions were made using the bean-feeding technique developed for use in the mealybug transmission of cocoa viruses[3]. Adults of *P. njalensis* from a naturally infested gall on a mature tree were transferred to 5 healthy cocoa half-beans at the rate of 10 insects per test bean. Three seedlings grown from these beans afterwards produced galls in the axil of the attached cotyledon (Fig. 2). In subsequent experiments, using insects from artificially colonized source galls, 18 out of 32 seedlings grown from test beans infested with *P. njalensis* and 12 of 15 infested with *F. virgata* produced galls. The disease has also been transmitted to test beans by rubbing and pricking them with macerated gall tissue and by the use of fine paint brushes first stroked over source galls or soaked in gall extracts. These methods gave a total of 47 transmissions in more than 300 bean tests, results from some of which are still incomplete.

The cause of the cushion gall disease in the western hemisphere is not known; but it has been suggested that virus-infections[4], eriophyid mites[7], a genetical abnormality, mineral deficiency or mineral toxicity, bacterial or fungal infections[8] may be involved.

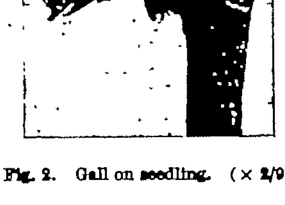
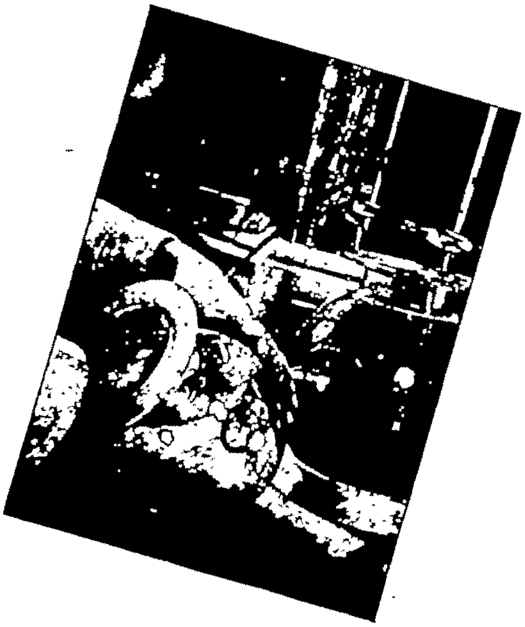


Fig. 2. Gall on seedling. (× 2/9)



Advantages of "QUICKFIT" Open Neck Flasks

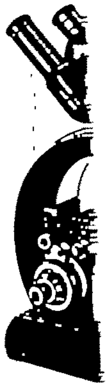
"Quickfit" manufacture and stock a complete range of open neck flasks, together with stainless steel retaining clips for use with the flanges.

The flasks can always be detached from their lids, even under conditions when conical joints tend to seize. Larger stirrer blades can be used and vessels are more easily cleaned. All "Quickfit" flasks and lids are completely interchangeable and the flask diameters are, of course, standard.

TELEPHONE Stone 481

QUICKFIT & QUARTZ LTD., Dept. Z.A.J., "Quickfit" Works, Heart of STONE, Staffs.

th



NEOZET

The ideal in
research wo
microscope
as magnifice
automatic o
capable of in
application c
transmitted l
The NEOZE
utmost rigidi
exceptional v

SHANDON

6 Cromwell Pla

Reicherts

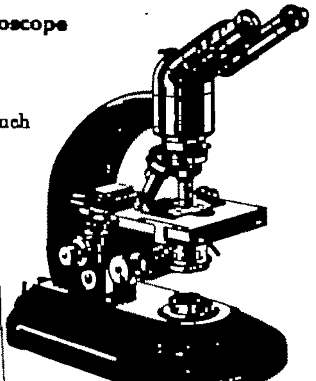
l in optical
anical perfection

IOZET Laboratory Microscope

The latest addition to the Reichert family—a thoroughly modern instrument for biological routine work with particular emphasis on robustness and simplicity of operation. Available with and without built-in lamp, interchangeable bodies and nosepieces and, of course, phase- or anoptral-contrast equipment.

roscope

uch



PAN Universal Microscope

his truly universal instrument for transmitted and incident light is available with interchangeable nent, zirconium arc and mercury vapour lamps, and is thus the ideal photo- and projection-microscope, for both the biologist and the metallurgist. A most comprehensive range of accessories covers such diverse fields as metal grain size measurement and fluorescence microscopy.

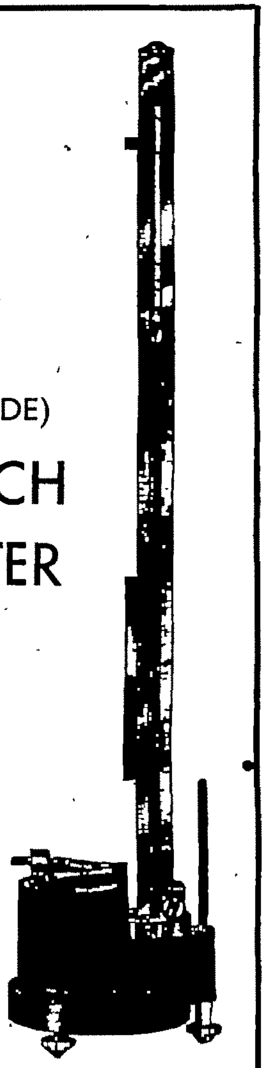
n request

DON

COMPANY LIMITED

7. Tel: KNIghtsbridge 1131

THE DARTON (INFINITE ALTITUDE) TEST BENCH BAROMETER



Suitable for testing and calibrating altimeters and other pressure related instruments.

Scaled in inches, millimetres, millibars, feet or any combination of two scales. National Physical Laboratory Certificate of Accuracy supplied if required.

Satin-chromed frame, with polished chrome fittings mounted on heavy stove-enamelled base.

F. DARTON & CO. LTD.
WATFORD, HERTS.
'PHONE : WATFORD 26019

Transmission of the West African gall disease by mechanical methods in the absence of insects and other pests suggests that the disease has a pathogenic origin. Although fungal hyphæ have been observed in some stained sections of galls, only the ubiquitous *Botryodiplodia theobromae* Pat. and *Calonectria rigidiuscula* (Berk. and Br.) Sacc. have been isolated occasionally from gall-tissue. Grafting and insect transmission experiments have failed to demonstrate a systemic pathogen, and filtrates from seedling gall extracts passed through a Seitz filter (grade *EKS*, sterilizing asbestos film, Griffin and George, Ltd.) were non-infectious. Moreover, when young seedling-galls were macerated under sterile conditions in a small volume of water and centrifuged for 10 min. at 8,000 r.p.m. only the precipitate was infectious to beans. The results of these preliminary experiments indicate that the West African gall disease is of bacterial or fungal origin, although a virus cause cannot be completely ruled out.

Records from the survey[9], in which only 44 trees were found in a half-million acres of cocoa surveyed, show that the disease is at present of little economic importance in Ghana. However, because of the high infectivity of the West African disease in bean-transmission tests, and the similarity of its galls to those of the important 'cushion gall' disease in the western hemisphere, the disease is now considered to be of potential importance and the destruction of all galls on infected trees has been recommended.

A. A. Brunt
A. L. Wharton

West African Cocoa Research Institute,
Tafo, Ghana.

[1] Garces, C. O., "Enfermedades del cacao en Colombia", 32 (Pub. Min. de la Econ. Nacional, 1940).
[2] Hutchins, L. M., Desrosiers, R., and Martin, H., Rep. Inter-Amer. Inst. Agric. Sci. No. 33 (1959).
[3] Orellana, R. G., *F.A.O. Plant Prot. Bull.*, 7, 53 (1959).
[4] Dade, H. A., Ann. Rep., Gold Coast Dept. Agric., 1925–26, 26 (1926).
[5] Posnette, A. F., and Strickland, A. H., *Ann. App. Biol.*, 35, 53 (1948).
[6] Kevorkian, A. G., *Phytopath.*, 41, 562 (1951).
[7] Losada, S. B., Rep. Seventh Inter-Amer. Cacao Conf., Colombia (1958).
[8] Wellman, F. L., and Orellana, R. G., *Plant Prot. Bull.*, 2, 71 (1954).
[9] Wharton, A. L., and Brunt, A. A., *Commonwealth Phytopath. News*, 5, 61 (1959).

Effect of Glutathione and Alloxan on the Photoperiodic Response of *Xanthium*

It has been recently reported by Brachet[1] that a morphogenetic process in the alga *Acetabularia* is promoted by a substance containing —SS— and that the same process is inhibited by substances containing —SH. It appeared of interest, therefore, to test the morphogenetic responses of higher plants to substances containing thiol groups. For this purpose the effect of reduced glutathione on the process of floral induction in *Xanthium*, a short-day plant, was investigated. Alloxan, on the other hand, was chosen as an agent known to reduce rapidly the content of reduced glutathione of blood by both oxidation and coupling reactions[2,3].

Plants of *Xanthium pennsylvanicum* Wall. were grown from seeds, kindly supplied by Prof. K. C. Hamner of the University of California, Los Angeles. The general procedure followed that described by Salisbury[4]. On December 17, when six weeks old, 60 plants were defoliated to a single leaf (third from the apex), to the exclusion of any apical leaves exceeding 4 mm. in length. Immediately after defoliation, 50 plants were sprayed with an excessive amount of freshly made reduced glutathione solutions while 10 control plants were sprayed with distilled water. All sprays contained 0·1 per cent 'Tritone-*X*-100' spreader. The experimental plants were then subjected without delay to a single inductive 16-hr. dark period. An identical procedure was carried out the next day with alloxan. After 14 days the stage of floral development was determined applying Salisbury's system[4]. In addition measurements were made of the diameter of the growing point. The length of the largest leaf retained at the apex was adopted as a criterion of growth increment.

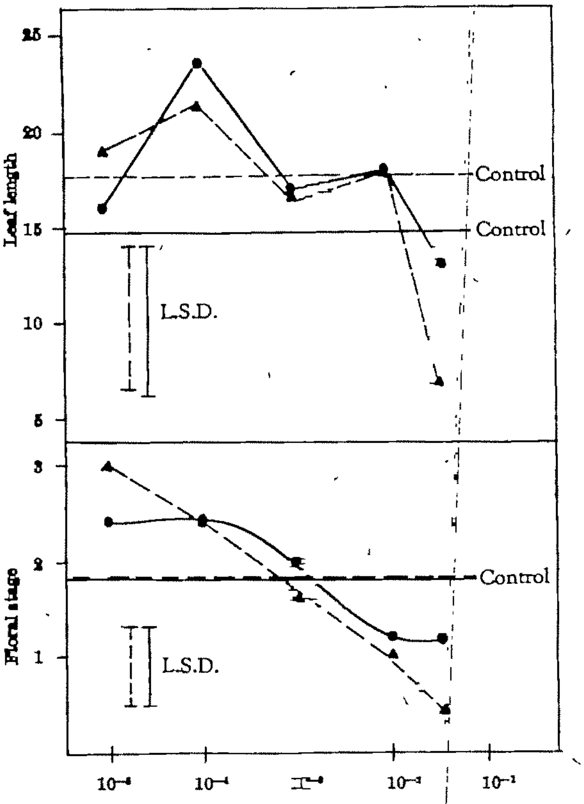


Fig. 1. Responses to different concentrations of reduced glutathione (●) and alloxan (▲)

The results show a promotive effect of both reduced glutathione and alloxan on floral development at low concentrations and an inhibitory effect in concentrations exceeding 10^{-3} *M*. A maximum effect of reduced glutathione appears to occur in the region of 10^{-5}–10^{-4} *M*, whereas in the case of alloxan the optimum concentration is possibly lower than 10^{-5} *M*. These trends were fully confirmed by the diameter measurements.

Both substances, when applied in low concentrations, exerted a promoting effect on apical leaf growth, with a pronounced maximum in 10^{-4} *M* for reduced glutathione. This substance at a concentration of $10^{-1.5}$ *M* caused a slight curling in the inductive leaf while the application of $10^{-1.5}$ *M* alloxan resulted in a partial necrosis of that leaf. Concentrations lower than $10^{-1.5}$ *M* did not produce any visible detrimental effects.

While it is very probable that the inhibitory effect of the high concentrations on morphogenesis is a

function
sion of f
10⁻⁴ *M* s
process n
morphoge
Brachet[1].
oxidized
effect on
effects of
The abe
tions of r
might pos
to oxidize
thione wa
while redu
tion with
which is i
An exce
to be one c
Xanthium
important
of superop
its multiple
possibly pr
different fr

bition, the absence of depres-
ent at the concentration of
more specific morphogenetic
d. The effect of alloxan on
istent with the findings of
rising that alloxan, being an
acil, produced an inhibitory
h[6]. No growth-promoting
o far been reported.
ory effect of low concentra-
hione on floral development
ted for by rapid autoxidation
However, oxidized gluta-
e growth-inhibitory effect;
e resulted in growth promo-
t 3 to 6 × 10⁻⁴ *M* (ref. 8),
with our results.
ation of auxin is suspected
factors in floral induction of
lutathione might play an
ating the inhibitory effect
ncentrations[8,9]. In view of
e[7], reduced glutathione may
genetic effects by pathways
ation of —SH.

J. NITSAN

Plant Ph
Instit
Agricultu

ratory,
ny,
tation,

---

[1] Brachet, J.,
[2] Leech, R. S.,
[3] Patterson, J.
197 (1949).
[4] Salisbury, F.
[5] Salisbury, F.
[6] Povolotskaya,
[7] Crook, H. M.,
1959).
[8] Erazpo Marre
[9] Leopold, A. C.,
1105 (1953).

1959).
J. Biol. Chem., 157, 525 (1954).
nd Levey, S., *J. Biol. Chem.*, 177,
22, 600 (1957).
30, 327 (1955).
Abst., **51**, 8913*i* (1957).
posium (Univ. of Cambridge Press,
1, *Chem. Abst.*, **52**, 2172*g* (1958).
S., *Proc. U.S. Nat. Acad. Sci.*, **39**,

Xylan

eous Green Algae

COMPARATI
chemical na
siphonous gr
septate grou
belonging to
ceae has bee
callose (a na
like substance
in the callus p
Bryopsis and
reliable chara
far been made
being inferred

nown at present about the
ell wall constituents of
ecially that of the non-
he cell wall of the algae
Caulerpaceae and Codia-
sist for the most part of
ally to a polysaccharide-
hemical nature occurring
e tube) and pectin and in
tion to some cellulose, no
hese substances has thus
nce in the algal cell wall
basis of staining reactions

and solubility test[1]. Quite recently Mackie and Percival reported the presence of xylan in *Caulerpa filiformis* and established its structure as of β-1,3-linkage[2].

In the course of our work on the cell wall constituents of green algae we have found that each of the main cell walls of *Bryopsis maxima*, *Caulerpa anceps*, *Halimeda cuneata* and *Chlorodesmis formosana* consisted not of cellulose but of xylan, in which xylose residues are linked by a 1,3-bond. Besides these the presence of xylan also in *Udotea orientalis* and *Pseudodichotomosiphon constricta* was probable.

Of the materials used those of *Bryopsis*, *Caulerpa* and *Halimeda* were collected on the Pacific coasts not far from Tokyo and those of *Chlorodesmis*, *Udotea* and *Pseudodichotomosiphon* were obtained from Okinawa Island. Each of the air-dried algae was treated with 1 per cent hydrochloric acid at room temperature and then successively with 1·25 per cent sodium hydroxide and 1·25 per cent sulphuric acid at 100° for 1 hr. respectively. The residue was bleached with 1 per cent sodium chlorite, thoroughly washed with water and dried. Of the crude fibres thus obtained only that from *Bryopsis* gave weak but definite staining reactions for cellulose with iodine reagents, while with others the reactions were negative. None of these preparations showed optical anisotropy. On acid hydrolysis each crude fibre yielded crystalline D-xylose. Determination of xylan content by Tollens method gave the following results (per cent of moisture-free crude fibre): *Bryopsis*, 78·9; *Caulerpa*, 75·9; *Halimeda*, 78·0. From the crude fibre xylan was obtained by extraction with 10 per cent sodium hydroxide at room temperature followed by precipitation with ethanol. Purification was effected by repeating the ethanol precipitation of xylan from alkaline solution and finally by treating the product with hot water to remove soluble contaminants.

With these xylan preparations the following determinations were made, the results of which are given in Table 1.

When acted upon by sodium metaperiodate, the xylans consumed only a small amount of this oxidant as shown in Table 2.

The resistance of xylans towards periodate would indicate that xylopyranose as well as glucopyranose residues might be linked through C-1 and C-3. Assuming the 1,3-linked xylans to be of linear structure the oxidation by periodate will be restricted to the sugar residues situated at both ends of the chain, where per mole of xylan 3 moles of periodate will be reduced and 1 mole of formic acid produced. Based on the periodate consumption the degree of polymerization was calculated (Table 2), the values of which agree fairly well with those obtained by physical methods (Table 1). The 1,3-bonding of the xylans was also indicated by the production of intact

Table 1. PROPERTIES OF XYLANS

Source of xylan	cu- 0, 06	$[\alpha]_D$ in 2·5 per cent NaOH	Glucose content (per cent)	Viscosity in *N* NaOH at 20·0° η_{sp}/c. (c., 0·045)	Molecular weight from: Sedimentation equilibrium	Molecular weight from: Viscosity*
Bryopsis		−38°	8·4	4·0	6,120 (46)†	5,500 (42)†
Caulerpa		−25°	9·1	4·4		
Halimeda		−26°	9·2	4·0		5,500 (42)†
Chlorodesmis		−31°	8·8	5·1		7,100 (54)†

* Calculated
M, where km. value for *Caulerpa*-xylan, 7·2 × 10⁻⁴, as obtained from sedimentation data was applied to
other xylans.

† Degree of p
ulated from sedimentation and viscosity data.

Table 2. Periodate Oxidation of Xylans

Source of xylan	Periodate consumed per xylose residue (mole)	Degree of polymerization, calculated from periodate consumption
Bryopsis	0·068	45
Caulerpa	0·068	48
Halimeda	0·068	45
Chlorodesmis	0·045	67

xylose and glucose as hydrolysis product of the periodate-treated xylans.

From *Udotea* as well as from *Pseudodichotomosiphon* of which the taxonomical position is still in dispute, crude fibres were obtained yielding a large amount of xylose on hydrolysis. Accordingly, these algae seem to contain a xylan of similar structure.

In some moulds belonging to *Aspergillus* and *Chaetomium* as well as in the hepatopancreas of certain molluscs the occurrence of enzymes was recognized which hydrolysed the xylans to xylose.

All these observations would indicate that the major constituent of these siphonaceous green algae, *Bryopsis*, *Caulerpa*, *Halimeda* and *Chlorodesmis*, and probably also that of *Udotea* and *Pseudodichotomosiphon*, is xylan with 1,3-linkage, which might correspond to so-called callose of these algae. Interesting in this respect is the observation that the 'callose' of *Codium*, unlike that of *Halimeda*, *Chlorodesmis* and *Udotea*, all of which are included usually in Codiaceae, is represented not by xylan but by mannan[3].

We wish to thank Prof. S. Segawa, Drs. M. Chihara, S. Kamura and Y. Miyazawa for their generous support.

Yoshihiko Iriki
Takeo Suzuki
Kazutosi Nisizawa
Tomoo Miwa

Botanical Institute and
Shimoda Marine Biological Station,
Tokyo Kyoiku University,
Otsuka, Tokyo.

---

[1] Prinz, H., in Engler–Gilg's "Die natürlichen Pflanzen-familien", Bd. 3, 2 Aufl., 300 (1927). Iyengar, M. O. P., in "Manual of Phycology", edit. by Smith, G. M., 32 (Chronica Botanica Co., Waltham, 1951). Blinks, L. R., *ibid.*, 278.

[2] Mackie, I. M., and Percival, E. E., *J. Chem. Soc.*, 1151 (1959).

[3] Iriki, Y., and Miwa, T., *Nature*, 185, 178 (1960).

Bacterial Effect and Radiophosphorus Assimilation in Organic and Inorganic Forms in Salmon

Approximately 90 per cent of phosphorus present in the body of a fish is found in the skeleton. The remaining 10 per cent is chiefly intracellular and plays a major part in energy-transfer mechanisms. The reservoir of phosphorus in the skeleton is also of great importance in maintaining adequate levels of this element in the tissues. Fish selectively absorb inorganic salts from water, and concentrate in various tissues the elements of which these salts are composed[1,2]. Furthermore, freshwater fish do not swallow water nor absorb salts through their skin but they carry on salt exchange only across the gills[3,4]. The present work was taken up to study the effect of bacteria and radiophosphorus assimilation in organic and inorganic forms in salmon, *Salmo salar* L.

By the courtesy of the Canadian Fish Cultural Development Branch, yearling salmon were brought from the Grand Lake rearing ponds and placed in a temperature-controlled room at 10 ± 1° C., where they were given two days to settle down to the conditions of the laboratory. The experimental aquaria were in two sets, to one of which antibiotic tetracycline was added (0·1 gm. per litre) and left for 4 hr. so that the bacteria would be inactivated. Phosphorus-32 (Atomic Energy of Canada, Ltd.), in the form of phosphoric acid in diluted hydrochloric acid, was then added to both sets to give an activity of 2,100 counts per min. per ml. After 2 hr., fishes, which were roughly of the same size and weight (approximately 15 gm.), were put in both the sets. When phosphorus-32 was added to water in inorganic form a considerable portion is either ingested or transformed into organic form by bacteria and a condition of equilibrium is reached in about 24 hr.[5,6].

From each set, henceforth called control and treated (with antibiotic), four fishes were taken out at regular intervals and their tissues (liver, kidney, muscles, brain, heart and bone) were variously treated for counting the radioactivity. All the readings were corrected for decay and were standardized according to the uranium standard readings. When phosphorus-32 entered the body of the fish its distribution in the tissues was similar in both sets, bone taking up the maximum followed by liver, kidney, heart, muscles and brain. In the initial stages, up to about 24 hr., the uptake of radiophosphorus in both treated and control was almost similar. This can be explained by the fact that radiophosphorus in the control had not yet become completely equilibrated so that most of the radiophosphorus in both sets was in the inorganic form. After 24 hr., the uptake in treated set went up. In treated set, fishes could take up from water 39·6 per cent of phosphorus-32 and the control only 27·5 per cent. The turnover-time, which may be defined as the time required to renew completely the amount of substance present in the tissue, was calculated both for water as well as fish, and it came to 116·1 and 54·7 hr. in treated and 142·2 and 71·4 hr. in control respectively. These experiments indicate that fish absorbed more phosphorus-32 from the aquaria which had all the phosphorus in inorganic form. In the control, where three-fifths of phosphorus was transformed into organic form, the uptake was low.

The question which still remains to be answered is whether fishes can absorb phosphorus in organic form or not ? If so, what is the relationship between the two ? Another set of experiments was arranged to answer this question. Large quantities of phosphorus-32 were added to the aquaria and left for two weeks, after which the water was passed several times through a demineralizer until all the inorganic phosphorus was eliminated. Then it was passed through a millipore filter, which removed all the bacteria, and only phosphorus-32 in organic form was left in water. In other aquaria inorganic phosphorus-32 was put in water and tetracycline was immediately added to both the sets so that the activity of bacteria would be suppressed. In 144 hr., fish could absorb only 24·5 per cent of radiophosphorus in organic form, whereas in inorganic state they could utilize 43·0 per cent. The turnover time for water and fish came to 156·0 and 82·6 hr. for fishes maintained in organic phosphorus-32 and 107·[illegible] and 51·8 hr. for fishes kept in inorganic phosphorus-32.

The oc
preferenc
and rapic
remain w
will go or
is very m
published.
My tha
valuable e
assistance
from the
gratefully

Zoology
Dalhous
Halifa

[1] Krogh, A., Z
[2] Krogh, A., '
Universit
[3] Smith, H. W
[4] Smith, H. W
[5] Harris, E., (
[6] Hayes, F. R.

Use of D

THE cont
Guinea Sava
developed i
a single app
wettable po
to kill the y
three or fou
Guinea Sava
humid, and
applications
centrations
cent have no
population c
order to ov
decided to ca
was claimed
persistence u
The site of
of the South
vegetation is
broken up b
the majority
year. These r
varying betw
bank and ty
guineense, *U*
senegalensis,
Raphia spp., f
a dense thic
Along the riv
population of
and it is age
measures are a
gambiense. 4
vegetation ha
other rivers b
tsetse control
the fly popula
previous years
the behaviour
were well know
for the trial, b

ed at is that fishes have a
rb, inorganic salts more easily
ic; but if they are forced to
ganic state, the assimilation
of absorption and turnover
The detailed results will be

Prof. F. R. Hayes for his
encouragement. Financial
f a post-doctorate fellowship
earch Council of Canada is

P. N. SRIVASTAVA

, 654 (1937).
on in Aquatic Animals" (Cambridge

l., 93, 480 (1930).
, 7, 1 (1932).
, 769 (1957).
, *Limno. and Oceano.*, 3, 450 (1958).

IOLOGY

e Control of *Glossina* D) in Nigeria

tachinoides in the Northern
Northern Nigeria has now
routine measure in which
er cent suspension of DDT
gives sufficient persistence
h emerge from their pupae
praying. In the Southern
ere the dry season is more
form at night, even five
intervals of DDT at con-
n 2·5 per cent and 5 per
successful against a mixed
and *G. tachinoides*[2]. In
mited persistence it was
trial using dieldrin, which
xic and to have a longer
ditions.
owards the southern limit
vannah Zone[1], where the
extensive farming and
river systems of which
g water throughout the
ain-forest type vegetation
0 yards wide on either
x cienkowski, *Syzygium*
hoenix reclinata, *Khaya*
hala, *Sterculia* spp. and
continuous canopy with
and creepers beneath.
found a reasonably high
d a few *G. tachinoides*,
e species that control
e vectors of *Trypanosoma*
river supporting heavy
been isolated from the
as part of the existing
the area. In addition
studied for the three
ther experiment so that
on of flies on this river
o control river was used
river about 10 miles to

the south was being kept under observation this was considered to be a sufficient control.

To assess the fly population before spraying, twenty fly-catching points were chosen at nearly equal intervals along the length of the river. Four teams of two fly catchers each visited five points during a day, spending 1 hr. at each point, so that both rivers were completely inspected daily. The number of flies caught was recorded and the flies released at the end of each hour before moving on to the next point.

In contrast to the formulation used in the previous trial, where wettable powder was used, the spray was prepared from a water-miscible concentrate containing 20 per cent dieldrin and packed in 5 gal. drums. One part of this concentrate was added to four parts of river water, giving an emulsion containing 4 per cent dieldrin. The sprayers used were five 2-gal. 'Eclipse Warley' pneumatic sprayers.

It was found that a great advantage of using this preparation was that the concentrate could be added directly to water in the sprayers and therefore no bulk mixing or carrying of mixed solution was necessary. Spraying was concentrated mainly on all tree trunks and leaves up to 4 ft. from the ground throughout the width of the riverine vegetation, special attention being paid to fallen logs and the undersides of leaves overhanging the river-bed. Immediately after spraying the emulsion left a deposit from which the water phase evaporated after about 15 min., leaving the almost invisible oil phase. It was not until some 24 hr. later that a white deposit of crystals could be seen on the foliage. To eliminate the risk of spraying twice or of under-spraying due to being unable to see what had been sprayed before, a man with a matchet followed each sprayer and slashed trees that had been sprayed so that those following behind would know what had been already treated.

The effect of the insecticides on the fly population was immediate; the average daily total catch over all points for the week before spraying had been 31 *Glossina palpalis* per day (no *G. tachinoides* were present for the few weeks preceding the trial) and since early December 1957, when spraying took place, until December 1958, when fly rounds were discontinued, no flies were caught or seen on the river. This is in direct contrast to the results obtained using DDT, when a gradual fall-off in population was experienced. It has been noted previously in the Northern Guinea Savannah Zone, for example, in Katsina and Kano Provinces, where a single application of DDT is now used as a routine measure, that an absolute kill immediately following the application usually forecasts the success of the project. There was no significant drop in fly population on the control river.

In all, 52·5 gal. of water-miscible concentrate were used to treat the 4·5 miles of river, at a rate of 11·7 gal. of 20 per cent dieldrin per mile, the whole operation taking six working days to complete. The cost of spraying came to £41 per mile, which, in spite of the increased initial cost of dieldrin, compares very favourably with DDT, where the cost was £50 10s. per mile for five applications. Partial clearing by paid labour on this river would have cost between £100 and £200 per mile.

The use of dieldrin, if it is found in other cases to be as successful as the one just described, will represent a saving not only in the cost of the materials and transport, by needing only one application as against four or five applications of DDT, but also in that a small spraying unit should be able to cover a length of river five times greater than would have been possible in the same time had DDT been used.

On the strength of the success of this trial a river system in the south comprising some 60 miles of river was treated with dieldrin as a field trial early in 1959 and the results so far are encouraging.

This communication is published with the permission of the Ministry of Health, Northern Nigeria, and the general administration and supervision of the fly rounds was carried out by Mr. J. Milton, sleeping sickness control officer.

J. B. Davies

Sleeping Sickness Service,
Ministry of Health,
Kaduna,
Northern Nigeria.

---

[1] Keay, R. W. J., "An Outline of Nigerian Vegetation" (Government Printer, Lagos, 1949).

[2] Davies, J. B., *Bull. Ent. Res.*, 49, Pt. 3, 427 (1958).

CYTOLOGY

Acetone Fixation for the Cytochemical Demonstration of Dehydrogenases in Blood and Bone Marrow Cells

The demonstration and localization of certain dehydrogenases within cells has been achieved cytochemically by exposing the cells to appropriate substrates upon which the dehydrogenases may act, in the presence of tetrazolium compounds capable of accepting hydrogen with the production of coloured insoluble pigments (formazans). The most satisfactory tetrazolium salt for this purpose is 'Nitro *B.T.*', a *p*-nitrophenyl substituted ditetrazole, which, under appropriate conditions, readily yields a finely granular formazan deposit[1,2].

The application of this technique to the study of blood and bone marrow cells has been hampered by problems of fixation, since fixatives giving adequate cell preservation generally inactivate the enzymes. Using air-dried smears of blood or bone marrow we have found this to be the case with most common fixatives, including methanol, ethanol, formalin solutions and formalin vapour. Attempts have been made to overcome the difficulty by allowing fresh suspensions of heparinized blood or marrow cells to react with the enzyme substrate and tetrazolium compound in test-tubes, smears then being made of the centrifuged deposit and afterwards fixed and counter-stained[3]. Unfortunately, considerable cell damage tends to occur during incubation and centrifugation, and accurate cell identification proves difficult to achieve.

There has recently been increasing interest in acetone as a fixative for enzyme cytochemical work, since it appears less inimical to enzyme activity than most other fixatives[4,5]. We have therefore carried out a series of experiments using different concentrations of acetone, alone or in various combinations with methanol, ethanol or formalin, at different temperatures and for different periods of time, as fixatives applied to air-dried smears of blood or bone marrow prior to incubation in the substrate–tetrazolium mixtures for cytochemical detection of succinic and lactic dehydrogenases. Mixtures of acetone with other fixatives generally gave excellent cell preservation, but invariably reduced enzyme activity, even when used for only 30 sec., whereas solutions of acetone alone allowed strong enzyme reactions to occur while providing, after an exposure of 30 sec.–1 min., a degree of fixation quite adequate for identification of cells and for enzyme localization at an intracellular level. The most satisfactory concentration of acetone was 60 per cent in distilled water, preferably used at room temperature, since ice-cold acetone solutions tended to wash off smears from the slides. Consistent and reproducible results were obtained with this method of fixation, and there appeared to be no decrease in enzyme activity in smears kept for 5–6 hr. before fixation. After this time dehydrogenase activity lessened, but was still detectable at 24 hr.

The full technique we have used for dehydrogenase cytochemistry in blood and marrow smears may be summarized as follows:

(1) Blood or marrow is smeared directly on glass slides and allowed to dry in air.

(2) Within 5–6 hr. the smears are treated with 60 per cent acetone in distilled water at room temperature for 30 sec.–1 min., rinsed in distilled water and air-dried.

(3) After fixation the smears are incubated for 1 hr. in the appropriate substrate, for example, for succinic dehydrogenase:

Phosphate buffer 0·2 *M* pH 7·4	10·0 ml.
Sodium succinate 0·2 *M*	10·0 ml.
Sodium bicarbonate 0·6 *M*	2·0 ml.
Calcium chloride 0·03 *M*	0·2 ml.
Aluminium chloride 0·03 *M*	0·2 ml.
'Nitro *B.T.*'	10 mgm. in 10 ml. of distilled water
Distilled water	to 40·0 ml.

(4) The smears are then rinsed with distilled water, dried and counterstained with 0·1 per cent nuclear fast red for 10 min.

Acetone not only provides a reasonable degree of fixation without inhibiting dehydrogenase activity, but also removes lipid particles on which the coloured formazan may otherwise be falsely localized. The pattern of positivity in leucocytes revealed by

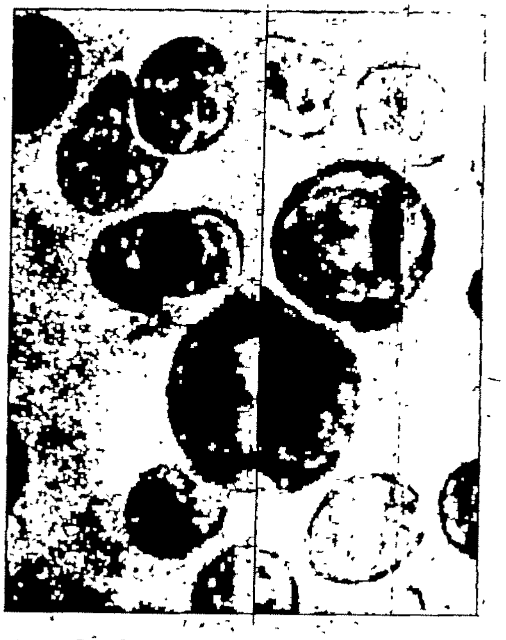


Fig. 1. Cytoplasmic positivity in lymphocytes. (× 2,000)

Fig. 2. Sc

staining w
turbed, sin
similar to
Patterns
lymphocyt
2. Granul
cytes and
enzymatic
antly nega
hitherto.

Departm
Universit

[1] Tsou, K.-C., J. Amer. C
[2] Nachlas, M. I man, A. M
[3] De Souza, E., (1959).
[4] Willighagen, I
[5] Novikoff, A. chem., 8, 2

Absorb

ANALYSIS
measuremen
from rat liv
croton oil t
mouse neur
straight line
plotted agai
diameter. (
expression :

The ways in
acid-content
that the nu
geneously al
the absorbi

activity in leukaemic monocytes. 2,000)

k B is not, however, dis-
s after acetone fixation are
malin fixation.
hydrogenase distribution in
tes are shown in Figs. 1 and
s up to the stage of myelo-
tes also showed sites of
polymorphs were predomin-
pecimens we have studied

DENNIS QUAGLINO
F. G. J. HAYHOE

e,
e.

hlas, M. M., and Seligman, A. M., 9 (1956).
Souza, E., Cheng, C.-S., and Selig- ytochem., 5, 420 (1957).
N., J. Histochem. Cytochem., 7, 77
eydt, H. T., Nature, 183, 263 (1959).
nd Drucker, J., J. Histochem. Cyto-

gen-stained Somatic
Nuclei

data on cytophotometric
stained somatic cell nuclei
id gland[1], untreated and
ear epithelial nuclei[2] and
nuclei[3] has shown that a
hen the absorbance, E, is
ocal of the squared nuclear
and b are constants in the

$+ bD^{-2}$

al nuclear deoxyribonucleic
calculated[4-8] demonstrate
imagined as being homo-
ts, that is, objects in which
are randomly distributed,

non-interacting and retaining their shape and number. But according to the equation the mass (= deoxyribonucleic acid-content) must remain constant, no synthesis can therefore take place, and this is contradictory to experimental facts. We can therefore conclude that in spite of the finding that the equation describes the data well, it does not mean that the nuclei are homogeneously absorbing objects. A non-random distribution of the Feulgen-stain was observed by DeSmul and LeComte[9], and reconstructions of serially cut human and rodent somatic nuclei in this laboratory[10] have shown that the Feulgen-stained material and the nucleoli are distributed in a peripheral zone. We can therefore conclude that the absorbing material, that is, deoxyribonucleic acid, is not randomly distributed and consequently that published data on the total nuclear deoxyribonucleic acid content, calculated from cytophotometric measurements of fixed tissue assuming a random distribution of the absorbing particles, are erroneous. The linear relationship between the nuclear absorbance and the inverse nuclear surface area may simply mean that both the absorbance and the geometrical dimensions are dependent variables of a common variable as, for example, the growth process, thus:

$$E = f_1(X) \text{ and } D^2 = f_2(X)$$

A practical consequence of this is, as is also evident from the equation, that a simple measurement of the nuclear geometrical dimensions will yield the same information as that obtained by the far more complicated and costly photometric method.

The numerical value of the constant b, which may well have different absolute values for different tissues, is thus not a direct measure of mass, but is a measure of the rate at which the absorbance decreases for unit surface area increase over a given mass range. For nuclei retaining their ploidy the growth process results in a doubling of the chromatin mass (deoxyribonucleic acid) and an increase in size between two consecutive divisions. As the relative mass of nuclei of different ploidy has the value of 1 : 2 : 4 . . ., it follows that for a stationary population of nuclei of different ploidy the relative numerical values of the constant b will show this ratio. If transitions from one nuclear class to another occur the relative value of b will depend upon the intensity of transition. Deviations in the relative values of b from 1 : 2 : 4 . . . can accordingly be interpreted as a measure of the degree of cell differentiation. We would therefore expect, as also found by Moore[11], that the degree of deviation from the ratio of 1 : 2 : 4 varies from individual to individual as well as with age.

SIMON IVERSEN

Cancer Research Department,
Royal Beatson Memorial Hospital,
Glasgow.
Feb. 29.

[1] Alfert, M., Bern, H. A., and Kahn, R. H., *Acta Anat.*, 23/24, 18 (1955).
[2] Pasteels, J., and Bullough, W. S., *Arch. Biol.* (Paris), 64, 271 (1953)
[3] Swift, H., *Physiol. Zool.*, 23, 169 (1950).
[4] Swift, H., *Int. Rev. Cytol.*, 2, 1 (1953).
[5] Swift, H., and Rasch, E., "Physical Techniques in Biol. Res.", 3, 35 (1956).
[6] Kurnick, N. B., *Int. Rev. Cytol.*, 4, 221 (1955).
[7] Vendrely, R., and Vendrely, C., *Int. Rev. Cytol.*, 5, 171 (1956).
[8] Leuchtenberger, C., "General Cytochemical Methods" (1958).
[9] DeSmul, A., and LeComte, C., *Arch. Biol.* (Liège), 64, 259 (1953
[10] Iversen, S., *Acta Anat.* (in the press).
[11] Moore, R. C., *Chromosoma*, 4, 565 (1952).

FORTHCOMING EVENTS

Tuesday, July 5

Institute of Physics (at 47 Belgrave Square, London, S.W.1), at 5 p.m.—Annual General Meeting.

Tuesday, July 5—Friday, July 8

Fourth International Goitre Conference (at Church House, Great Smith Street, Westminster, London, S.W.1).

Wednesday, July 6

Bone and Tooth Society (at 234 Great Portland Street, London, W.1), at 4 p.m.—Annual General Meeting, followed by Scientific Papers.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer or Lecturer (preferably with suitable qualifications in entomology) in the Department of Zoology—The Registrar, The University, Liverpool, quoting Ref. CV/N (July 9).

Junior Lecturer (with a medical degree and preferably a degree in physiology) in Physiology—The Secretary, The Medical College of St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (July 11).

Research Assistant in the Department of Botany, to carry out research with Dr. L. Fowden on nitrogen metabolism—The Secretary, University College, Gower Street, London, W.C.1 (July 11).

Temporary Lecturer in Medical Physics in the Department of Medicine—The Registrar, The University, Manchester 13 (July 11).

Biochemist, Basic grade (preferably with previous experience in steroid work), to work in general clinical biochemistry, under the direction of the Consultant Biochemist—The Secretary, Edmonton Group Hospital Management Committee, North Middlesex Hospital, Silver Street, London, N.18 (July 12).

University Lecturer in the Department of Applied Mathematics and Theoretical Physics—Dr. F. G. Friedlander, Secretary of the Appointments Committee of the Faculty of Mathematics, The Arts School, Bene't Street, Cambridge (July 13).

Research Assistant (Physicist) in the Ceramics Division of the Houldsworth School of Applied Science, to undertake an investigation of the influence of dissolved water on the physical properties of glass—The Registrar, The University, Leeds 2 (July 15).

Chemist, Assistant Experimental Officer or Experimental Officer grade, in the Pedology Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (July 16).

Lecturer or Assistant Lecturer (preferably with an interest in experimental study of molecular structure by diffraction techniques) in Inorganic or Physical Chemistry—The Registrar, University College of North Staffordshire, Keele, Staffs (July 16).

Lecturer or Assistant Lecturer (with a special interest in inorganic chemistry) in Chemistry—The Secretary and Registrar, The University, Southampton (July 16).

Lecturer (with special competence in statistical and experimental methods) in Psychology—The Secretary, The University, 36 North Bailey, Durham (July 16).

Assistant Lecturer in the Department of Chemistry and Biochemistry—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (July 18).

Demonstrator (with an honours degree in chemistry or biochemistry, and prepared to engage in research in biochemistry with a view to obtaining a higher degree in this subject) in the Department of Chemistry and Biochemistry—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (July 18).

Senior Lecturer (with a first- or second-class honours degree in mathematics, and teaching experience in both pure and applied mathematics) in Mathematics at the Royal Naval College, Greenwich, London, S.E.—The Civil Service Commission, 17 North Audley Street, London, W.1, quoting Ref. S/5154/60 (July 21).

Senior Lecturer (with a science degree specializing in geology, research experience in igneous and/or metamorphic petrology to Ph.D. or comparable level, an interest in field work, and preferably some overseas experience) in Geology (Petrologist) at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or The Registrar, University of Queensland, Brisbane, Queensland, (Australia and London, July 29).

Senior Lecturer and a Lecturer in Applied Mathematics at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Cape Town and London, July 30).

Professor of Physical Chemistry at the University of Natal, Durban, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, July 31).

Senior Lecturer or Lecturer, to be responsible for courses in forest botany at graduate and postgraduate level; and a Lecturer (with research interests in either tree physiology and sylviculture or forest zoology) in the Department of Forestry—The Secretary, The University, Aberdeen (July 31).

Lecturers (qualified in some branch of applied thermodynamics or applied mechanics, including automatic control, or engineering materials) in Mechanical Engineering—The Secretary of University Court, The University, Glasgow (August 6).

Metallurgist (with a science degree, preferably with honours or equivalent, and experience in metallurgical research) in the Research Laboratories, Australian Post Office, Melbourne, for research into the properties of metallic protective coatings, the investigation of metallurgical failures and the analysis of metals, etc.—Australian Post Office Representative, Australia House, Strand, London, W.C.2 (August 8).

Senior Lecturer (with medical qualifications or higher degrees in physiology) in the Department of Physiology, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, August 15).

Statistician, Scientific Officer or Senior Scientific Officer grade (with a good honours degree and preferably postgraduate experience)—The Secretary, East Malling Research Station, near Maidstone, Kent (August 22).

Lecturer (with an honours degree in psychology, together with acceptable qualifications and practical experience in clinical psychology) in Psychology at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, August 31).

Lecturers (2) in Geography at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 31).

Senior Demonstrator (graduate) in Zoology at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 31).

Basic Grade Biochemist (graduate in chemistry or biochemistry), to work in the Group Pathological Laboratory under the supervision of the Principal Biochemist—The Group Secretary, Reading and District Hospital Management Committee, 3 Craven Road, Reading.

Biochemist (non-medical), for hospital biochemical work in the Mansfield Area Pathology Service—The Hospital Secretary, King's Mill Hospital, Sutton-in-Ashfield, Notts.

Chemist (with an honours degree in chemistry, some veterinary/agriculture or medical experience, and some experience in biochemistry) with the Government of Tanganyika, to supervise the Chemical Section of the Veterinary Research Laboratory, duties will include frequent safaris for experiments in the field—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/020.

Chief Electronics Technician, to assist in the developments related to cardiac surgery—The Assistant Administrator, Radcliffe Infirmary, Oxford.

Dean of the School of Pharmacy—Chairman of the School Council, School of Pharmacy (University of London), 29-39 Brunswick Square, London, W.C.1.

Lecturer (experienced graduate teacher with a knowledge of psychology) in Education in the College (Training Department and School of Art)—The Warden, University of London, Goldsmiths' College, London, S.E.14.

Lecturer (qualified to teach physiology or comparative animal physiology to degree level) in Physiology or Comparative Physiology—The Registrar, Bradford Institute of Technology, Bradford 7.

Lecturer (single, male, preferably specializing in entomology and/or animal physiology) in Agricultural Zoology and Assistant Warden—The Clerk to the Governors, Essex Institute of Agriculture, Writtle, near Chelmsford, Essex.

Lecturer (well qualified physicist with research and/or industrial experience, and with, or prepared to develop, a strong interest in the physics of materials) in Physics—The Principal, Rugby College of Engineering Technology, Eastlands, Rugby.

Post-Doctoral Fellow in Organic Chemistry—Dr. R. A. Abramovitch, Chemistry Department, University of Saskatchewan, Saskatoon, Canada.

Research Assistant (with a good honours degree in psychology, and preferably postgraduate training in psychology), to help in the investigation of intelligence and memory functions in normal and psychiatric elderly subjects at Bethlem Royal Hospital, Beckenham, Kent—The Secretary, The Institute of Psychiatry, The Maudsley Hospital, Denmark Hill, London, S.E.5, quoting Ref. R.F.94.

Research Chemist (graduate in chemistry with research experience), for analytical studies in soil and tissue—The Chairman, Dental Committee, Medical Research Council, P.O. Box 647, Dunedin, New Zealand.

Scientific Officer (honours graduate in biology/zoology) in the Biophysics Section, for work relating to the physical-chemical basis of virus-antibody relationships and other aspects involving serological and biological assay—The Secretary, Research Institute (Animal Virus Diseases), Pirbright, Surrey.

Scientific Officer (male or female, with an honours degree in science, pharmacy or biology), for duties which will consist of technical work in the Blood Transfusion Service Laboratories—The Director, Blood Transfusion Service, Roby Street, Manchester 1.

Scientific Officer (with a first- or good second-class honours degree), to work in the Cardio/Thoracic Laboratories—The Secretary to the Board, The General Infirmary, Leeds 1).

Senior Research Technician (with a knowledge of electronics and vacuum techniques, and preferably previous experience in electron microscopy), to assist in research projects of biological and medical significance—The Secretary, St. Bartholomew's Hospital Medical College, West Smithfield, London, E.C.1.

Technician (preferably with some laboratory experience in cytology or histology) for Cancer Research Laboratory—The Administrative Officer, Mount Vernon Hospital, Northwood, Middlesex.

Technician (with experience in routine histology) at the Royal Cancer Hospital, Chester Beatty Research Institute, Fulham Road, London—The Secretary, Institute of Cancer Research, 33 Sumner Place, London, S.W.7, quoting Ref. 801/B/32.

Visiting Lecturer (with previous experience in the teaching of philosophy at university level) in Philosophy—The Chairman, Department of Philosophy, The University of Kansas, Lawrence, Kansas, U.S.A.

REPO

Institution
Mankind. B
Lecture.) P
1960.)
Report of
Pp. 43+2 pl
and Adminis
The Lever
Trustees. Pp
Ministry of
Analysing C
(London: M
Questions c
tions for Fail
The Depar
By Lyndall I
Ltd., 1960.) 2
Freshwater
A Key to the
T. T. Macan.
Biological As
Royal Inst
Principles of
vi+57. (Lond
Henry Wig
Engineering
Wiggin and C
British El
Technical Re
of Inflammab
Riddlestone.
Terrestrial an
Pp. 8. 9s. (
Research Asso
Internation
approved for s
the Internatio
January 1960
dated 26th Ja
Stationery Off
Governmen
No. 7: Resul
of Agriculture.
The Rowett
Subject Revi
Rowett Resear
The Fauna
Notices, April
c/o The Zoolog
1960.)
Department
Research and I
H.M. Statione
The British
J. Dalladay.
Co., Ltd.; Ne
covers); 10s.
Henry Wig
Alloys. Pp.
1960.)
De Havillan
De Havilland
pellers, Ltd., 1
Imperial Co
Postgraduate C
Imperial Colleg
The Royal S
saries Scheme.
and Nuffield Fo
Solid State
Bi-monthly,
postage): (A)
establishments.
scribers who wr
is for their pers
and New York
Journal of Ch
1960). (Officia
Psychiatry.) P
members of the
per annum, in
(15 dollars) per
per volume. (L
Pavlov Journa
from the Russia
1,000 pages p
(London and N

Bechuanaland
Survey Departm
(Lobatsi: Geol
Metropolitan
(February, 1960
weight Men. o
Company, 1960.
East Africa H
(Nairobi: Gove

ther PUBLICATIONS

onthly Books Supplement)

tain and Ireland

tallurgy. Exploitation of Minerals for
The Fifth Sir Julius Wernher Memorial
Institution of Mining and Metallurgy,
[74
Timber Borer Research Unit, 1958–59.
rown Agents for Oversea Governments
[74
e Third Report of the Leverhulme
e Leverhulme Trust, 1959.) [74
ional Insurance. Digest of Statistics
acity, 1956–57. Pp. 33+52 tables.
and National Insurance, 1960.) [74
. By Dr. J. N. Hawthorne. (Founda-
: The Tyndale Press, 1960.) 2s. [84
Informal Talk on Store Organization.
(London: Urwick, Orr and Partners,
[84
tion. Scientific Publication No. 13:
Brackish-Water Gastropods. By Dr.
Pp. 47. (Ambleside: Freshwater
[84
Monographs for Teachers. No. 3:
Metals. By Dr. D. J. G. Ives. Pp.
te of Chemistry, 1960.) 6s. [84
The Nimonic Heat-Resisting Alloys—
n. Pp. 52. (Birmingham: Henry
[84
d Industries Research Association.
Spontaneous Ignition Temperatures
urs: a Critical Résumé. By H. G.
10s. 6d. Technical Report Z/T119:
g Discharges. By Dr. C. E. R. Bruce,
tish Electrical and Allied Industries
[84
sociation. Articles of Agreement as
ndments by the Executive Directors of
nstruction and Development on 26th
ng Report of the Executive Directors
25. (Cmnd. 965.) (London: H.M.
t. [84
d: Ministry of Agriculture. Leaflet
Trials. Pp. 14. (Belfast: Ministry
[144
e. Collected Papers—Summary and
p. ii+41. (Bucksburn, Aberdeen:
[144
y. Annual Report 1959 and Urgent
ondon: Fauna Preservation Society,
don, Regent's Park, London, N.W.1,
[144
Industrial Research. Industrial
nditure, 1958. Pp. iv+13. (London:
3d. net. [144
Almanac, 1960. Edited by Arthur
(London: Henry Greenwood and
1960.) 8s. net., 2.50 dollars (board
bound). [144
An Introduction to Wiggin Nickel
: Henry Wiggin and Co., Ltd.,
[144
Precision Flow Measurement by the
22. (Hatfield: De Havilland Pro-
[144
Technology (University of London).
wer, 1960–61. Pp. vii+8. (London:
chnology, 1960.) [144
d Foundation Commonwealth Bur-
rt. Pp. 7. (London: Royal Society
[144
No. 1 (March 1960). Pp. vi+96.
e. Subscription rates (including
ernment departments or industrial
dollars) per volume; (B) For sub-
ublishers certifying that the journal
A. 15 dollars) per annum. (London
1960.) [254
Psychiatry, Vol. 1, No. 1 (January,
sociation of Child Psychology and
quarterly. Subscription rates: To
ild Psychology and Psychiatry 63s.
hip. To private individuals 105s.
s and institutions 140s. (20 dollars)
ork: Pergamon Press, 1960.) [254
s Activity, Vol. 9, No. 1. Translated
lished bi-monthly. Approximately
l subscription £10s.; 30 dollars.
n Press, 1960.) [254

ountries

Annual Report of the Geological
nded 31st December 1958. Pp. 42.
.) 2s. [144
pany. Statistical Bulletin, Vol. 41
d for 1959. Mortality Among Over-
rk: Metropolitan Life Insurance
[144
Annual Report, 1959. Pp. iv+100.
960.) Sh. 5. [144

American Book Publishing Record, Vol. 1, No. 2, for the mont ending March 1, 1960. Pp. 96. (Arranged by subject according to th Dewey Decimal Classification, and Indexed by Author and by Title. Subscription: 11 dollars for 12 monthly issues (U.S.A. 10 dollars) (New York: R. R. Bowker Company, 1960.) [14

United States Department of the Interior: Fish and Wildlif Service. Bureau of Commercial Fisheries Circular No. 60: Take a Ca of Salmon. Pp. 16. (Washington, D.C.: Government Printing Office 1960.) 15 cents. [14

International Atomic Energy Agency, Vienna. Review Series No. 3 Équipement Électronique pour l'Industrie Nucléaire Française. Pa P. Desneiges, M. Dotreau, L. Koch et T. Weill. Pp. 59. (Vienna International Atomic Energy Agency; London: H.M. Stationer Office, 1960.) 21 schillings; 6s.; 1 dollar. [14

Comptes Rendus des Travaux du Laboratoire Carlsberg. Vol. 31 Nos. 18–19: Localization of Invertase in a Strain of Yeast. By J Friis and P. Ottolenghi. Pp. 259–271. Localization of Melibiase in Strain of Yeast. By J. Friis and P. Ottolenghi. Pp. 272–281. 3 kr 10 øre. Vol. 31, Nos. 20–21: Difference Spectra of Amino Acids an Proteins in Aqueous Media of High Refractive Index. By Charles C Bigelow and Irving I. Geschwind. Pp. 283–304. Difference Spectra o Ribonuclease and Two Ribonuclease Derivatives. By Charle C. Bigelow. Pp. 305–324. 5 kr. Vol. 31, No. 22: The Life Cycle o *Kluyveromyces africanus*. By C. Roberts. Pp. 325–341. 3 kr. 50 øre Vol. 31, Nos. 23–24: Priority in Gene-Conversion. By Ø. Winge Pp. 343–347. Polymeric or Isomeric Genes—Some Considerations o Genus Terminology. By Ø. Winge. Pp. 348–350. 1 kr. 50 øre. (Copen hagen: Danish Science Press, Ltd., 1959 and 1960.) [14

World Health Organization. Technical Report Series. No. 185 Epidemiology of Mental Disorders: Eighth Report of the Exper Committee on Mental Health. Pp. 29. 1 Swiss franc; 1s. 9d.; 0.3 dollars. No. 186: Appraisal of Fellowships: Report of a Study Group Pp. 15. 1 Swiss franc; 1s. 9d.; 0.30 dollars. No. 188: Exper Committee on Addiction-Producing Drugs—Tenth Report. Pp. 16. 1 Swiss franc; 1s. 9d.; 0.30 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) [144

National Academy of Sciences—National Research Council. Publication No. 718: More Effective Organization and Administration o Materials Research and Development for National Security. (A Report to D. W. Bronk, President, National Academy of Sciences, by the Committee on Scope and Conduct of Materials Research.) Pp. ix+30. (Washington, D.C.: National Academy of Sciences—National Research Council, 1960.) 1 dollar. [144

United States Department of Health, Education and Welfare. Public Health Service Publication No. 736: Highlights of Progress in Mental Health Research 1959: Items of Interest on Program Developments and Research Studies Conducted and Supported by the National Institute of Mental Health. Pp. v+51. (Washington, D.C.: Government Printing Office, 1960.) 25 cents. [144

Canada: Department of Mines and Technical Surveys: Geological Survey of Canada. Bulletin No. 53: The Oxfordian Beds of the Jurassic Fernie Group, Alberta and British Columbia. By Hans Frebold, E. Mountjoy and Ruth Reed. Pp. viii+47+12 plates. 1 dollar. Memoir No. 305: Elbow-Heming Lakes Area, Manitoba. By J. C. McGlynn. Pp. vi+72. 75 cents. (Ottawa: Queen's Printer, 1959.) [144

Indian Forest Records (New Series). Entomology. Vol. 9, No. 11: Description of Larva of *Brephos infans* Moeschler (Lepidoptera, Geometridae, Brephinae), with a Note on the Relationship and Affinity of Larvae of Subfamily Brephinae with Larvae of other Subfamilies of Geometridae. By Balwant Singh. Pp. 211–214. (Delhi: Manager of Publications, 1960.) Rs. 0·44 nP., 8s. [144

Jahresberichte des Deutschen Wetterdienstes, Nr. 7: Jahresbericht 1959. Pp. 76. (Offenbach a.M.: Selbstverlag des Deutschen Wetterdienstes, 1960.) [144

United States Department of Agriculture. Farmers' Bulletin No. 2147: The Boll Weevil: How to Control It. Pp. 12. (Washington, D.C.: Government Printing Office, 1960.) 10 cents. [224

United States. 86th Congress, 2nd Session. Legislative Reference Service—The Library of Congress. Radio Frequency Control in Space Telecommunications. Prepared at the request of Hon. Lyndon B. Johnson, Chairman, for the Use of the Committee on Aeronautical and Space Sciences, United States Senate, by Edward Wenk, Jr. Pp. vii+235. (Washington, D.C.: Government Printing Office, 1960.) [224

United Nations Educational, Scientific and Cultural Organization. Centro de Co-operación Científica para America Latina. Scientific Institutions and Scientists in Latin-America. Argentina (Instituciones) (IV Volumen), Fascículo 1. Pp. vi+126. (Montevideo: UNESCO, Centro de Co-operacion Cientifica para America Latina, 1960.) [224

Buletinul Institutului Politehnic din Iasi. Serie Noua. Tomul V (IX), Fasc. 1–2, 1959: Les Cartes Magnétiques de la Roumanie de 1895 à 1954, les Éléments Magnétiques de Bucarest de 1772 à 1954 et de Jassy de 1828 à 1954 et les Variations Cycliques Séculaires de la Roumanie. Par St. Procopiu et C. Papusoi. Pp. 161–176. (Iasi: Institutului Politehnic, 1959.) [224

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

CO-OPERATION AND SCIENTIFIC AND INDUSTRIAL RESEARCH

THE dominant impression left by a first reading of the third report from the Council for Scientific and Industrial Research, for the year 1959*, is the effort which the Council has made to provide the basis for informed judgment as the balance of the Department's effort. A new feature appears in the appendixes giving the percentage distribution of effort in the Department's research stations, 1960–61, based on the cost of staff working in particular fields in relation to the cost of total staff of the station; taken with the analyses hitherto regularly provided of the distribution by subject or field of study of research grants, studentships and fellowships, this enables the detail of the Department's contribution to the research effort of Britain to be seen more clearly. A summary of the more important financial items appears elsewhere in this issue (p. 118). With this goes a determined effort to further co-operation between the various research organizations with which the Department is concerned; this is, indeed, distinguished as one of three central themes of the report, and a feature which is likely to grow as the Council identifies, and endeavours to meet, the present and emerging needs of Great Britain for scientific and industrial research.

To this comment, one reservation must be made. The veil hitherto drawn over the activities of the Department's information or intelligence division remains unlifted. Nothing is said about the expenditure on this division, which has now been merged with the Overseas Liaison Division, and only passing reference is made to the National Lending Library for Science and Technology, apart from the appointment of a consultative committee, the representation of users on which has already drawn some adverse comment. The report refers, indeed, to the establishment last year of an *ad hoc* committee under Sir Walter Drummond to review the activities of the Headquarters Information Division and to consider how extra money might best be spent, between now and 1966, by the Division and on a scheme for assisting research associations to conduct special experiments in communication.

This Committee reported later in the year, and the Council accepted its proposals, though they are not specified. It is merely stated here that the proposals involve three main groups of services: publicity, chiefly through the mass media; publications; and stimulation of regional information services. The Council is convinced that there should be a general increase in publicity services, particularly for the Press, radio and television, and it is recruiting the necessary staff. As regards publications, its main concern is to present the Department's scientific work to wider audiences at all levels in industry, chiefly through brief summaries of useful information made available by research and through reviews of recent achievements in selected fields of inquiry. It is already supporting five regional technical information services from Conditional Aid Funds, based on Birmingham, Bristol, Cardiff, Manchester and Newcastle, and proposes to continue this support, subject to satisfactory reports on their existing and potential value for industry and to the continuation of local support. It is also proposed to consider well-founded proposals for assistance to new centres, provided there is evidence of adequate local backing. Concurrently, it is expanding the Scottish and Welsh offices of the Department.

This policy seems to be sound and reasonable, but there are two comments to be made. First, if its value is so clearly demonstrable, such a service should not be dependent on Conditional Aid Funds. Secondly, it may be questioned whether such regional technical information services could not be more efficiently and economically developed as part of the public library service as a whole. Action on the Roberts Report is still awaited, and Britain's technical and other resources are too limited to permit duplication or dissipation. It is difficult to regard the divorce of the project for a National Lending Library for Science and Technology from that for a Central Reference Library covering those fields as other than a reprehensible waste of resources and man-power. Full efficiency can only be secured as part of a genuine national system which takes full account of local resources, and the very growth of the Department's effort in the field of information makes some annual account of that effort increasingly desirable in the national interest—an account which will display that effort quantitatively as well as qualitatively between the various sections of the Information Division, the National Lending Library for Science and Technology and the grant-aided bodies, such as the Association of Special Libraries and Information Bureaux. There may be good and sufficient reasons for not publishing the report of the Drummond Committee itself; but merely as a contribution to the growing concern for co-operation between the various organizations which the Council maintains or assists it is important that full information as to their activities should be made available.

This is, in fact, a useful means of strengthening the links between research stations, the research associations, the universities and the colleges of technology—links which have this year also been reviewed by the Council. The Council comments in the present report on three new ways in which relations can be developed, apart from strengthening existing contacts and making more use of consultants and of students during the vacations. First, in awarding renewable

---

* Department of Scientific and Industrial Research. Report of the Research Council for the year 1959. Pp. 75. (Cmnd. 1049.) (London: H.M. Stationery Office, 1960.) 4*s*. 6*d*. net.

grants for
colleges of
initiated b
by the in
Secondly,
special ap
hosts to us
a few, for
specting a
and vario
possibility
their servi
universitie
colleges.
The dire
consider al
functions
stressed in
Council hop
maintain a
universities
Developme
Roxbee Co
Sir Willis J
support of
Council ha
the Departr
ment Corpo
of common
mittee has
into the rese
British indu
too small a
for technolo
first inquiry,
is now unde
industry.
All these a
of the natior
whole; but
balance, the
and that of
of the Overs
considered.
the Minister
for Scientific
with other r
is made in
stimulate th
correspondin
of the Coun
colleges in th
is the secon
emphasis is
It was ex
second five-y
outside nucle
four-fold ove
stead, howev
academic yea
applications
151 applicat
previous yea

searches to universities and
e Council welcomes proposals
ent's own stations as well as
which the awards are made.
suggests that stations with
uipment could often act as
sities and other institutions;
ht provide facilities for in-
new laboratory apparatus
Thirdly, it suggests the
he research stations offering
ppropriate, for teaching in
technology and technical

ns are being encouraged to
ilities, and the educational
h associations have been
of the Department. The
search associations will also
heir many links with the
and besides setting up a
consisting of Sir Harold
Prof. P. M. S. Blackett and
se on policy in the further
velopment in industry, the
joint committee between
ational Research Develop-
ine development problems
Council's Economic Com-
series of detailed inquiries
opment needs of important
believes, may be attracting
ational resources available
ent. The results of the
the machine-tool industry,
ith representatives of the

ist in giving a clear picture
d development needs as a
hat to secure a reasonable
Medical Research Council
l Research Council, if not
Council too, must also be
e, is the responsibility of
d of the Advisory Council
part from the direct links
ations to which reference
e Council's policy should
h councils to develop on
should certainly be true
help to universities and
of their researches, which
e report on which special

under the Department's
l expenditure on grants
ld be increased three- or
1958–59 to 1963–64. In-
being gradual, in the first
the Council received 360
3 million, compared with
; only £636,000 in the
ial provision for research

grants under the five-year plan has been insufficient to support all applications of sufficient merit, and this appears to be equally true of grants for nuclear physics.

With Treasury concurrence, however, the Council is entering into commitments for research grants at a substantially higher level than was contemplated in the plan, and this level will be reviewed year by year; this arrangement should enable the Council to support all applications which seem to be worth while. In 1958–59, 295 grants totalling £2,232,000 were finally made, including 52 (£826,000) in nuclear physics and 14 (£137,000) in the human sciences, compared with 119 awards totalling £445,000 in the previous year. The Department is also now the national centre for administrating the scheme for Senior Visiting Fellowships of the Organization for European Economic Co-operation, as well as the Studentships and Fellowships for Britain of the North Atlantic Treaty Organization. Postgraduate awards also expanded steadily and smoothly, although the scheme for Advanced Course Studentships did not develop so rapidly as expected.

While the Council reports that the Department now has the staff needed to handle the continued expansion of the schemes for research grants and training awards and at the same time to visit the universities and colleges of technology more often, it is obvious that the educational function of the Department will need to be kept continually under review. The Department is already playing an important part in the development of university and technological education in Britain as in our research effort, and the Minister for Science will need to have regard to its work here as well as in research. There may be implications, too, for the Minister of Education, as indeed Lord Hailsham seemed to hint at the end of his speech in the House of Lords debate on university education on May 11. Lord Hailsham raised explicitly the question whether our arrangements for co-ordination between the universities and other places of higher education are satisfactory, referring in particular to the use and location of expensive equipment such as cyclotrons, and stating that he has already asked the secretaries of the Research Councils to examine the question of the use of central facilities by universities and the use by universities of research facilities available in Government research institutes.

All these matters indeed merge into the broad question of co-operation generally which was discussed at the outset, and this question recurs in the third main theme to which the Council directs attention in the present report: the consolidation of changes which have been made in previous years in the functions and organization of some of the Department's research stations. Here the Council announces the completion of its survey of present and projected research. This year it has made no new changes in organization or scope of work. The review, however, has led the Council to reconsider the broad aims and functions of the stations as a whole, and perhaps one of the most important passages in the report is that which sets forth the re-definition of the terms of reference of the research stations. Taken with the analysis of the distribution of effort already noted, it facilitates accurate assessment of the character of their contribution to the nation's research effort and the identification of gaps or weaknesses.

Basic research at the research stations, in the Council's view, must be directed to the general advancement of technology and applied science, although each station should be free to follow up new ideas falling within its sphere of interest and thus include some research not directed towards any immediate need of industry or the Government. Stress is laid on the need for each station to limit its work to selected carefully defined objectives, the criteria for selection being the end to which the work is directed. Directors are also to ensure that the appropriate Government interests are linked as closely as possible with the work of the station and, in consultation with research associations where appropriate, to secure financial or other co-operation with industry.

Within these terms of reference, the major purposes of the research stations may be catalogued as follows: keeping their fields of research under constant review in order to define objectives and help the Government, industry and the public to maintain a lively interest in the value of research; conducting research which can provide information to the central and to local government on matters such as air and water pollution, road safety, noise, and the extinction and prevention of fires, in which the Government has a clear responsibility for protecting the health, safety and welfare of the citizen; carrying out research and development in subjects, such as the natural resources of the country and the design and construction of buildings and roads, which are important to the Government and which affect the efficiency of industry as a whole; extending the frontiers of knowledge in applied science so that industry can be provided with the basic information required for the solution of particular problems; paying special regard to the research needs of industries that lack an adequate scientific background, and to research problems that are common to more than one industry; carrying out particular researches, in co-operation with industry wherever possible, which will enable the stations to appreciate industry's problems more fully and to recognize those fields in which more basic research is most urgently needed; providing for industry national and international standards of measurement of various fundamental physical quantities (such as length, mass and time), related secondary standards and reference materials; conducting research on matters of broad public interest; and disseminating the results of research and securing their application.

The Research Council emphasizes the last of these functions, believing it is increasingly important for the research stations to promote good relations with the users of research results. But by and large, these objectives demonstrate conclusively the reason for the existence of Government-maintained research stations. In their absence much of the work indicated is unlikely to be undertaken, or at the most in very piecemeal fashion. So far, however, as extending the frontiers of knowledge in applied science is concerned, it may be necessary to review continuously the relations of the research stations with the colleges of technology. If the latter are to develop adequately and make their full contribution to the supply of technologists, a very considerable extension of research in applied science in the colleges themselves is needed, and there may be the less need for such research by the Department's own stations. It might be noted in passing that several of the Department's stations carry out work on behalf of Colonial or overseas territories for which the Overseas Research Council might otherwise need to make special arrangements, though the Overseas Research Council is not mentioned in this report.

Three other areas of research in which opportunity for co-operation has arisen are, however, specially mentioned. First, research on creep, for which a new building is being erected at the National Engineering Laboratory, and a Creep Information Centre has been opened; the Electrical Research Association is planning an extended programme of tests designed to give new information on steels and temperatures of particular relevance to steam-raising plant and turbines for generating electric power. The National Physical Laboratory will analyse and evaluate the relevant metallurgical data, and a Committee of the British Iron and Steel Research Association is organizing co-operative creep-tests by several steel firms. Secondly, a committee has been set up under the chairmanship of Sir Alfred Pugsley to consider what research needs to be done into the fatigue of engineering structures made of metal, to survey existing research facilities and make recommendations. The third example is in shipbuilding research, and the Council emphasizes its concern that the resources of the National Physical Laboratory, including the new Ship Hydrodynamics Laboratory at Feltham, shall continue to be used to the full along with those of the British Shipbuilding Research Association and the Parsons and Marine Engineering Turbine Research and Development Association.

On the distribution of effort, it must suffice to mention the much greater emphasis the Radio Research Station is placing on research related to the Government's space programme. About half the Radio Research Station's research effort is now to be devoted to space investigation. Its study of the propagation of radio waves is to be widened, taking advantage of the new techniques provided by rockets and artificial Earth satellites. Its present studies of the world distribution of radio noise are to be supplemented over the entire radio-frequency spectrum, and later it is likely to supplement the work at Slough in predicting the tracks of satellites, and at the sub-station in Singapore, with radio telescopes and other specialized equipment. Since, however, the Department's expenditure on radio research in the year ended March 31, 1959, was a little short of £200,000 out of some £8,000,000, even with £12·7 million provided in the 1960–61 Civil Estimates,

expenditu
Scientific
excessive,
the alloca
stations.
in this fi
laboration
expenditu
from Defe
Meanwh
Research
vide the l
resources
the differe
persuade
distributio
promote c
the way
Research
and waste
creasing e
Advisory
stronger p
unwise prc
more dub
genuine ne

research by the Council for
l Research is unlikely to be
derable change were made in
ources between the different
ants for promising researches
Council is making in col-
yal Society, any considerable
search seems likely to come

l for Scientific and Industrial
ne some way further to pro-
nd allocation of the national
nd development as between
the Minister for Science can
arch councils to analyse the
efforts on similar lines, and
d co-ordination of effort in
or Scientific and Industrial
any untoward duplication
uld be eliminated with in-
ortant, the Minister and the
entific Policy should be in a
t any attempt to devote an
rt into specific fields on the
of prestige rather than of
and practical return.

CAL AND MODERN
ENCE

Causality
The Place Principle in Modern Science.
By Prof. Pp. xx+380. (Cambridge,
Mass.: Ha ty Press; London: Oxford
University 60s. net.

THIS is ok by an unusual man in a
most u . The author is professor of
theoretical hilosophy of science. The
university of this stupidity or bold
initiative, y be, is Buenos Aires. The
author is a criticism, for he is not only
thoroughly his two fields and presents
his work w ty, but also he has a strong
sense of rel lance. Despite the fame of
the subject o find a book of this length
devoted to o written without wasting
words. Th is far from epoch making,
it is of an o er of competence and value,
indispensab o those who may wish to
enlighten t the subject, but even to
specialists c Of those who have thought
carefully a ut this subject, there must
be few who are of the great complexity
and detaile ls that they will find here.
In short, t not transform our view of
causation, I the whole matter in such
balanced a rspective that anyone who
attempts to out knowing this book may
well be re having graduated in the
subject.

The broa e put as follows. Few will
require to b at not all laws and explana-
tion in phy l; in fact, the pendulum
has swung ny deny that the principle
of causation has any role at all. Against this view, the author argues patiently and temperately to point out that causal laws and causal explanations do in fact exist, but he is emphatic that they are not the only kind; but he also holds that there are quite a number of non-causal types of law and explanation, and he describes these carefully. In short, his thesis is that the principle of causation takes an important role, though not a dominating one. It may be remarked that this may sound insipid, but if so, it is not insipid through compromise, but because, if the author is right, the world is governed by heterogeneous types of law. Another important part of the thesis is this. Certain thinkers, whom the author calls romantic, have denied that the causal relation connects one event with another event; and they have done so on what the author considers the correct grounds that every event is connected in innumerable ways with all sorts of other events and therefore that an event is not simply nicely and neatly connected with another one as, say, its cause. On the other hand, the romantics go on to deny that causation has any role because of the warp and weft in which events find themselves. This the author disputes, because it rests upon a misunderstanding of the nature of scientific laws, which, whether causal or not, deliberately abstract from the warp and weft and for scientific purposes isolate events satisfactorily.

The one main criticism to which this book would seem to be open is that it may fail to satisfy those who regard statistical laws as having superseded causal laws. Such critics would doubtless concede the existence of causal laws as described by the author, but insist that these should be reducible to statistical terms. It would be interesting to know whether they regard such a contention as a purely scientific one (in which case they would be refuted by the fact that science contains both types of law) or as a piece of philosophy of science (they would probably agree that it was the latter). Then the contention would seem really to concern the ultimate nature of scientific laws, and it is not easy to see what bearing this contention would have upon science itself. Further, it would be interesting to know how its exponents would set about proving the contention.

It would be valuable if critics would commit themselves on these points and if Prof. Bunge were to make a detailed reply. He would no doubt do so highly effectively.

J. O. WISDOM

AUTOMATIC PROGRAMMING IN THE U.S.S.R.

Programming Programme for the BESM Computer
By A. P. Ershov. Translated from the Russian by M. Nadler. Edited by J. P. Cleave. Pp. vi+158. (London and New York: Pergamon Press, 1959.) 60s. net.

AUTOMATIC programming is aimed at allowing us to present to a computer a statement of our problem in a form as close as possible to that in which we are used to expressing ourselves. This may be a mathematical form for the scientist or mathematician or perhaps 'technical English' for the business man.

The book under review describes Russian work along these lines based on a "symbolic or pseudo-mathematical" form. In my view this work is marred by the fact that the *Besm* computer used can only accept numerical forms of information so that all the symbolism has to be recoded. It is true that the programming programme *P.P.* ('compiler' would be better understood) removes from the programmer the necessity for detailed coding of loops, operators, minimization of working space and so on, but I cannot believe that the automatic nature of the coding "practically rules out the chance of error".

The value of this book is greatly reduced by its shoddy presentation. Why must we have the translator's typewritten notes? Smudges and smears make a number of tables and diagrams ambiguous.

Part 1 of the book describes the symbolism which the programmer must use. I feel a less fearsome notation could have been chosen. (See example on p. 21.) The numerical coding of this symbolism is inadequately described. Part 2 describes techniques for programming such things as loops, operators, and working-space economy. This is marred by the quality of some of the flow diagrams. The notation of these diagrams is not described until Part 3. This Part describes the *P.P.* itself and is the most detailed part of the book. There is undoubtedly some very useful information here.

After some rather optimistic conclusions follows a brief review of the *Besm* programming system. This part would have better been at the beginning, for implicit references are made to it earlier in the book. The ideas would have been easier to digest if more examples had been given. When these are given they are often incomplete or contain errors. The illustration of a *Besm* word on pp. 141–143 contains three errors. In spite of being, by computer standards, a rather old account and having the shortcomings described above, this is a book to be studied by those interested in the mechanism of automatic programming.

R. J. ORD SMITH

CONFLUENT HYPERGEOMETRIC FUNCTIONS

Confluent Hypergeometric Functions
By Dr. L. J. Slater. Pp. ix+247. (Cambridge: At the University Press, 1960.) 65*s*. net.

THIS is the first book in English to be devoted entirely to confluent hypergeometric functions. There are two predecessors in other languages, "Die konfluente hypergeometrische Funktion" by H. Buchholz, and "Funzioni Ipergeometriche Confluenti" by F. G. Tricomi, but this book is no mere copy of its predecessors.

The general plan of the work is reminiscent of G. N. Watson's well-known "Treatise on the Theory of Bessel Functions". The first part gives the main properties of the confluent hypergeometric functions and the Whittaker functions, and the second part consists of tables—the most complete so far published—which were computed by the author on the electronic calculator *Edsac* 1 in the University Mathematical Laboratory, Cambridge.

The first three chapters are concerned with differential equations and differential and integral properties of the functions. Chapter 4 is devoted to asymptotic expansions; this is a long chapter as the theme "has been treated in great detail because it seems to cause most difficulty to students of the subject". To me this is a most impressive chapter, and I imagine that it will contain enough to meet the needs of most mathematical physicists.

Chapter 5 is given over to related differential equations and particular cases, while Chapter 6 gives the descriptive properties of the functions, such as the distribution of the zeros, expansions for the zeros, and notes on the tabulation of the zeros. There are also notes on the numerical evaluation of Kummer's function.

The second part of the work consists of tables, running to about 120 pages, giving the smallest positive zeros of Kummer's function, ${}_1F_1(a; b; x)$, and the values of this function over those ranges most useful to the computer. Since confluent functions contain one parameter more than Bessel functions, it is natural that the properties of the functions should be correspondingly less in number, and it is also natural for the tables of the functions to be much longer and more complicated in form.

This is an impressive work which contains many important contributions by the author herself, and the printing is of the high standard that one expects from the Cambridge University Press. The book should certainly be the standard book on the subject in English for many years to come, and it will be indispensable to those mathematical physicists who meet these functions in the course of their researches.

W. N. BAILEY

DENDRITIC GROWTH OF CRYSTALS

Dendritic Crystallization
By D. D. Saratovkin. Translated from the Russian by Dr. J. E. S. Bradley. Second edition, revised and enlarged. Pp. iv+126. New York: Consultants Bureau, Inc.; London: Chapman and Hall, Ltd., 1959.) 6 dollars; 50*s*. net.

THE growth of crystals is a subject of great theoretical interest and practical importance. The process is the building of a periodic three-dimensional pattern of atoms which in crystals, such as diamond or quartz, is simply a giant molecule the size of which is limited only by that of the crystal. Internally, a perfect crystal would have a regular arrangement of atoms, and its external form would be a convex polyhedron with plane faces. In fact, real crystals not only show departures from regular internal structure but also often develop shapes far removed from simple, compact, polyhedral ones. Departures from regular internal structure are known to have considerable effects on the physical and chemical properties of crystals, and the external form developed by a growing crystal is also of great importance. The repeated branching leading to fern-like growths, of which the snowflake is a well-known example, can take place not only if a crystal is growing from a solvent or vapour but also when a melt is cooled. A dendritic structure may first form and the spaces between the branches are then filled in when the remainder of the melt solidifies. Dendritic crystallization is often encountered in metallic systems.

After briefly classifying the various types of crystal growth, the author describes observations on dendrites made some ninety years ago by D. K. Chernov, described as "the famous Russian metallurgist, founder of the modern theory of metal crystallization". This section is followed by a review of existing (Russian) theories of dendritic crystallization, by

accounts c
crystalliza
section de
solid solut

This bo
as regards
attainmen
is much p
eyes of his
edition of
as typical
research.
has no sin
showing th
"When the
informed t
views that
currently ı
given that
in the origi

I did nc
effective ov
tion, and th
of separate
from openi
when stere
By English
it would se
books of th

[

Early India
By Sir Mo
Places, Vol
Thames and

THE rea
the pen
India and I
appointed. S
logical exper
where he wı
Pakistan, w
Government
archæology
the past his
but it is am
what a balar
cannot be tr
of short cha
fluences hav
the great d
country into
not everywh
importance.
be true. Th
occurs in M
where it is r
early Soan.

With reg
sequence can
in the case
any absolut
chapters on
Palæolithic,
briefly under
Upper Palæo
ones. But t
connexions w

microscopical studies of the
ety of substances, and by a
formation of dendrites in
tic alloys.

ersonal account reminiscent,
writing and level of scientific
duate thesis, and the author
th justifying himself in the
agues who criticized the first
e work is not to be regarded
of recent Russian scientific
the following excerpt (p. 20)
m; it is also of interest as
indeed a literal translation.
f this book appeared I was
ting my time to deal with
ame out of date and were
As example I was only
[1] (Footnote: [1]Line missing

reoscopic micrographs very
or quality of the reproduc-
nding (stapling and glueing
boards) prevents the book
is particularly inconvenient
graphs are being viewed.
book is very expensive and
justify the translation of

A. F. Wells

RIC INDIA

to Ashoka

r. (Ancient Peoples and
1 (57 plates). (London:
, 1959.) 25s. net.

rst-class piece of work from
er Wheeler and in "Early
hoka" he will not be dis-
as had a very wide archæo-
n Britain but also in India,
eral of archæology, and in
chæological adviser to the
the specialist on Indian
for a detailed account of
part of the sub-continent,
ch has been included and
erges. India and Pakistan
whole, and the first couple
stage. Many outside in-
peninsula, but owing to
the breaking up of the
by ranges of mountains,
outside influences of equal
early times this seems to
leo-Acheulean civilization
rcely at all in the north,
ething quite distinct, the

ology, while a relative
obtained, naturally only
st-Neolithic cultures can
be determined. Two
s touch on this, and the
Neolithic cultures come
Mortimer uses the terms
olithic for want of better
necessarily any cultural
named cultures in western

Europe. Pigmy industries in India do not necessarily denote cultures Mesolithic in time; as Sir Mortimer mentions later on, some of them occur with much more recent cultures.

The Indus civilization has been described so often that one might wonder whether there is much more to be said. This fact presents no problem to Sir Mortimer; his chapter in this volume gives shortly all the really relevant facts and paints a splendid picture of this brilliant culture which grew up by the northern river. But the Indus civilization should not blind us to developments which took place about the same time and somewhat later both in the Ganges valley and in Central India. Much has still to be learnt, especially about the former, but work has been undertaken of recent years by a number of investigators. In this connexion it is somewhat surprising that there is no mention of the many painted rock-shelters in the Central Provinces, which have been known for a long time and studied by Col. Gordon. As they seem to be associated with a pigmy tool-making culture in the process of learning to use pottery they are of some interest. Incidentally, there are some interesting rock carvings in the Indus valley which might have been worthy of a mention, though their date is, to say the least of it, doubtful.

The south Indian megaliths next come under review. Once again no connexion with our megalithic structures need be stipulated, though certain structural similarities, even the port-hole entrances, can be noted. But the date of the Indian examples is considered to be late—c. 300 B.C. A final chapter entitled "Ashoka" concludes the volume. This great emperor, who may have had Selucid blood in his veins, carries the story down to the period of Alexander the Great and so provides a fitting ending to the prehistory of India.

Sir Mortimer Wheeler's book gives the reader one of the best short accounts of prehistoric times in that sub-continent. Civilizations grew up early in those regions, and it is a humbling thought to recall the unsophisticated kind of life being led in western Europe at a time when the civilization of Mohenjo-daro was in full swing in the Indus valley.

M. C. Burkitt

XENOBIOCHEMISTRY

Detoxication Mechanisms

The Metabolism and Detoxication of Drugs, Toxic Substances and other Organic Compounds. By Prof. R. Tecwyn Williams. Second edition, revised and enlarged. Pp. x+796. (London: Chapman and Hall, Ltd., 1959.) 126s. net.

THE second edition of the book by Prof. R. Tecwyn Williams on metabolism of drugs and other organic compounds which are usually foreign to the body has been eagerly awaited, and it should be of great value to investigators in many fields. Since the first edition appeared in 1947 not only many new facts and details of metabolic changes have been discovered but also the general hypotheses of the processes have changed considerably. With the development of civilization, synthetic organic compounds are being widely used as poison gases, rubber additives, pesticides, preservatives, food flavours, contraceptives, cosmetics, as well as drugs and detergents. In order to know whether these are likely to present a toxic hazard to man and in some cases to understand the mechanism of action, knowledge of the metabolic processes which the compounds undergo is of value.

The author explains that the short title of "Detoxication Mechanisms" has been retained, although some of the processes considered lead to the production of substances with increased rather than reduced toxicity. He suggests that the subject might be called 'xenobiochemistry' (*xenos* = strange or foreign).

Since the first edition appeared the techniques for the study of metabolism have changed enormously. The use of such aids as that of labelled compounds (particularly with carbon-14 or sulphur-35), of chromatography on columns or paper or as gas chromatography, of counter-current distribution, of electrophoresis, of spectrofluorimetry, of increased use of ultra-violet and infra-red spectroscopy and of high-speed centrifugation have increased the resources and complicated the investigations of these metabolic processes. The use of modern methods has shown these processes to be much more varied and complex than was thought twelve years ago. Most of the changes which foreign substances undergo in the mammalian body lead to increase in solubility in water and generally to the formation of ionized compounds which can be excreted in the urine or bile. The development of the ability to convert foreign compounds into derivatives which could be easily excreted was essential for animals to live on dry land. Fishes and some other aquatic animals do not possess many of the enzymes which change insoluble unionized toxic compounds into ionized harmless derivatives.

Prof. R. T. Williams is to be congratulated and thanked for his service in collecting, collating and presenting the great amount of material. Among many facts there appear to be few errors. [One on p. 193 is the statement that such a compound as 1 : 2-dihydro-1 : 2-dihydroxybenzene "is at present unknown" is probably due to the long delay in publication.] The book is well produced; but it is a pity that the publication should take two and a half years and that the cost is so high. I hope that a third edition will be available; but the labour which would be involved in its preparation is increasing rapidly.

E. BOYLAND

CORAL STRUCTURES AND CLASSIFICATION

Contribution à la Systématique des Madréporaires Fossiles

Par James Alloiteau. Tome 1: Texte. Pp. 462. Tome 2: Planches. 286 figures + 20 planches. (Paris: Centre National de la Recherche Scientifique, 1957.) 4,500 francs.

THIS is a work of importance to all concerned with the structure and classification of corals whether Recent or fossil. It has been known for several years that this thesis was awaiting publication, and some of its conclusions had already been incorporated in other works by Alloiteau and his students, notably in his section on Coelenterata in "Traité de Paléontologie", tome 1, edited by J. Piveteau (1952). But this does not detract from its importance.

The author sets out to found a classification of the hexacorals based on his investigations of the microstructure and histology of the skeletal parts of many genera and species. Some research along these lines had been carried out in the past by von Koch, Pratz, Ogilvie and others, and the classification used by Vaughan and Wells (1943) and by Wells (1956) embodied the nature of the microstructure. Alloiteau, however, gives far greater importance to it than did any of the previous workers, and arrives at classificatory conclusions which in many cases are very different from those generally accepted. Many well-known genera are split, and a large number of new ones is introduced; sometimes this is justified, but in other cases it is doubtful. There are also new suborders and families, in addition to others Alloiteau had already introduced in 1952, but many will probably be rejected by other systematists.

The author tackles the difficult problems of the relationship of some of the hexacorals to the Palaeozoic Rugosa. Thus the Amphiastraeidae of Ogilvie, which Alloiteau has raised to the position of a suborder, are considered to be derived from the Lonsdaleiidae of the Carboniferous, and the ancestors of the Turbinoliidae and Caryophylliidae are to be sought among at least four families of the rugose corals. There is a long section, too, on the evolution of the various parts of the skeleton of the Madreporaria, and the author records many useful observations and comparisons of structures in Palaeozoic and later corals.

Alloiteau is led to unusual views concerning *Heliopora* (the blue coral), *Polytremacis* and the Heliolitidae. Not many will agree with his denial of any relationship between the first two, and with his erection of a new suborder of Actinanthida (= Zoantharia) to include *Polytremacis* and certain madreporarian genera. *Heliopora* itself remains, for Alloiteau, an isolated genus among the Anthozoa, with characters both of the Alcyonaria and the Actinanthida, but its histological structure is nearer to that of the latter. The Heliolitidae are also considered as Madreporaria and to have evolved from the Silurian through the Jurassic Stylinida into *Stylophora* of the Tertiary. He places a new Upper Cretaceous genus *Selidolithus* in the same family as the Silurian genus *Pycnolithus*.

One of the best services that Alloiteau renders is his re-description of the type species of several genera, based either on the original material, or, where that is lost, on neotypes. He tries to follow the International Rules of Zoological Nomenclature, but in the case of the type species of *Heliopora* he does not arrive at the same conclusion as other law-abiding systematists. Nor is his retention of the name *Cunnolites*, which he resurrected in 1952 for *Cyclolites*, in accordance with sound taxonomic principles.

The work is not easy to assimilate and would have benefited from careful revision of the typescript. The figure illustrations are beautifully drawn, as is usual in Alloiteau's papers, but many of the plate-figures are poor, and one (Plate 15, figure 9) lacks explanation. There are several mis-spellings, including that of the genus *Extastraea* twice in headings on p. 215. The index omits references to at least seventeen important genera, including eight new ones, namely, *Dermosmiliopsis* (invalid in 1952, and now apparently only on Plate 4, figure 6), *Dichocaeniopsis* (sic—p. 264), *Haimeicyclus* (p. 105, footnote), *Heterohelia* (p. 303), *Paradichocaenia* (sic—p. 277), *Rhabdopsammia* (apparently only on Plate 4, figure 5), *Tabulocaenia* (sic—p. 187), and *Thecoseriopsis* (invalid in 1952 and now apparently only on Plate 9, figure 2).

The wor
knowledge
corals, and
in systema
tures of the

PHOT

Photoperic
and Ani

Edited by
Conference
ber 2, 1957
biology of
National R
National Sc
Pp. xvii+
Association
Bailey Bros

THIS is a
held in
comprises t
together wit
correspondin
discussion,
"ideas subm
a very wid
remote from
is indicated
presumably
chemical pri
tion, of veg
flowering pl
and animals
brates, in v
The object
flow of ideas
the plant an
(one might e
the conferenc
during infor
the reader c
through near
a great mass
will not easil
he retains th

I feel stron
ing at one
appraisals of
research grou
research of
publication i
greater mista
hensive revie
periodic phen
overdue, and
There are in i
authoritative
'growing poi
they are clu
section, wit
which could
particularly i
vening two ye
have already
Some surveys
are disappoi
are the bare I
been pressed

major contribution to our
t-Palæozöic madreporarian
e hard thinking on the value
n of the microscopic struc-

H. Dighton Thomas

IC PHENOMENA

ated Phenomena in Plants

hrow. (Proceedings of the
dism, October 29–Novem-
the Committee on Photo-
Academy of Sciences—
il, and supported by the
ion.) (Publication No. 55.)
ngton, D.C.: American
ement of Science; London:
Ltd., 1959.) 133s.

proceedings of a conference
the autumn of 1957. It
the formal contributions
short papers, presumably
he major items of informal
eface optimistically calls
n form". It wanders over
imes straying into paths
m. This breadth of cover
n sections, corresponding
ssions, embracing photo-
tocontrol of seed germina-
and of reproduction in
cal phenomena in plants
dic phenomena in inverte-
d also in bird-migration.
ium was to promote the
ers on photoperiodism in
This, the main function
be the only function) of
t achieved at the meeting
llowing the papers. But
volume, in his struggle
d pages of text containing
ghly specialized research,
cious of this flow, even if
ok for it.

mammoth congress, cater-
time for authoritative
dy, interim surveys of
d reports of the current
is misconceived. The
a 'pot pourri' is an even
t to say that a compre-
ork and ideas in photo-
eeded. It is in fact long
ent met by this volume.
review papers, providing
statements on the major
mplex of subjects. But
rticularly in the plant
research contributions,
ge have been omitted,
fact that in the inter-
onference was held some
in well-known journals.
s of which promise well,
he impression that they
es and their writers had

As with most American publications, the price is very high, and therefore calls for comment. The book should obviously find its greatest use in the hands of young research workers in this field and of advanced undergraduates, who would undoubtedly obtain valuable insight and stimulation from the better review articles. But the price is well beyond their pockets; even heads of university departments will no doubt have to balance carefully the virtues of this book against the more tangible advantages of the equally expensive encyclopædias which are now appearing and which cover this subject completely.

L. J. Audus

RELIGION AND SOCIAL STRUCTURE

Oedipus and Job in West African Religion

By Prof. Meyer Fortes. Pp. 81. (Cambridge: At the University Press, 1959.) 10s. 6d. net.

THIS book is an expanded version of the Frazer Lecture for 1956. In it Prof. Fortes gives a very interesting interpretation of the religious ideas of the Tallensi, and other West African societies, in terms of the Œdipus and Job stories, and tries to show that these ideas are reflexions of the social structure.

The aspect of the Œdipus story used here is not that made familiar by Freud: instead, it is the idea that some people are born with an evil destiny, and are never properly accepted by society; this is not of their choosing and they can do nothing about it. The interpretation of Job is that he was being tested and disciplined by a just God; Job was saved not by good works, but by recognizing his error in placing himself on a level with God.

Prof. Fortes finds parallels to these stories in West African religion, and he gives a detailed account of the ideas of the Tallensi. A parallel to Œdipus is found in their idea of good and evil predestiny: this makes sense for them of the fact that some people have persistent bad luck, fail to bear children, die of mysterious diseases, and so forth. It is believed that the ancestors are responsible, since each person is thought to be the ward of an ancestor. However, unlike the Œdipus story, it is possible to overcome an evil destiny by ritual offerings and service to the ancestors, and who Fortes sees as equivalent to Job's just God. One can be saved only by obedience and subservience to the ancestors.

A further part of the thesis of this book is that "the Tallensi have an ancestor cult because the social structure demands it" (p. 66). It is pointed out that there are different possible religious interpretations of good and bad fortune—the Azande blame it on witchcraft operated by living people, for example. The ancestor cult is a symbolic representation of the parents, resulting from the close discipline, authority and affection of the parent–child relationship.

Two general comments may be made about the book. In the first place, while the parallels drawn with European stories are interesting, and to some extent convincing, it is not made clear how the exposition or explanation of African religion is assisted by making them. Secondly, for a rigorous demonstration of the thesis that these religious ideas are a product of the social structure, a cross-cultural study would be required showing that ancestor cults are regularly associated with a certain quality of parent–child relations.

Michael Argyle

Demography

By Peter R. Cox. Third edition. Pp. xiv + 346. (Cambridge: At the University Press, 1959. Published for the Institute of Actuaries and the Faculty of Actuaries.) 25*s*. net.

In the third edition of his text-book Mr. Cox has taken the opportunity of including the "Addendum" to the previous edition in his text, and of fully re-writing the text, adding in particular references to populations outside Britain. Apart from these and other minor changes in arrangement, however, the coverage remains as in the previous two editions: a text, primarily on the methods of studying population written with the needs of actuarial students principally in mind. Its main weakness as a general text on demography is imposed by the limitations of the actuarial syllabus: namely, the fact that life tables are treated in a separate publication on mortality and other investigations. A book on demography, in which life-table techniques are only treated in passing is like Hamlet without the prince, and it is to be hoped that Mr. Cox will be able to persuade his editorial committee, when he brings out further editions, to include material on life-table techniques, thus making his book much more useful for those outside the actuarial profession.

E. Grebenik

The Instrument Manual

Third edition. Pp. viii + 742. (London: United Trade Press, Ltd., 1960.) 105*s*.

Everyone who is directly concerned with instrument technology will need to have a copy of "The Instrument Manual" for immediate consultation and reference, but it contains so much that is of interest and value to engineers and physicists in general, particularly those active in industrial, research or teaching laboratories, that every laboratory library ought to possess at least one copy. Its price is moderate when compared with that of modern text-books and similar reference books. The format is good, the diagrams are bold and clear, and the tables and graphs are well set out for easy reading rather than economy of space. Throughout, adequate reference is made to all relevant British Standard specifications.

During the seven years since the publication of the second edition great strides have been made in British instrument development, particularly in the fields of automation and nucleonics. Nevertheless, much basic instrumentation, well proved in practice, has remained unchanged. In the present third edition, therefore, while the general scheme follows that of the second edition, the section on navigational instruments has been omitted and replaced by one on analogue computers; discussion on digital computers has been deliberately omitted; the original optical section has been dispersed, with microscopy given a section to itself and the analytical pattern of optical instruments included in the section "Analytical Instruments" which has parts devoted to polarography, gas analysis, and moisture content.

The section on nucleonic instrumentation is divided into reactor-control instrumentation, health instrumentation, laboratory instrumentation, and industrial instrumentation. In all, there are twenty-eight sections, the last two being devoted to an alphabetical list of manufacturers, their names, addresses and telephone numbers, and a list of United Kingdom organizations interested in instrumentation. In each section the basic concepts are carefully described, and the relevant theory applicable to the various types of instruments illustrated and discussed is outlined. The text is naturally limited to measurement and instrumentation, but in dealing with physical properties like viscosity and temperature, the discussion is often more up to date and more clearly expressed than in many a modern physics text-book. Appended to each section is a short bibliography and a buyers' guide.

S. Weintroub

Genetics, Radiobiology and Radiology Proceedings, Mid-Western Conference

Edited by Dr. Wendell G. Scott and Dr. Titus Evans. Pp. xv + 149. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas, 1959.) 42*s*. net.

This conference was one of three convened in various parts of the United States by the National Research Council–National Academy of Sciences to provide a forum in which radiologists and geneticists could discuss the problem of the genetical hazards from radiation used for diagnostic processes.

The full proceedings of the two sessions of the conference are contained in this book.

The first session was devoted to the "Fundamentals of Radiation Genetics". It contained papers of varying standards, some of which were of an introductory nature. There were good papers by Russell and by Crow, on "Radiation Damage in Mammals" and "Population Aspects" respectively.

The second session contains papers on the problem of reducing radiation genetic effects in the medical use of X-rays. The most important papers in this section are those on gonadal radiation resulting from various diagnostic radiological proceedings, and reduction of radiation in obstetrical radiology. The standards of the other papers are lower.

The book would have been greatly improved if the papers had been edited to stress the important points and to cut out repetition. Most of the papers contain no references. However, radiologists and radiographers may find it useful to read this book, which brings genetics and radiology together within one cover.

Lorna J. Lilly

The Year Book of the Royal Society of London, 1960

Pp. 302. (No. 64.) (London: The Royal Society, 1960.) 21*s*.

The Yearbook of the Royal Society of London, 1960, contains a list of Fellows and foreign members of the Society with their current appointments and addresses, corrected to January 1. Also included is the membership of the Royal Society committees and committees formed jointly with other bodies. The Royal Society research appointments are listed, and scientific reports of the work undertaken by Professors, Fellows and Students are included. The regulations governing these appointments are also given. To complete the volume, the statutes, the annual report of Council, medal awards and lectures, funds and a summary of the accounts are included. The Yearbook maintains its usual form and high standard of presentation. The delay in publication can, no doubt, be explained by the printing strike; but it may be regretted that it was not delayed a little longer so that it could include the 1960 election of new Fellows. However, as is the habitual practice, these have since been provided in a supplement.

ONFLICT BETWEEN EVOLUTIONARY THEORY AND CHRISTIAN BELIEF*

By DR. DAVID LACK, F.R.S.

WE st
disc
berforce,
during the
Advancem
At the pr
the proble
troversy
inquiry sc
this view
Should we
quarter of
doctrine c
Theistic.
than the fi
In attec
involved,
clearly tha
efforts to r
iority. Ale
deeper div
for full fre
preservatio
In 1860,
diction bet
account of
Christians
widely acce
are, and we
spiritual m
conveyed a
discoveries.
When an
attack was
theory, here
occurring in
that is, non
dous annua
traits which
those which
while less-w
ated.
The critic
totally inade
and after th
that charact
could be pa
instead an e
or Holistic I
lar ways, cul
advanced of
Butler, Berg
times also b
Raven, and, f
The critic
selection ma
that it cann
and in partic
interlocking at

ctly at the centenary of the
lution between Samuel Wil-
ord, and T. H. Huxley, held
e British Association for the
e at Oxford in June 1860.
t people seem to think that
n aroused such excited con-
tled; but more searching
hristians and agnostics take
and incompatible, reasons.
Huxley's statement, made a
the initial debate, that "the
neither Anti-Theistic nor
no more to do with Theism
clid has"?
arify the complex issues
that, if we now see more
ndfathers, it is due to their
and not to our own super-
onflict over evolution was a
claiming that they fought
ry, and theologians for the
ritual values.
is difficulty was the contra-
ory of evolution and the
Genesis, but scarcely any
by this to-day, since it is
irst two chapters of Genesis
be, allegory, and that their
not otherwise have been
affected by later scientific

came to be accepted, the
natural selection. On this
te changes are constantly
r directions being random,
because there is a tremen-
balance those hereditary
re surviving offspring are
spread in the population,
iate characters are elimin-

so random a method was
produced animal evolution,
view had been discredited
ring the life of the parents
offspring, they postulated
orce, Creative Evolution,
evolution along particu-
an. Such views were first
ostics, such as Samuel
rd Shaw; but in recent
ristians, including Canon
n, by Teilhard de Chardin.
admitting that natural
or differences, still claim
g evolutionary novelties,
not produce the complex,
us changes, functional at

every stage, that are needed for such elaborate organs as a bird's wing or the human eye. The postulated synchrony in such adaptations may not, however, be needed. For example, de Beer showed that the wing of the bird-reptile *Archaeopteryx*, though fully feathered, lacked muscles to flap it; it was evidently used for gliding. Hence part of the elaborate mechanism of bird-flight was fully evolved before another part was started, and such 'mosaic evolution' has probably been widespread. Again, in different types of animals alive to-day, one can find many intermediate conditions between a mere light-sensitive area in the skin and the elaborate focusing eye of a man or octopus, all of these stages being functional and well adapted for the animals possessing them.

It was also argued that elaborate adaptations could never have been produced 'by chance'; but this is a misconception, for selection is the reverse of chance. Moreover, the alternative to natural selection, a Life Force or Holistic Urge, solves nothing; it is merely a name for what is not understood, and introduces an unverifiable pseudo-mystical entity into the domain of science, where such concepts are inappropriate. Anyway, it implies that the hereditary changes, the mutations, are directive, whereas in fact they are random, and it is their subsequent selection that determines the directions (not direction) of evolution. It is true that natural selection has so far been proved only for small changes; but it is a reasonable inference that it has operated to produce the big evolutionary changes of the past, very gradually, and functionally at every stage.

A century ago, the one popular argument for the existence of God was Paley's, that animal adaptations are so marvellous that they must have had a Designer. Darwin showed, instead, that they came about by natural means, not as already explained by chance, but by natural causes or laws. Theologians to-day reject Paley's argument based on particular adaptations. There is, of course, a much stronger philosophical argument from design, that a universe governed by natural causes or laws must have been divinely instituted; but acceptance of the biological theory of evolution makes this argument neither weaker nor stronger than before.

Darwin's views were also feared as implying a strictly mechanistic or deterministic view of the origin of living things, including man. But all that has been demonstrated is a particular historical sequence of animals, within which only some of the many possibilities have been realized. The relationship of such a sequence to determinism, and the bearings of determinism on Christian belief, are extremely complex metaphysical questions on which, once again, particular theories of biology can throw no special light. Hence Christians were wrong to attack Darwin's theory on the grounds that it meant that evolution was 'blind', since so far as the biological evidence is concerned, they are as free to hold that the natural means of evolution are a divine creation as atheists are to deny this.

---

* Substance of
Institution on Ma

Discourse delivered at the Royal

Natural selection was also rejected because it involves a huge annual death-rate, and to humanists like Bernard Shaw it seemed inconceivable that such terrible means could have led to man, with his sense of beauty, goodness and truth. The same grounds have led various Christians to assert that the natural creation must have been distorted by a spirit of evil; but this is another instance of argument from particular designs in Nature. A truer attitude for the Christian, surely, was that of Dr. Pusey: "What are we, that we should object to any mode of creation, as unbefitting our Creator?"

At the present time, nearly all evolutionary biologists fully accept natural selection as the main means of animal evolution, but various other writers, both Christian and agnostic, have continued to advocate Creative Evolution. Prof. M. Polanyi, for example, conceiving the animal world as "a continuous ascending evolutionary achievement", wrote that "the action of the ordering principle underlying such a persistent creative trend is necessarily overlooked or denied by the theory of natural selection, since it cannot be accounted for in terms of mutation plus natural selection", and the similar views of Teilhard de Chardin, have been acclaimed as the book of the year, if not of the century. So one is led to ask why views so unacceptable to biological specialists should be so widely accepted by others. The reason may, I suggest, be different for Christians and agnostics: that Christians, still misunderstanding the metaphysical implications of natural selection, want to see evidence for theistic design in Nature, while agnostics feel that Creative Evolution may provide the justification for human values which natural selection is incapable of doing.

In answer to the Christian difficulty I may quote the Oxford theologian Dr. E. L. Mascall: "We need not worry that science describes the course of evolution in impersonal concepts; that is its job. What is reprehensible is any attempt to treat the scientific account as if it were a metaphysical one". Again "Perhaps some modern apologists have gone badly astray in looking for direct evidence of God's design in the evolutionary process. The truth may be that God is able to achieve his ends without that sort of design". He added that, "for Christian theism, no events are fortuitous in the ultimate metaphysical sense".

The agnostic objection, that natural selection cannot justify human values, requires longer treatment. Especially since the finding of fossil men and ape-men in Java, Peking and South Africa no one can seriously doubt that man's body evolved by natural means. In addition, so much innate or instinctive behaviour has now been demonstrated in man, and so much learning and social behaviour in animals, that we may reasonably conclude that at least much of man's behaviour is a product of natural evolution. But what of man's special faculties, in particular his moral conduct? Herbert Spencer postulated that good conduct was the more evolved conduct, while theories of "evolutionary ethics" have also been advocated by modern biologists such as Waddington and Sir Julian Huxley, Waddington saying in effect that the direction of evolution is good.

Two problems are involved, the origins and the value of morality. Many of man's social attitudes, including his desire to help his fellows, are so deep-seated, and find such obvious parallels in other social mammals, such as apes or dogs, that partly innate tendencies would seem to be involved, which have presumably been subject to a natural means of selection. This might be through selection of the tribe, pack or other social unit; for social behaviour must, on balance, increase the chances of survival of the group and hence of the individuals composing it. Further, there is some reason for suggesting that at least part of what we now call evil behaviour was behaviour which contributed to individual survival in the past but which came to be selected against after men started to live in groups. However, all that has been said so far refers to social behaviour, not to moral conduct, and between them there is a great difference. The worker ant is social, but not moral, while the dog is social and we hesitate about a moral faculty, but probably decide against it.

Moral conduct is involved only when a genuine choice between actions is possible. We hold that man has free-will, through introspection and through what others tell us, while on the legal plane we accept as valid the distinction between a person being responsible or irresponsible for his actions even though it may be hard to decide in certain cases. But no test or experiment can be devised to determine whether another animal has free-will. Sometimes we may see it delay before acting, but then the biologist may say that it was subject to conflicting drives, one of which proved strongest. (This type of analysis is itself open to criticism, but the important point is that all biological interpretations leave out the possibility of the animal possessing free-will.)

Free-will depends in turn on self-awareness, which likewise we have no scientific means of demonstrating in other animals. We sometimes speak of a pet dog being pleased, or guilty, implying self-awareness, but we should strictly have said "as if pleased, or guilty", and we cannot pass beyond "as if". This is not necessarily to deny that other animals have self-awareness, but merely to say that we have no means of telling; and unless animals have free-will and self-awareness, we can scarcely speak of their having moral conduct. The gap in knowledge seems unbridgeable. This still allows the evolutionist to assert that man evolved these peculiar faculties gradually from rudiments in other animals, but it does not allow him any direct evidence for this, and it allows others to claim that, so far as free-will, self-awareness and moral conduct are concerned, there is an absolute difference between man and all other animals. (The growth from unconscious behaviour to self-awareness in the human young does not necessarily afford a parallel with the evolutionary development of the species, since the baby's self-awareness must wait on the physical maturation of the brain.)

It is even harder to find a natural basis for the value than the origin of moral conduct. The essential difficulty was put long ago by T. H. Huxley, and many hold that it has never been answered. "Cosmic evolution", he wrote, "may teach us how the good and evil tendencies of man may have come about; but, in itself, it is incompetent to furnish any better reason why what we call good is preferable to what we call evil than we had before." Thus even if good behaviour is simply that which has contributed to the survival of the group, this provides no compelling reason why we ought to be good now, nor does it sufficiently explain why, when a man knows what is right, he so often chooses what he knows to be wrong. I think it fair to say that all the attempts so far made to explain moral values on evolutionary grounds have broken down, and many claim that such attempts

will alwa
terms of r

I sugge
has partic
to reject r
a Life For
we have n
Force, and
necessarily
existence
biologists
minimizing
so for min
as I can se
made easie
logically fo
tary form .
even in the
modest ord
I can attac
which seem
misuse of t

The diffic
tion for hun
abstract rea
arises the c
as I fully I
low as that
when it d
difficulty, u
mentioned b
urgent, prob

Hence the
developed, b
for truth, be
no scientific
leaves the C
ness, free-wi
and goodnes
human soul,
words, from
On this view

e values come outside the
ence.

at it was this difficulty that
us agnostic and other writers
n. But the introduction of
ally solve the difficulty, for
for postulating that such a
nt direction of evolution, is
the Life Force is good, the
unexplained. Indeed, while
Teilhard de Chardin for
tion, theologians have done
oblem of evil. Nor, so far
ion of human self-awareness
's postulate that "we are
the existence in rudimen-
of psyche in every corpuscle,
mplexity is of such a low or
it imperceptible". Indeed,
meaning to this statement,
he underlying problem by
he".

ing a purely natural evolu-
xtends also to the power of
Darwin wrote: "But then
mind of man, which has,
developed from a mind as
e lowest animal, be trusted
and conclusions ?" This
ary ethics, has rarely been
nd there are similar, if less-
ect to aesthetic values.

ution, so far as it has been
vided a satisfactory basis
ness, and many hold that
r do so. This apparently
suppose that self-aware-
rehension of truth, beauty
s a gift from God to each
s resulted, in Newman's
le aboriginal calamity".
of evolutionary continuity

from ape to man so properly stressed by T. H. Huxley is broken, though on a spiritual rather than a natural plane. The agnostic, rejecting such views as myth, seems equally free to hold that man evolved gradually in every respect from other animals and wholly by natural means, acknowledging that not enough is yet known to determine the origin and value of these specially human faculties; though others might argue that this view provides too weak a basis for good conduct. There are also Christians who postulate a wholly gradual evolution of man from animals, some of them supposing that animals have an interior life, if not a soul, and others acknowledging ignorance as to the means involved. There are also atheists who consider moral values inexplicable in terms of natural evolution, leaving their basis unresolved. Each of these views involves unbridged, and perhaps unbridgeable, gaps in knowledge, but it seems much better to admit these freely than to seek to bring all into a deceptive unity by the application of a theory outside its proper sphere: such as Creative Evolution, which brings a pseudo-mystical concept into natural evolution, or Evolutionary Ethics, which interpret values in terms of natural survival. Enough has been said, I hope, to justify my statement that the conflict between Darwinism and religious belief has not been settled. Yet we can scarcely afford to leave the settlement entirely to posterity, since we need a basis for our lives and actions now.

REFERENCES TO QUOTATIONS IN TEXT
(for general history and references, see Lack, 1957)

De Beer, G. R., "*Archaeopteryx lithographica*. A Study based upon the British Museum specimen" (1954).
Huxley, T. H., "On the Reception of the *Origin of Species*", chap. 5 in "The Life and Letters of Charles Darwin", ed. F. Darwin, 2, 202 (1887).
Huxley, T. H., in Huxley, T. H., and J., "Evolution and Ethics, 1893–1943", 80 (1947).
Lack, D., "Evolutionary Theory and Christian Belief" (1957).
Mascall, E. L., "The Importance of being Human", 15, 17 (1959).
Newman, J. H., "Apologia pro Vita sua", 1913 ed., 335 (1864).
Polanyi, M., "Personal Knowledge", 385 (1958).
Pusey, E. B., "Un-science, Not Science, Adverse to Faith", 52 (1878).
Teilhard de Chardin, P., "The Phenomenon of Man", 301 (1959).
Waddington, C. H., "Science and Ethics", 17 (1942).

T L SOCIETY AND THE PROGRESS OF SCIENCE ABROAD

By PROF. R. J. FORBES
University of Amsterdam

THE Ter
Society d
host of officia
tives from for
names in scie
national signi

There are se
the Royal Soc
as the Nationa
but has also e
growth of sc
contacts in Eu

During the
scientists in I
similar associa
knowledge", b

ebrations of the Royal
th will be attended by a
ing some 220 representa-
s. This galaxy of famous
testimony to the inter-
occasion.

why through the centuries
not only to be recognized
Sciences of Great Britain
derable influence on the
arch problems and its
beyond.

l seventeenth centuries,
r countries had formed
e promotion of natural
se societies or academies
had but a short life or found their work interrupted for a considerable number of years by circumstances beyond their control. The Royal Society was the first association of scientists to study the "New Philosophy" for an uninterrupted period of three hundred years. Only one year after its foundation during the reign of Charles II (who granted its Royal Charter in 1662) a similar body, the Académie des Sciences, was founded in France. However, in contrast to the relations of the English Crown to the Royal Society, the French King and his ministers exerted considerable influence on the programme of research and studies of the Académie des Sciences.

The motto of the Royal Society, "Nullius in Verba", demonstrates clearly how it tried to realize the ideals of Francis Bacon and his "House of Salomon", and its message of truly independent scientific research was understood by many on the Continent and abroad. Similar bodies were founded with State aid during the eighteenth century in Brussels (1772), Copenhagen (1742), Berlin (1700), Göttingen (1751), Munich (1795), Turin (1783), Venice (1771), St. Petersburg (Leningrad) (1724), Madrid (1713), Prague (1700), Boston (1780) and Stockholm (1786), but none of them achieved that independence of Government control which characterizes the work of the Royal Society of London. The subtle influence of the Royal Society is none the less evident in the charters of most of these bodies.

However, the Royal Society's activities have had much more tangible influences on foreign research. Like most seventeenth-century learned bodies, the Royal Society started a collection of foreign animals, plants, minerals and instruments, the nucleus of which was formed by the "collection of rarities", bought from Mr. Hubbard for the sum of £100 in 1666. Sprat, in his "History of the Royal Society", mentions how at a very early date it started to "collect and send abroad inquiries" about the East Indies, China, St. Helena, Teneriffe, "Ginny, Barbary and Morocco", Spain, and Portugal, Turkey, France, Italy, Germany, Hungary, Transylvania, Poland, Sweden, Iceland and Greenland. As an example of such contacts abroad, from whom data on the local flora, fauna and geology were collected, he prints the full text of an "Inquiry" sent by Sir Robert Murray to Sir Philiberto Vernatti, "resident in Batavia in Java Minor".

More lasting contacts were undoubtedly established by the Royal Society's decision to make possible the printing of its Fellows' papers and other memoirs of scientific investigations. On March 6, 1665, Henry Oldenburg, secretary of the Royal Society and one of the most prolific correspondents of the century, published the first number of the "Philosophical Transactions: giving some Account of the present Undertakings, Studies and Labours of the Ingenious in many considerable Parts of the World". The very sub-title of this first scientific periodical shows that it would not be confined to the publication of memoirs submitted by Fellows of the Royal Society. Its columns were thrown open to any scientist, wherever he lived, provided his work came up to certain standards.

This step was a most significant one for science in general. Up to that date, the students of the 'New Philosophy' had been able to communicate their results and their theories to a local circle of friends only. Some managed to have them printed in pamphlet or book form, but it was virtually impossible to submit them for discussion to an international forum of critical fellow-scientists. Hence such data and theories took a very long time to spread. Oldenburg's effort solved the most important problem of communication of the day. A memoir published in the *Philosophical Transactions* could now produce reactions within a matter of months, where earlier workers had had to wait a generation before their results were absorbed and seriously discussed by foreign fellow-scientists.

A striking example of this feature of the *Philosophical Transactions* can be found in the correspondence of Anthoni van Leeuwenhoek published in the volumes from 1673 onwards. Van Leeuwenhoek was a native of Delft and one of the pioneers in the world hidden from the naked eye but penetrated by the use of lenses. With his 'microscopes' (in reality single lenses mounted between two small silver plates) he magnified the objects studied 200–250 times. As he did not speak or write English, the letters recording his adventures in this microcosmos were translated with the help of his fellow-townsman, the physician Reinier de Graaf, who was already corresponding with the Royal Society, and other friends. For nearly fifty years, most of the 280 letters written by him as well as a number of the 550 microscopes which he made, with objects mounted for observation, went to the Royal Society. The secretary published some 124 letters by van Leeuwenhoek during the fifty years of contact which the Royal Society had with him, as well as the observations by Robert Hooke, who often tried to repeat and equal the results of van Leeuwenhoek. However, Hooke possessed only a compound microscope, consisting of a very small plano-convex object glass and a large plano-convex eye-piece, which magnified his objects only about 40 times. This difference in their 'penetration' of the microcosmos led to violent accusations of misrepresentations on both sides; but from the discussions and the part taken by other scientists very valuable results ensued for microbiology and other fields of science.

The publication of his letters in the *Philosophical Transactions* soon made van Leeuwenhoek famous, and a correspondence with other scientists or amateurs ensued. Among his correspondents we find not only all the famous men in the United Provinces but also the Elector Palatine, the Landgrave of Hesse-Cassel, the chief librarian of Cosimo III, Duke of Tuscany, Leibniz and von Tschirnhaus. Even princes came to see him at his Delft home.

This is but a typical example of the benefits which many a Continental scientist derived from having his papers printed through the good offices of the Royal Society. In certain cases the Royal Society also had longer memoirs and books printed. In the early period, when funds were not always adequate, the Royal Society could not always publish these works itself and merely sanctioned their publication. In this way Newton's famous "Principia" received the Society's 'imprimatur' from the then president, Samuel Pepys, to be printed at the expense of Edmond Halley, the astronomer. However, this sponsoring of larger publications was not restricted to the work of English subjects only. As early as 1669 the Society published a book on the silkworm by the famous Italian biologist Marcello Malpighi, who was in constant correspondence with Robert Hooke. Six years later, in 1675, another book by Malpighi, on plant anatomy, was published by the Royal Society, which also helped to print his work posthumously in 1697. Among these early publications we also find two volumes on the "New Digester or Softener of Bones" (1681 and 1687), invented by the French physician, Denis Papin, who during certain periods of his life was the assistant of Huygens and of Boyle. These two publications deal with the ancestor of the modern 'pressure-cooker'.

Even during the early eighteenth century when the Society's scientific activities were at their lowest ebb, both the *Philosophical Transactions* and the series of publications maintained the high standard which still characterizes them to this very day.

The third way of promoting science abroad was the election of foreign scientists as Fellows. Not only was Anthoni van Leeuwenhoek thus rewarded in 1680, but in the earliest registers of Fellows we find the names of the Dutch physician, Christiaan Huygens (1663), the Frenchman Samuel Sorbière (1663),

Marcello M
Jean Casini
philosopher
Denis Papin
whose fame
Royal Socie
number had
century. D
distinguishec
scientific qu
less than 1
provisions fo
tions of suc
Statutes of
and in 1823-
50. At the
the privilege
of whom are
many being

As the ir
became more
Royal Society
abroad. In t
were never at
prominent Fe
of the Royal
considerable
Napoleonic V
hand to Fren
of war condi
difficulties wi
withstanding
to and fro b
war-time, and

, the French astronomer
erman mathematician and
r von Leibniz (1673) and
e but a few of the scientists
he centuries. In 1671 the
e foreign members; this
ty-four by the end of the
teenth century, too many
ere admitted who had no
d by 1766 there were no
mbers. This gave rise to
er scrutiny of the qualifica-
1761 and 1765). In the
nber was limited to 100,
n number was fixed at
8 foreign members enjoy
o the Royal Society, all
ous in their special field,
inners.

rotherhood of scientists
shed, the Fellows of the
ed more personal contacts
ning book, "The Sciences
n de Beer has shown how
Joseph Banks, president
1778 until 1820, took
the Revolutionary and
nce to extend a helping
tists in trouble because
nvolved him in serious
Government; but not-
ters and books still went
Britain and France in
cientist in difficulties in
British-occupied territories called upon the Royal Society in vain.

In Banks's days, joint ventures with foreign scientific bodies were already common features in the Royal Society's programme, quite apart from its own naturalist and astronomical expeditions. Thus in 1785, King George III authorized a grant needed for a triangulation from Greenwich, which connected across the Channel with similar French triangulations from the Observatoire Royal. This was but one of the many co-operative ventures which culminated recently in the antarctic expedition in connexion with the International Geophysical Year, when the Royal Society established a station at Halley Bay for various scientific observations. Just after the First World War, the Royal Society took the initiative in re-establishing international co-operation, which resulted in the setting-up of the International Research Council, reconstituted in 1931 as the International Council of Scientific Unions. Through this International Council and through the United Nations Educational, Scientific and Cultural Organization, the Royal Society is now very active in promoting international research and not least in disseminating scientific knowledge, as it has done for centuries. The latter effort culminated in the Scientific Information Conference of 1948, held to establish the proper means of disseminating scientific information in general. Through its numerous committees the Society now co-operates with a variety of international commissions and in various international scientific projects, true to its motto, that research knows no master but is for the benefit of mankind as a whole.

T TIFIC WORK OF J. S. HALDANE (1860-1936)

By PROF. J. B. S. HALDANE, F.R.S.
Indian Statistical Institute, Calcutta

MY father,
took arts
of Edinburgh,
ties. Althoug
Laboratory at
of which time
source of incor
his employmen
posts which he
of mining at
Institution of
lectureship on p
mainly with his
touch on his c
relevant to thi
few of his publ
can be read wi

His first two
future. The fir
Mind. The sec
the air of Dunc
with Carnelley
numerous analy
then widely helc
were due to 'ba
crowding were d
than to bacteri

, was born in 1860. He
egrees at the University
ear in German universi-
in the Physiological
g 1890–1916, for most
er or reader, his main
sent century was from
feree; and among the
t decade were the chair
the presidency of the
eers, and the Gifford
this brief sketch I deal
to physiology, and only
so far as they were
raphy only includes a
which in my opinion
to-day.

et the pattern for the
fe and Mechanism" in
elley and Anderson on
l schools, and a third
sewers, are records of
acked the hypotheses,
seases as typhoid fever
at the effects of over-
l changes in air, rather

His next important publication[2], with J. L. Smith, refers to work done at Oxford. A subject was shut up in an airtight chamber, with or without a tray of soda-lime to absorb carbon dioxide; or mixtures were breathed from bags. The highest and lowest concentrations breathed were 18·6 per cent carbon dioxide and 6·7 per cent oxygen. Their conclusions as to the physiological effects of these gases, which disagreed completely with those of several contemporaries, are now universally accepted. They also found that water condensed from breath was no more poisonous, when injected into rabbits, than any other distilled water, whereas the contrary had been claimed.

In 1894, he began going down mines to collect air samples, and established the composition of 'black-damp' in which oxygen is deficient, and carbon dioxide in excess. But his main interest was in carbon monoxide, on the effects of which he published a paper[3] in 1895. He found that 0·06 per cent carbon monoxide produced symptoms in mice when added to the air breathed, while 0·2 per cent was fatal. When added to pure oxygen about ten times as much carbon monoxide is needed. He then himself breathed mixtures containing carbon monoxide. He reached 49 per cent saturation of his hæmoglobin, at which point "stopped experiment. Vision dim.

Limbs weak. Had some difficulty in getting up or walking without assistance, movements being very uncertain". When a mouse breathed the same mixture as a man the final results were not very different, but symptoms appeared in about one-twentieth of the time. He at once applied this fact to the detection of carbon monoxide in mines while collecting gas samples from heated coal. He later found that small birds, with their higher gas exchange per gram per minute, reacted still quicker. In the next year he went down three collieries which had recently exploded, took samples of blood from dead men and horses, and concluded that they had died of carbon monoxide poisoning. In the course of this work he developed analytical methods which were later improved.

In 1896, Haldane and Lorrain Smith found that when a man is in equilibrium with a small percentage of carbon monoxide, his blood contains less of this substance than when it is equilibrated with a gas mixture believed to approximate to his alveolar air. Later work with Douglas confirmed this conclusion. His explanation that this is due to oxygen secretion by the lungs has been strongly criticized, but the facts must be explained. They also found that light decomposes carboxyhæmoglobin. He made a number of experiments on hæmoglobin derivatives, giving spectra of several new ones, and making the important discovery[4] that when ferricyanide is added to oxyhæmoglobin the oxygen is given off quantitatively. This was the basis of his subsequent work on oxygen transport. He also[5] described the gas-analysis apparatus which bears his name.

During the last two years of the nineteenth century he was largely occupied with other matters. He took the teaching of physiological chemistry seriously, and was, for example, the first to use Kjehldahl's method of nitrogen estimation in Britain. Among his publications in applied physiology at this time are reports on three colliery explosions, in which he recommended the use of rescue apparatus, after personal experience with one of his own design, on poisoning by lighting gas, and on the air of the London Metropolitan railway, the electrification of which he recommended.

The period 1900–14 was the most productive of his life. In 1900, with Smith[6], he administered about 120 ml. of carbon monoxide in closed-circuit breathing apparatus to 12 men. About 20 per cent of their hæmoglobin combined with this gas, and he thus determined their blood volumes. In the next year[7] he established standards of hæmoglobin for men, women and children, using his well-known pocket hæmoglobinometer; and in 1902, with Barcroft, described a blood gas manometer the subsequent modifications of which by Barcroft, Brodie and Warburg have been very widely used for many purposes.

In 1901 he found that an outbreak of anæmia in Cornish tin mines ascribed to 'bad air' was due to ankylostomiasis, and later, with A. E. Boycott[8], described its course and eradication. During this investigation he became interested in the much more serious disease, miners' phthisis, and with R. A. Thomas[9] proved that it was due to rock dust. It had been attributed to nitrogen peroxide, ladder climbing, and even lack of sunlight. The fact that it is now called pneumoconiosis is sufficient proof that his views have been accepted. He continued work on it for the rest of his life.

In 1905, with J. G. Priestley[10], he published what I think he regarded as his most important single paper, showing that under normal conditions human breathing is so regulated as to keep the percentage of carbon dioxide in the alveolar air almost constant at atmospheric pressure. It was characteristic of Haldane that, before going into compressed air, he verified that the partial pressure remained steady when the density of the air changed, by descending a tin mine and ascending Ben Nevis. With Fitzgerald he established norms for men, women, boys and girls. His work in mines and textile factories prompted a series of experiments in which he showed that the main factors in determining human reaction to heat are wet-bulb temperature, air-flow, and clothing. This work has since been greatly extended by others.

He next investigated diving with A. E. Boycott and G. C. C. Damant, R.N.[11]. His first discovery was that the pumps used by the Navy to send down air to divers leaked atrociously even at four atmospheres. It was believed to be dangerous to ascend or descend at more than 1·5 m./min. The present record is about 60. There is no danger in rapid descent provided the air supply is adequate and the diver can hold his Eustachian tubes open. But Bert had shown that too quick an ascent can lead to the liberation of bubbles of nitrogen which may cause death from embolism, paralysis, pain and other symptoms. Experiments on goats showed that however long they had been kept at a given pressure it was safe to halve it. Simple calculations based on this fact and on the hypothesis that various tissues exchange nitrogen with the blood by simple diffusion at different rates, while the arterial blood is in equilibrium with the alveolar air, allowed the preparation of tables for decompression by stages; and these were tested, first on goats and then on men. In the subsequent fifty-two years these tables have needed very little alteration, though they have been extended to greater depths and longer times.

At this time he was also serving on Royal Commissions on the ventilation of factories, and on mines. Among the measures which he recommended, in the face of much opposition, were the provision of pit-head baths, and means for reversing the ventilation in coal mines. Both have since been made compulsory. A moment's consideration of the results of a fire near the down-cast shaft, when the air stream can be reversed and when it cannot, should make the value of reversal clear.

Meanwhile, in a series of papers, mainly with C. G. Douglas, he worked out the details of the regulation of breathing. Their results are summarized in "Respiration"[12], though a student of physiology may well read the original papers to see how the conclusions were reached. In 1911, with Douglas and two American colleagues, Yandell Henderson and E. C. Schneider, he spent six weeks at the summit of Pike's Peak (14,019 ft.) in the Rocky Mountains. They studied acclimatization, which included changes in the blood volume, increased hæmoglobin production, and a lowering of the plasma bicarbonate which permitted increased breathing. Their further conclusion, that the lungs secrete oxygen into the blood, has been denied by Barcroft and others; but it is not sure that the last word has yet been said about it. In 1912, he published a paper[13] with Douglas and myself on the equilibria between hæmoglobin, oxygen, and carbon monoxide, and the effects of carbon dioxide on them. In 1914, with Christiansen and Douglas[14] he confirmed, and above all quantified, Bohr's observation that the oxygenation of blood drives carbon dioxide out of it.

The outb
his work. I
to advise o
brief and d
myself and
could be m
partial prot
respirator o
generals, me
thought oth
ber 1915, wa
in his critic
advice was
against gas.

In 1916 he
on kidney f
papers with
oxygen-want
breathing, a
physiological
Hancock and
latter years
hygiene with
died in 1936
The patholog
mortem exa
heart with a
had been ad
account of c
good many r
died earlier t

My father's
misunderstoo
ialism, which
chemical real
sentation of c
sciences in t
reality, can b
phenomena o
haviour". In
described hims
written[14] duri
preted the phy
"An ultramicr
of organism w
molecular size
may possibly
biological inte
regard as the i
The discovery
suggests the p
must be regar
biology". "A
ordinated inte
become dissipa
both its mass
Thus the assum
physics have b
and we are p
resemble in ess
cal study forces
wart for physics
as co-ordinated

He was perh
The following
complete comp
production of a
breathing which
the body, illu
compensation w
in the position

1914 greatly slowed down
e was called out to France
m chlorine. In a series of
ents on himself, Douglas,
vised a respirator which
large numbers, and gave
isted, however, that only a
would be adequate. The
r, concerned in the matter
saster of Loos, in Septem-
But he had been too frank
officers, so after this his
poradically on protection

hort paper with Priestley
n 1919 and 1920 several
nnaway and others, on
low pressures, shallow
His last contribution to
a paper in 1929 with
sweating; but during his
much important work on
ence to ventilation. He
re following pneumonia.
equest, carried out a post-
that he had never seen a
ting tissue. In 1900 he
the life of an invalid on
ms. Had he done so a
and soldiers would have

views have been widely
d what he called mater-
"the belief that physico-
umption that the repre-
universe by the physical
al form corresponds to
as to cover, not only the
those of conscious be-
s an idealist, but later
The following passages,
ade, show how he inter-
s of the present century.
eems to represent a form
aps be of not more than
so minute an organism
k in the extension of
o what we at present
of molecules and atoms.
phenomena strongly
ch an extension, which
the scientific aims of
to maintain intense co-
tivity, which does not
ronment, and on which
properties depend. . . .
ptions of the Newtonian
to be in reality basic;
d with what seem to
the facts which biologi-
he was not prepared to
He took the fact of life
ven.
e opposed to vitalism.
ring to the allegedly
e increased metabolic
regnancy by increased
el of carbon dioxide in
jection. "But if the
ot we should be landed
of assuming effects to

be produced without any measurable cause. In reality the acidosis is not completely compensated, and the incompleteness is only hidden by the extreme roughness of the method of measurement in comparison with the fineness of the physiological reaction". A corollary of his rejection of vitalism was his disbelief in personal immortality, which he combined with a lively belief in God; his theological views were definite enough to prevent him from joining any religious organization.

Many contemporary physiologists thought in terms of mechanism, and did not see why he was not content with the notion that the mechanisms concerned were very numerous and delicate. They twitted him with making accurate physical and chemical measurements. In this article I have only referred to a few of his analytical methods; for these have often been superseded by more speedy and accurate ones, though sometimes by methods which are more expensive and no more reliable. His answer was as follows. "As a mere physicist or chemist I should never have dreamt of looking for such things as constant dissociation curves or carbon dioxide pressures or hydrogen-ion pressures or chlorine percentages in such liquids as blood; and if I had chanced to find one it would only have appeared as a very unintelligible fact". Even if (as I do not believe) his point of view is fundamentally false, it has great heuristic value.

To take a concrete example, Gemmill and Reeves, in 1933, working on dogs trained to breathe through respiratory valves, showed that the receptors for oxygen want are in the carotid sinus, but those for carbon dioxide excess are elsewhere, probably in the medulla. But Haldane, Meakins and Priestley[14] had found in 1919 that oxygen want mainly increases the frequency of human breathing, while carbon dioxide excess mainly increases its depth. Hence these two stimuli cannot act in summation on the same receptors, a fact ignored by many workers in the interval between the two papers cited. Even if the aim of physiology is regarded as a mere cataloguing of the functions of various organs, a study of the organism as a whole will tell physiologists what to look for.

Haldane's research was based on his beliefs in the unity of organisms as self-sustaining systems, and in the value of accurate measurements. If an organism is seriously damaged it may no longer be capable of self-regulation, and large and easily measurable changes may occur in it. But very great accuracy is often needed to measure the small changes which occur in healthy organisms, and which give the clue to their self-regulation. That is why he preferred to experiment on himself with an accurate apparatus rather than on rabbits with an inaccurate one.

At present biochemists are largely concerned with research which, on a molecular scale, is the equivalent of human and comparative anatomy on a larger scale. This work has been of immense practical value when, as with antibiotics and weed-killers, the desired end could be obtained by killing species *A* while sparing species *B*. It has been of much less value when, as in the therapy of cancer and psychosis, we desire to restore normal self-regulation within an organism.

I can perhaps best illustrate the value of my father's approach by citing the work of the two living biologists whose approach seems to me closest to his, though I doubt if they were directly influenced by him. Karl von Frisch discovered the system by which bees communicate the direction and distance of a food source. He observed them under almost normal conditions, and investigated quantitatively the correspondence between the dance of a bee, the voyage which it had made, and those made by other bees which responded to the dance. He discovered that bees respond to the polarization of light. But this was first inferred from their behaviour under natural conditions. It was not discovered by measuring the response of isolated organs to physically well-defined stimuli. Jacques Monod and his colleagues studied the synthesis of β-galactosidase by bacteria under a variety of external and internal conditions. The results give no direct information as to the process of protein synthesis, such as are given by studies of enzymes which phosphorylate amino-acids. But they tell us enough about its regulation to offer at least a possible partial explanation of why different cells in the same organism make different proteins. The by-products of this work, such as Cohen and Cowie's production of bacteria in all the proteins of which selenomethionine completely replaces methionine, are as important as they are unexpected.

Haldane's approach to biology is not the only fruitful one. But I think that in most fields of biology it is not being applied as fully as it should be if research is to be as efficient as possible. However that may be, a study of his work and thought can still, I believe, be of great value in suggesting topics, and above all, methods, of research to biologists to-day.

[1] Carnelley, T., Haldane, J. S., and Anderson, A. M., *Phil. Trans. Roy. Soc.*, B, **178**, 161 (1887).
[2] Haldane, J. S., and Smith, J. L., *J. Path. Bact.*, **1**, 168, 318 (1893).
[3] Haldane, J. S., *J. Physiol.*, **18**, 430 (1895).
[4] Haldane, J. S., *J. Physiol.*, **22**, 298 (1898).
[5] Haldane, J. S., *J. Physiol.*, **22**, 465 (1898).
[6] Haldane, J. S., and Smith, J. L., *J. Physiol.*, **25**, 331 (1900).
[7] Haldane, J. S., *J. Physiol.*, **26**, 497 (1901).
[8] Boycott, A. E., and Haldane, J. S., *J. Hyg.*, **3**, 95; **4**, 73 (1903, 1904).
[9] Haldane, J. S., and Thomas, R. A., *Trans. Inst. Min. Metall.*, **13**, 1 (1903).
[10] Haldane, J. S., and Priestley, J. G., *J. Physiol.*, **32**, 331 (1905).
[11] Boycott, A. E., Damant, G. C. C., and Haldane, J. S., *J. Hyg.*, **8**, 445 (1908).
[12] Douglas, C. G., Haldane, J. S., and Haldane, J. B. S., *J. Physiol.*, **44**, 275 (1912).
[13] Christiansen, J., Douglas, C. G., and Haldane, J. S., *J. Physiol.*, **48**, 244 (1914).
[14] Haldane, J. S., Meakins, J. C., and Priestley, J. G., *J. Physiol.*, **52**, 420 (1919).
[15] Haldane, J. S., "The Philosophical Basis of Biology" (Hodder and Stoughton, London, 1931).
[16] Haldane, J. S., and Priestley, J. G., "Respiration" (Oxford Univ. Press, 1935).

NEW LABORATORY OF THE DEPARTMENT OF METALLURGY, UNIVERSITY OF OXFORD

MR. ISAAC WOLFSON officially opened the new Laboratory of the University Department of Metallurgy at Oxford on May 31. The building (Fig. 1) is the first section of the new science area of the Keble Road triangle, and it was designed by Mr. George Buzuk, of Messrs. Murray, Ward and Partners.

In a speech welcoming the visitors, Prof. W. Hume-Rothery, head of the Department, outlined the history of metallurgy in Oxford and expressed the Department's appreciation of the support received from many sources, and from Mr. Wolfson, whose endowment of the chair of metallurgy had supplied the crowning touch to the establishment of the subject.

Mr. Wolfson spoke of the increasing dependence of many branches of modern science, and of industry, on research in metallurgy. The small Oxford school, in spite of the scale on which it has been compelled to work, has played a prominent part in the scientific study and understanding of the subject. In the new building this work will continue, and the introduction of the teaching course will help to provide more of the trained metallurgists which Britain so urgently needs.

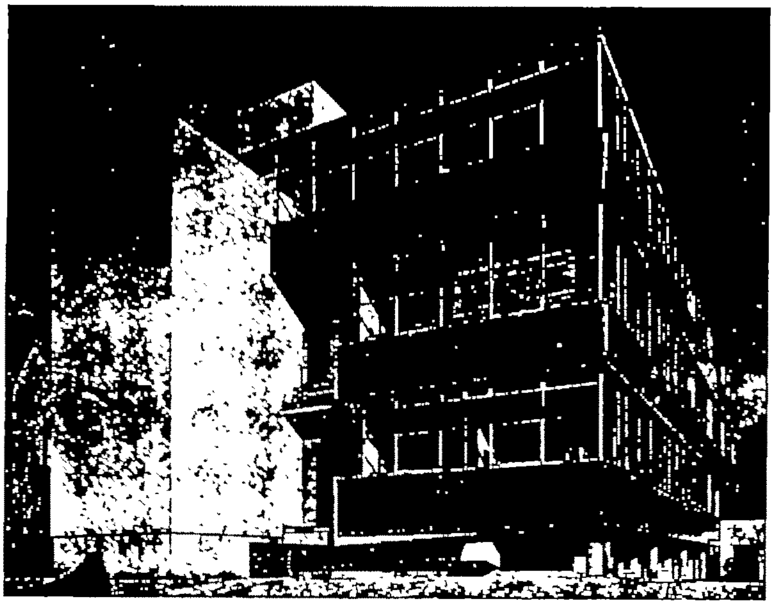


Fig. 1. Department of Metallurgy, University of Oxford. By courtesy of *The Architect and Building News*

The Vice-Chancellor of the University of Oxford, Mr. T. S. R. Boase, paid a tribute to Mr. Wolfson and his Trustees, who are one of those foundations that play such an immense part in the expansion of university life to-day. He described the building as the first unit of what will undoubtedly become the great centre of twentieth-century architecture in the Oxford of the future.

After the opening ceremony, the laboratories were open to inspection by the visitors, and the apparatus and results of some of the research in progress were displayed.

The new building has four floors: in the basement there is the main

workshop,
furnace r
temperatu
X-ray roo
temperatu
On the
microscop
hardening
testing, an
tains the
room and
are on the
the consti
high-melti
bardment
and the fr
of metals
The bu
Birmingh
The ope
stage in
gradually
Prof. F. S
lurgy at
Wolfson
metallogr
Royal Sc
had to b
metallurg
room lent
of the Dy
After a
m the Ol
that Hu
students,
some of th
this peric
under Hu
Armourer
Research
was made
received
Tizard at
and the
research
ment of
British
In 1937,
Dr. Lee's
guidance
ally intr
Oxford.
and held
during
expandec
stitution
Supply.
School,
graduate
was reco
and labo
When
organic
first arra
as a sub
pendent
in 1953,
from Pr
guided t
and skil
The gen

cal testing room, and the
t present devoted to high-
ork. There are also two
ich is being used for high-
k.
e rooms devoted to electron
xidation and precipitation
igh-temperature mechanical
tometry. The first floor con-
laboratories, the microscope
he study rooms for the staff
ther with rooms for work on
ys, the thermal analysis of
melting and electron bom-
rain boundary precipitation
s, and mechanical properties

Messrs. Whittalls, Ltd., of

w laboratory marks a further
nent which has proceeded
thirty-five years. In 1922,
the establishment of metal-
ranged for the present Isaac
Hume-Rothery, to study
r Harold Carpenter at the
n London. Many difficulties
nd the first appearance of
1926 was on one bench of a
L. Perkin on the ground floor
aboratory.
nove was made to two rooms
Department, and it was here
with one or two research
ny years helping to establish
ry of alloy structures. During
t was entirely postgraduate
who held, in succession, the
s fellowship and a Warren
he Royal Society. Research
e continual interest and help
V. Sidgwick and Sir Henry
rof. C. H. Desch at Sheffield,
al Laboratory, together with
e Royal Society, the Depart-
Industrial Research and the
etals Research Association.
r Cyril) Hinshelwood became
hemistry and, thanks to his
pport, metallurgy was gradu-
official scientific circle at
became a lecturer in 1938,
special election at Magdalen
oratory accommodation was
the War, work on the con-
arried out for the Ministry of
re given in the Chemistry
as such remained a post-
1949, when metallography
fficial supplementary subject
were introduced.
for the expansion of the In-
oratory were put forward, the
for metallography to develop
f that Laboratory. The inde-
metallurgy was first advanced
uggestion coming apparently
rancis) Simon. The idea was
conclusion by the perseverance
registrar, Sir Douglas Veale.
Pressed Steel Company enabled

the foundation of the George Kelley Readership in memory of its late managing director. The late Major A. Pam, of the Pressed Steel Co., was responsible for raising an industrial fund; this has contributed much towards the running of the Department, which became independent in 1956. Meanwhile, the University Grants Committee provided a grant for the building of the new Laboratory on the Keble Road triangle, and the establishment of the subject was completed by Mr. Isaac Wolfson's endowment of the chair of metallurgy in 1957, when Hume-Rothery, who had controlled the subject since 1926, was elected first Isaac Wolfson professor of metallurgy.

The present staff consists of the Isaac Wolfson professor, the George Kelley reader (Dr. J. W. Christian), two lecturers (Dr. J. W. Martin and Dr. S. L. Altmann) and a graduate assistant (Dr. A. Hellawell). An independent honours degree course was established in 1956, while metallography remains a supplementary subject which may be read by those whose main subject is in another branch of science.

The introduction of metallurgical research into Oxford under Hume-Rothery coincided with an exciting period in the history of the science of metals and alloys. In spite of extremely limited accommodation and numbers, the Oxford School made substantial additions to the theory of alloys. The early work was concerned mainly with alloys of copper, of silver, and of magnesium, but many conclusions applied to alloys of other metals. This work was later extended to alloys of aluminium, of iron, and of the high-melting transition alloys such as those of molybdenum which are becoming of increasing importance. Under the present George Kelley reader, the Oxford work spread into other fields of physical metallurgy, including phase transformations and mechanical properties. Contributions have been made to the theory of martensite, of stacking faults, and of the factors controlling the flow stress of metals and alloys. Dr. Martin has introduced the new techniques of electron microscopy, and has used these to study dispersion hardening of alloys, and is also investigating the high-temperature mechanical properties of alloys, and the fracture characteristics of uranium. Dr. Altmann, as a mathematical physicist, is investigating the theory of the band structure of metals, and Dr. Hellawell's work is concerned with the freezing of alloys and the structure of grain boundaries.

On the teaching side, the University now provides a four-year honours degree course in metallurgy. The metallurgical work, in which emphasis is placed on fundamental principles rather than technological processes, is combined with the full Oxford course in inorganic and physical chemistry. Written and practical papers in these three subjects are taken after three years, and constitute Part I of the final examination. The fourth year is spent on research in some topic related to metallurgical science, and the student submits a thesis and has an oral examination. The honours class is awarded on the combined results of Parts I and II.

In thirty-five years, metallurgy at Oxford has thus expanded from one bench in an organic chemistry laboratory to a laboratory of its own, which is equipped and staffed to deal both with purely theoretical investigations and with experimental work at temperatures ranging from 3,000° C. to that of liquid air, and this lower limit will soon be extended to within a few degrees of the absolute zero of temperature.

UNIVERSITY EDUCATION IN NEW ZEALAND

THE report of the Parry Committee on the New Zealand Universities* follows in many respects that of its predecessor, the Murray Report on the Australian Universities (see *Nature*, 181, 300; 1957). It does, however, right through its various sections, emphasize again and again the present more parlous condition of the New Zealand Universities. This condition has been "engendered by the alarming rate at which staff has been leaving, the inability to recruit new staff of adequate calibre because of low salary rates, the inadequacy of buildings and equipment, and the poor teaching conditions that, in large measure, stem from the high proportion of part-time students."

The Committee stresses that to fulfil their part "the Universities must play a much greater role in the New Zealand community, and must be much better supported financially than they have been in the past". One major difficulty has been that the New Zealand Universities have not been "widely regarded as having a primary responsibility for original investigation and research". If the report succeeds in changing this attitude within the country, it will have achieved a major success, and, provided the time, money and facilities become available, the staff should then be able "to think about the future of their society in relation to its past, to compare and relate the contributions of other cultures to those of their own, to investigate the nature of the physical world and to keep abreast of the investigations of others".

The report directs attention to the serious shortage of university graduates in New Zealand to meet the demands of a number of professions, of many sections of industry, commerce, education and of the public services. In particular, it concludes that a substantial increase in the number of science and engineering graduates will be required for many years to come. An analysis of figures given in the report shows that in 1962 there will be about 1,300 students graduating with bachelor's degrees, and that 2,440 will be wanted in post-primary teaching, agriculture, the Civil Service and universities alone, so that "all the evidence points to an acute shortage of the university-educated persons needed for the country's educational services and economic development". As the report points out, it is going to be essential in the future for the universities and potential employers to give more attention than they have in the past to assessing the probable future demands for people with university education and then preparing plans to meet them.

One reason for this acute shortage may be the high rate of failure among the students. There are those who believe that the entrance standards are too low and that accrediting should be replaced by examination; these people will be disappointed that there is no recommendation to change from accrediting to examination, even when an increase has taken place in the staff of the universities.

One recommendation, which will certainly be hotly debated, is that more of the better students from selected schools should be allowed to commence their university studies at the second-year level. This is already permitted in Greek and mathematics, but if it is extended it will be very difficult to eliminate later. It would surely be better, if the Government accepts the Committee's recommendations for increased staffing, to introduce pass and honours degrees. The University of Canterbury already has this system in the Science Faculty, and the Science Faculties of Victoria and Otago have just introduced it. Much could also be done by raising the standards in secondary schools, though this is naturally associated with the supply of graduates for the teaching profession. The Committee further considers that more could be done to reduce the rate of failure by providing extra assistance to students in coping with the transition from school to university.

The report refers to the fact that at present about 32 per cent of those passing university entrance examinations do not offer mathematics or a language, and that only 9 per cent offer both. Despite the importance of mathematics for a range of disciplines, more than 55 per cent of those passing entrance examinations do not offer the subject. This indicates that some changes, at least, are required in entrance requirements.

The Committee is adamant that the proportion (46 per cent) of part-time students (mostly in arts, law and commerce) is far too high, and that their rate of first-year failure of 60 per cent is also too high. It believes that the value of full-time study has not yet been sufficiently appreciated by students, parents, employers and the Government. It rightly recommends the transition to full-time study for as many students as possible, though this will automatically involve extra expenditure on bursaries and halls of residence.

The recommendations of the Committee on scholarships and bursaries are far-reaching. Many of the awards are at present too low and must be increased. Some of the awards, such as the bonded bursaries for teachers, are out of all proportion to other awards and the demands of the situation. Students who accept such bursaries commonly make a decision on their future vocation far too early in their university careers, and the recommendation to abolish the bonded bursaries should be welcomed by staff and students alike. Other important financial recommendations will enable more students to proceed to the degrees of master and doctor. For too long now students have been leaving New Zealand to study overseas, even though some departments are increasingly able to offer first-class postgraduate instruction. If the recommendations on staffing and research finance are met by the Government, there is no reason why New Zealand postgraduate training in all departments should not be the equal of any university in the Commonwealth.

The staffing position in the New Zealand Universities has reached an alarming condition, almost solely as a result of inadequate salaries. The Committee says that academic salaries must in future bear a relationship to those paid in Australia, since New Zealand has become an important source of

---

* Report of the Committee on New Zealand Universities. (Government Printer, Wellington, 1960.) 4s. 6d.

Australian r
scale: pr
(£2,250), se
(£1,250–£1,7
It is gratify
accepted th
as from Ap
teachers and
class new st
salaries unde
sity salaries
these increa
Government
country, to s
mendations c
definite. This
has shown th
mendations,
protracted ne
ment in the t
grants. If th
recommendat
administrativ
assistance, es
technical assi
The libraries
their collectio
where. The r
of £50,000 m
associated wit
ment.

The report
New Zealand
that when so
structed are
The Committ
expenditure o
be increased t
and further, th
Government i

The encour
and technolog
of any count
neglected or n
ally in industr
play here, and
more of the a
degree courses
co-ordination
Universities a
Industrial Res
of important
Bureau and th

t has recommended a new
0), associate professors
(£1,750–£2,000), lecturers
cturers (£900–£1,100), and
that the Government has
tion and implemented it
ould stop further loss of
niversities to recruit first-
essential, however, to keep
ially if Australian univer-
e. It is to be hoped that
assist scientists in the
ave also been leaving the
heir salaries. The recom-
ttee on leave are not so
ted, since past experience
sence of definite recom-
to be a long period of
re there is any improve-
and the amount of travel
is prepared to accept the
technicians, library and
ould be of great material
nce departments, where
sent grossly inadequate.
ch more money to make
garded as essential else-
n of an immediate grant
inadequate even when
n proposals for improve-

t university building in
ars behind schedule, and
ldings now being con-
will be over-crowded.
at the present annual
buildings will have to
ver the next ten years,
have to be done by the
lls of residence.
development of science
well-being and economy
e, so far, been unduly
in New Zealand, especi-
sities have their part to
recommends that much
should be included in
that there is insufficient
research between the
ment of Scientific and
er has located a number
for example, the Soil
Nuclear Research) in

places distant from the universities, and there is no doubt that more co-ordination would benefit both the Universities and the Department. Science in the Universities should also receive a long overdue stimulant if the Government accepts the Committee's recommendation to increase the present research grant of £25,000 to £65,000 this year and £100,000 in 1961. Another notable recommendation is for the establishment of a National Scientific Research Council, which should overcome the present disproportionate expenditure on research between Government research institutions and the Universities, and the present lack of co-ordination.

The recommendations not to establish a veterinary school or a second school of medicine will certainly be unwelcome in some quarters in New Zealand, though the recommendation not to establish further teacher-training colleges away from the present universities will command general support.

The impending disappearance of the University of New Zealand, the coming autonomy of the constituent Universities and the implementation of the recommendations will require, the Committee reports, the re-organization and enlargement of the present University Grants Committee under a full-time chairman. Many, however, will not agree with the suggestion that only a minority of the members of the Committee should be drawn from the academic institutions. The proposal to retain the University Entrance Board may not commend itself to some, and the proposed constitution of five University and five Department of Education representatives under a chairman may well stultify its operations.

It is evident from the foregoing that the Committee has unerringly indicated the present difficult conditions prevailing in the New Zealand Universities. The recommendations it has made will, in nearly every case, if accepted, bring these Universities up to the point where their status will be equal to that of the best universities in the Commonwealth. If the Government of New Zealand, in conjunction with the University Senate, will act as promptly on the other recommendations as the Government has on the salary proposals, there should be little need for those concerned with higher education in New Zealand to fear the future, and the Universities should be able to play their full part in the further development of the country, its economy and social life. It will also give new heart to those among the present staff who have laboured, often under incredibly difficult conditions, to build departments worthy of recognition throughout the world.

V. J. CHAPMAN

RADIO UM AND RADIOCÆSIUM IN MILK DURING 1959

ANDERSON, L. K. BURTON and J. O. CROOKALL

P nt, Institute of Cancer Research, Royal Cancer Hospital, London, S.W.3

IT is clear fr
concentratio
tium-90, caesiu
Britain was sub
of 1959 than du
In consequence,
was comparativ

of reports[1-3] that the
fission products (stron-
n falling over Great
er during the first half
ous half-yearly period.
l-out during this period
as shown recently[4], the

levels of strontium-90 in milk sampled widely in Great Britain rose during the period April–June 1959 to values which were generally higher (by a factor of the order of 1·5) than the peak-levels during 1958. It has also been noted[5] that the levels of strontium-90 in human bone formed during the early part of 1959 showed a significant increase when

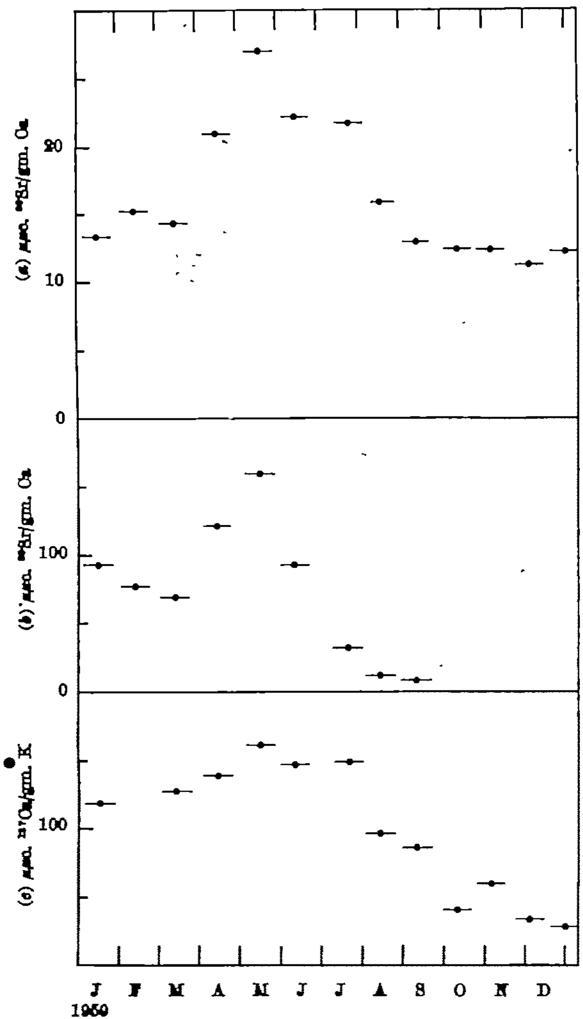


Fig. 1. Levels of fission products in milk from Felinfach, west Cardiganshire, Wales (1959)

compared with earlier levels. We report here the values found for strontium-90, strontium-89 and cæsium-137 in milk samples produced at Felinfach Creamery in west Cardiganshire, Wales, throughout 1959, and we compare these results with those already described for samples of the same series during 1957–58[6,7]. As before, the samples were received at weekly intervals and measurements made on bulked samples, compounded from four consecutive weekly samples. The values obtained for 1959 are shown in Fig. 1.

In our previous report[7], we showed that the average level (15·7 strontium units) of strontium-90 in milk produced at Felinfach during May–August 1958 was 2·2 times the corresponding level (7·0 strontium units) in milk derived from neighbouring pastures (Carmarthen) during May–August 1957 (1 strontium unit = 1 μμc./gm. calcium). A comparison of the average level (21·4 strontium units; Fig. 1) for May–August 1959 with that for the same period of 1958 shows that a further increase occurred in the levels of strontium-90 present in the pastures of this region between 1958 and 1959 (× 1·36).

The 1959 increase of strontium-90 in milk may be due partly to an increased rate of fall-out and partly to an increase in the soil reservoir of strontium-90. The strontium-89/strontium-90 ratios in the milk (from Fig. 1) during the months May–August are on the average 62 per cent of the corresponding ratios in rain falling during the same months[8]. This result is similar to the figure (70 per cent) found for 1958 and it again indicates that a substantial fraction of the activity in the milk was derived from material deposited at or near to the time of milk production. It may be noted that the strontium-89 levels in both milk and rain-water fell sharply over the period May–August 1959 and we have not measured this nuclide in samples collected after that time.

It is useful to compare the 1958 and 1959 rates of fall-out. Estimates of the amount of strontium-90 deposited over the Felinfach–Carmarthen region for successive May–August periods give a 1959/1958 ratio ≃ 0·9 (estimates based on meteorological and fall-out data[1,8]). This fall-out ratio is, in fact, somewhat lower than the corresponding ratio (1·36) for strontium-90 in milk. It should be noted, however, that the deposition of strontium-90 in the region was notably high during April 1959, and the (April–August 1959)/(April–August 1958) fall-out ratio was 1·3. To account for the 1959 increase of strontium-90 in milk, by relating it to an increased fall-out rate, it is therefore necessary to assume that the levels in milk during a given month were influenced by the deposition-rate of the immediately preceding month. This appears to be a reasonable assumption since some integration of activity will occur in the herbage before grazing takes place. In fact, a comparison of the fall-out and milk activity-levels for the open pasture feeding period May–October 1959 indicates that, during this period, the changes which occurred in the milk between any two successive months reflected changes which had occurred in fall-out rate between the two immediately preceding months (Fig. 2).

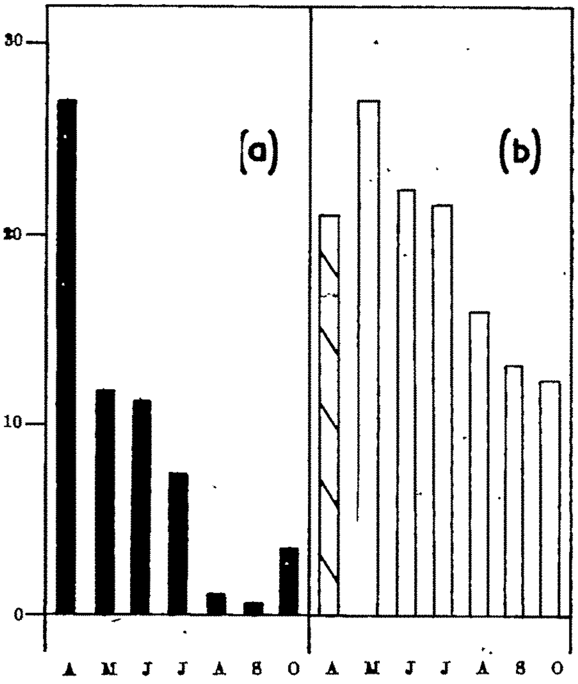


Fig. 2. Comparison of strontium-90 deposition in rain (a, arbitrary units) with levels in milk (b, strontium units) (Felinfach, 1959). The milk-level during April partly reflects the activity present in winter fodder

It is not p
tribution is
strontium-90
teristics of thi
of the activity
from this sou
during periods
activity levels
appears to be
pasture feedin
levels in milk
rate changes.
that up to 5·
mid-1958 mig
accumulated i
responding fig
(based on a co
mid-1959 with
appears that u
tium-90 in mil
ascribed to an
accumulated o

As before[7], t
milk (Fig. 1c)
strontium-90, a
the fall in caesi
nificantly steep
caesium-137 (μμ
May–August 19
corresponding
1958. At the
further (averag
6·5, December =
the case of caesi
derived from the
important than
be noted that
at December 1
lowest value ye
which covers
(max. value =
1959).

The significanc
lies in their bear
trend of fission pr
there is no large-
and that the 196
average, an esti

ine precisely what con-
milk activity from the
ervoir, since the charac-
ticularly the availability
nown. The contribution
comes more important
te of fall-out, and the
relatively low. This
e end of the 1959 open
. 2) when the activity
sensitive to the fall-out
ous report[7], we showed
its in milk sampled at
from the strontium-90
o that time. The cor-
is 8·3 strontium units
mulative deposition at
-1958[1]). From this it
nt of the rise of stron-
58 and 1959 might be
the total strontium-90

sium-137 levels in the
parallel to that for
is some indication that
after May 1959 is sig-
or strontium-90. The
-90 (μμc./l.) ratio for
ewhat lower than the
the same period of
e ratio has decreased
er–November 1959 =
results suggest that in
ction of milk activity
may be relatively less
strontium-90. It may
37 level in the milk
m. potassium) is the
our Felinfach series,
ted during 1956–59
potassium, at May

ents presented above
ognosis of the future
milk. Assuming that
n of weapons testing,
be near (or less than)
current theory[3] of

fall-out mechanisms suggests that the average rate of strontium-90 fall-out during March–August 1960 will be somewhat less than half that during the same period of 1959. Similarly, the total strontium-90 accumulated on the ground in the Felinfach–Carmarthen region at mid-1960 would not be expected to rise to more than 1·2 times the value at mid-1959. On this basis, the figure noted above (8·3 strontium units) as the mid-1959 upper limit for milk activity derived from the total soil reservoir becomes 10·0 strontium units at mid-1960. Likewise, the component which depends on the rate of fall-out is expected to be less than 0·5 × (21·4 – 8·3) strontium units = 6·6 strontium units at mid-1960. This treatment suggests that the mid-1960 strontium-90 level in milk from this region will be less than 16·6 strontium units, that is, less than three quarters of the mid-1959 value. The corresponding figure for caesium-137, based on the caesium-137/strontium-90 ratio (6·5) at the end of the open pasture feeding period of 1959, is 80 μμc./gm. potassium.

It should be noted that the figures presented above refer to levels in milk from a single region and they should not be taken to represent the average values for Britain as a whole. The trend of the strontium-90 levels is, however, broadly consistent with the country-wide picture so far described[4]. In view of the outstanding importance of the contribution from milk to the levels of activity which occur in human bone, the above prediction of a downward trend in milk activity suggests that the future trend of strontium-90 levels in newly formed bone should also be downward.

We are indebted to Prof. W. V. Mayneord, in whose Department the work was carried out, for his constant guidance and encouragement.

[1] Crookes, R. N., Osmond, R. G. D., Owers, M. J., and Fisher, H. M. R., Atomic Energy Research Establishment, Harwell, *R 3094* (1959).

[2] Peirson, D. H., Crookes, R. N., and Fisher, H. M. R., *Nature*, **186**, 224 (1960).

[3] Anderson, W., Bentley, R. E., Burton, L. K., Crookall, J. O., and Greatorex, C. A., *Nature* (in the press).

[4] "Strontium-90 in Milk and Agricultural Materials in the United Kingdom 1958–1959", Agricultural Research Council (H.M. Stationery Office, London, 1960).

[5] Arden, J. W., Bryant, F. J., Henderson, E. H., Lloyd, G. D., and Morton, A. G., Atomic Energy Research Establishment, Harwell, *R 3246* (1960).

[6] Mayneord, W. V., Anderson, W., Bentley, R. E., Burton, L. K., Crookall, J. O., and Trott, N. G., *Nature*, **182**, 1478 (1958).

[7] Anderson, W., Burton, L. K., and Crookall, J. O., *Nature*, **184**, 89 (1959).

OBITUARIES

Pr

PROF. JOHN F.
the son of John F
and was born at S
1899, going later t
M.S. in 1921. He w
had the good for
College, Oxford, w
class honours in
Howard Florey, la
known for his work
time, was extreme
taken in 1932 show
strator in physiolo
and in 1925 had a

ulton

died on May 29, was
dith Stanley Fulton,
ota, on November 1,
graduating there as
Rhodes Scholar and
epted by Magdalen
ated B.A. with first-
the same group as
internationally well
Fulton, at about this
g, as a photograph
a University demon-
Charles Sherrington,
his twenty-seventh

publication in journals. Sir William Osler had died in 1919, but the very wonderful Lady Osler still regarded her home at 13 Norham Gardens, Oxford, as a centre for the young, and she and Lady "Sherrie" were two on whom one never failed to call, usually on Sundays at tea-time, every term. Fulton helped to catalogue "Bibliotheca Osleriana", which was finally published in 1929; but before that, with the M.A. and D.Phil. Oxon. to his credit, he returned for a while to Harvard, where he took his M.D. in 1927. As assistant neurological surgeon at the Peter Bent Brigham Hospital, he worked under the master neuro-surgeon, Harvey Cushing, and he became in succession his pupil, close friend and, later, biographer.

As a Fellow of Magdalen he continued research in neurophysiology during 1928–30, and then in 1931 he was appointed to the Sterling chair of physiology at Yale, where one of his first decisions was to name his new home the 'Laboratory' rather than the 'Department' of Physiology. Many came to him from outside, attracted, as *The Times* obituary notice of him stated, by his breadth of outlook, humanistic approach, and personal example, his own interests being mainly electrophysiological, electro-cardiographic, and endocrinological, with the physiology of aviation becoming an outstanding fourth during the Second World War.

In Oxford he had married Lucia Pickering Wheatland, and in 1956 there was a reception in the History of Medicine Library at Yale to mark his total of twenty-five years of service in the Laboratory of Physiology and in the Department of the History of Medicine. Fulton was given a bound copy of a special issue of the *Yale Journal of Biology and Medicine*, and a silver medal which his friends had inscribed to him as physiologist, teacher and humanist.

In 1959, on his sixtieth birthday, friends met again, this time at his home at Mill Rock, to be presented with copies of "The Making of a Library", in the letters on which it was based being one from Arnold C. Klebs which quoted:

> "Grau ist alle Theorie
> Und grün der goldne Baum des Lebens",

and in which he stated that he believed in loving the old authors when they had something lovable. Wilmarth S. Lewis briefly said that Dr. Fulton alone survived of the three friends (Harvey Cushing, Klebs and Fulton) who brought the Historical Library to Yale, and that November 1, 1959, was a moment of congratulation and thankfulness: of thankfulness for Fulton's restored health, and of congratulation on his being only sixty, with years more of discovery and instruction before him. Elizabeth Thomson, who with Madeline Stanton was responsible for most of the planning of the reception, wrote to me that Mrs. Fulton was meeting guests at the top of the steps looking lovely and giving no hint of the strain of arranging a party of seventy *sub rosa*. However, Fulton found everything a real surprise and he was simply delighted with the book.

For myself I am indebted to him for countless kindnesses over the years, including the period after the First World War, and I am truly sorry that I am not to greet him in person at the tercentenary of the Royal Society, and at the centenary of the National Hospitals for Nervous Diseases. He would, I know, have entered with zest into both occasions.

KENNETH J. FRANKLIN

Dr. S. F. Birch

STANLEY FRANCIS BIRCH was born in November 1899 at Pewsey in Wiltshire, and was educated at Hurstpierpoint College and St. Paul's School, before going to the Imperial College of Science and Technology, whence he graduated. Working with Prof. J. F. Thorpe, he obtained the degree of doctor of philosophy for research work on three-carbon tautomerism, after which he joined the staff of the (then) Anglo Persian Oil Company, with which he was to spend the whole of his working life.

His great interest was in research connected with organic chemistry, and it was in this sphere that, in 1923, he commenced his career. Under Dr. A. E. Dunstan and with a small band of scientists, he worked in a country house at Sunbury-on-Thames; these premises he was to see develop into the Research Centre of the British Petroleum Co., Ltd. An investigation of the malodorous components of the lighter fractions from Persian crude oils led to the identification of mercaptans and from this discovery stemmed a major research effort concerning the nature and properties of sulphur compounds in petroleum, which he continued, with some interruptions, for the next thirty-five years. In this field he was regarded as an authority, and he published numerous scientific papers and gave many lectures both in Britain and the United States. He visited the latter country many times and was well known in many industrial research centres, universities and organizations connected with the American Petroleum Institute and American Chemical Society, of which he was a member.

The study of the reactions of hydrocarbons was, however, a branch of chemistry in which he made signal contributions to the petroleum industry. This work had, as its major achievement, the discovery of the sulphuric acid alkylation process in 1936 which, together with processes resulting from the determination of the octane numbers of pure hydrocarbons, and studies of the fractionation of petroleum distillates, formed the basis of the supply, by the Abadan refinery, of vast quantities of aviation spirit during the Second World War. His researches connected with the reactions of hydrocarbons made him realize, from a very early date, the potentialities of the petroleum chemical industry, and at his death on March 25 he held the position of research associate in the Petroleum Chemicals Department.

Birch believed very strongly that research could only be directed by those in close contact with the practical operations and that most discoveries came about as a result of critical observation and experimental skill. Until the last three years of his career, when administrative duties forced him, reluctantly, to move, he occupied an office situated close to the laboratories and was a frequent visitor to the bench where many informal technical discussions took place. 'Bill', as he was known to his friends, had wide-ranging interests apart from his research work. He was keenly interested in the theatre and ballet and antique works of art, and many of his leisure hours were spent building electronic and other gadgets.

He died on March 25, and is survived by his wife, Hilda Mary, whom he married on June 24, 1925. His many friends will sadly miss the pleasure of his company and the stimulation of his personality.

R. A. DEAN

Dr. J. H. Oliver

ON June 1 James Herbert Oliver died suddenly in Ankara. He had undertaken a visit to Ceylon and India and was returning to Britain by way of Turkey, where, in pursuance of a life-long interest, he was proposing to study native barleys.

Born in Portsmouth in 1901, he was educated at St. John's College, Southsea, and the Municipal College, Portsmouth, and after a period of private study he graduated in 1920. His first post was at the Olympia Agricultural Research Station near Leamington, where he worked under Dr. Herbert Hunter, who was widely known for the production of the brewers' barleys, Spratt Archer and Plumage Archer. It was here that Oliver developed the interest that he followed so assiduously throughout

his life. Re
of the Re
obtained a S
read for a
Science ; he
and rowed fo
In 1924 D
Harman, bre
and three ye
eventually b
the most au
industry in
on the Analy
Convention in
After the S
an interest ir
ticular regar
content, and
Hayling Islan

tsmouth after the closing
at Leamington, Oliver
p and went to London to
the Imperial College of
the full life of the times

d the firm of Briant and
ts in the City of London,
ffered a partnership. He
ed all over the world as
nsultant to the brewing
presented Great Britain
of the European Brewery

Var, Dr. Oliver developed
y of the sea, with par-
phate, nitrate and iron
a private laboratory at
. His researches in this

field led him to the conclusion that coastal mud and sand become an important reservoir for these nutrients, which are distributed during times of storm and gale.

Dr. Oliver was a member of the Salters' Company, honorary hydrologist to the Zoological Society, and a member of the Challenger Society, whose meetings frequently were enlivened by erudite contributions delivered with a refreshing humour. He was a tireless and inventive worker, always striving to improve his apparatus or to increase the accuracy of his results. His energy and enthusiasm were infectious, and he was ever ready to lay aside his own work to help others. Over all his life there pervaded an ebullient and generous personality. He enjoyed life to the full because he had come to terms with it—his terms. He was a gracious and charming friend, and he will be sorely missed by all who had the good fortune to know him.

N. Ingram Hendey

NEWS and VIEWS

New Foreign
the Royal Society :
Prof. G. Beadle

Prof. Geor
membership o
to many. Alre
geneticists, esp
with Ephrussi
became one of
biology when, i
he established
of vital bioche
material. This
Tatum shared
in 1958. There
In fact, the con
synthesis follov
in man, and t
Lawrence on f
work provided
sense that it wa
and, most imp
the biochemical
metabolic proce
could be made
bolites externall
a strong argum
genetics only
organisms and t
changes are inh
techniques cann
result is that it
relation betwee
to-day, and is
developments th
of biological kno
'molecular biolo
Britain and gav
Genetical Society

ecent election to foreign
ociety will give pleasure
name to cytologists and
work on maize and that
lants in *Drosophila*, he
ames in the history of
with Prof. E. L. Tatum,
of studying the genetics
es using *Neurospora* as
for which Beadle and
el Prize for Physiology
hemical genetics before.
controlled biochemical
m the work of Garrod
e, Scott-Moncrieff and
But the *Neurospora*
material, both in the
y and quickly handled,
it permitted study of
es that affect the vital
ms, for the deficiencies
ing appropriate meta-
incidentally, provides
se who maintain that
nificant variation of
mportant evolutionary
way that Mendelian
But its important
he knowledge of the
roteins that we have
stor of the exciting
forefront of progress
e coming to be called
adle was recently in
endel Lecture of the

Prof. Ragnar Granit

Prof. Ragnar
the Nobel Institut
Caroline Institute
he worked in Sir
Oxford, and it a

fessor and director of
ysiology at the Royal
Earlier in his career
ngton's laboratory in
iate, and a measure

of the great honour in which he is held by physiologists, that he should have been chosen in 1954 to deliver the Silliman Memorial Lectures, exactly fifty years after the delivery by Sherrington of the classical series published as "The Integrative Action of the Nervous System". Granit's researches in sensory physiology have explored the relationship between sense organs and the nerve centres into which they send signals, and which, in turn, exercise centrifugal control over receptor sensitivity. In 1947 he published an important book, "Sensory Mechanisms of the Retina". The retina offered him a central nervous structure, uniquely accessible to stimulation by the natural and selective agency, in which the interplay of excitation and inhibition could be studied. More recently, he has found that the sensitivity of the retina can be modified by signals sent out to it from the brain. Newer work in his laboratory has extended his general approach to sensory problems to the special case of muscle receptors. This work has shown that these receptors are under the control of the central nervous system, and that such control can drive the motor nerve cells of the spinal cord servo-fashion over the muscle reflex arcs. The bold conception of a balance between direct control and servo-control of muscle is a typical product of Granit's imaginative insight, and is likely to stimulate research into the physiology of posture and movement for many years to come.

Prof. G. B. Kistiakowsky

The announcement of the election of Prof. G. B. Kistiakowsky as a foreign member of the Royal Society will have given great pleasure to physical chemists everywhere and especially to those interested in reaction kinetics. He was born and received his school education in Kiev, but his lifelong interests were probably shaped during his research student days in Berlin which, in the 1920's, was surely the world centre of the maturing science of physical chemistry and which has been the seminary of so many distinguished workers in this field. In 1926, Dr. Kistiakowsky went to Princeton and in 1930 he migrated to Harvard. From his pen have come numerous accounts of investigations which have always been marked by an elegance in conception, execution and interpretation which is unmistakably his. He gave resonance quantitative significance by his measurements of heats of hydrogenation of unsaturated compounds; with Gomer, he was the first to measure the rate of combination of methyl radicals; he has developed methods for studying very fast reactions and, latterly, by his studies of the reactivity of photochemically produced methylene-type radicals, directed attention to fundamental problems of rate-theory. Light, spectrometers, shock tubes, mass-spectrometers and explosives—the tyrants of many chemists—have been his slaves. He has also been a great public servant in the United States in war and in peace, which fact has been recognized by many awards and has culminated in his present appointment as scientific adviser to President Eisenhower. These are but a few of his accomplishments, to which one must add his consummate skill in making quartz spiral gauges, as a skier, and raconteur, which, with his vivacity and friendliness, have made him so warmly regarded by students and colleagues from the United States and overseas.

Academician L. D. Landau

ACADEMICIAN L. D. LANDAU, who has been elected to foreign membership of the Royal Society, is a theoretical physicist with interests in all basic problems of physics regardless of the particular special field in which they arrive. His best-known work includes the theory of the diamagnetism of free electrons, the theory of transitions in atomic collisions, liquid helium, the divergence problems in quantum field theory. He has inspired and trained many distinguished pupils, and the series of text-books on theoretical physics written by him with E. M. Lifshitz on the basis of his lecture courses have had a profound influence on teaching in the U.S.S.R. He approaches physics with a very personal style, as impatient of pedantic purism as of slipshod physical argument. After working in Leningrad and Kharkov, he has now for many years held a professorship at the Institute of Physical Problems in Moscow.

Marshall Chair of the Physiology of Reproduction, Cambridge: Dr. A. S. Parkes, C.B.E., F.R.S.

DR. A. S. PARKES, whose appointment to the newly established Marshall chair of the physiology of reproduction in the University of Cambridge has recently been announced, has worked for nearly thirty years in the National Institute for Medical Research, where he is head of the Division of Experimental Biology. Before joining the scientific staff of the Medical Research Council, Dr. Parkes had held a Beit Memorial Fellowship and a Royal Society Foulerton Studentship, and he had, at an early age, established himself as a leading investigator of the physiology of reproduction. His first interest was in ovarian function, knowledge of which was much advanced by his work; in later researches he contributed to most aspects of the physiology of sex hormones. In recent years he has paid much attention to the effects of cold on cells, tissues and the whole animal and, in collaboration particularly with Dr. Audrey Smith and Dr. C. Polge, he has made remarkable observations in this branch of biology. Dr. Parkes has always been alive to the practical applications of his researches; to him is due the method of administration of steroid hormones by tablet implantation, and the work on hypothermia has led to important developments in the storage of erythrocytes, of spermatozoa and of tissues for grafting. Apart from his laboratory researches, Dr. Parkes is keenly interested in world population problems. It is indeed appropriate that he should be the first to occupy a chair that bears the name of his former teacher, and which will give him the opportunity to develop a university department devoted to an important branch of physiology.

Educational Co-operation in the Commonwealth

IN a written answer to a question in the House of Commons on June 24, Mr. R. Thompson, replying for the Minister of State for Commonwealth Relations regarding progress with plans for the award of scholarships under the Commonwealth Scholarship and Fellowship Plan, gave the following information from the Association of Universities of the British Commonwealth. Canada proposes to make ten scholarships tenable from October 1960 and twenty nominations from the United Kingdom have been requested. Offers of scholarships, tenable from March 1961, for study in Australia have now been made of Commonwealth countries and twenty-five nominations requested from the United Kingdom. New Zealand has announced the offer to other Commonwealth countries of twenty-six scholarships and fellowships tenable at any one time and up to five nominations for scholarships tenable from March 1961 have been requested from the United Kingdom. India has announced the offer of forty-five scholarships and fellowships to various countries of the Commonwealth, and the Federation of Malaya has offered postgraduate awards to more than ten Commonwealth countries, including the United Kingdom, tenable from May 1961. The Federation of Rhodesia and Nyasaland is offering about five postgraduate scholarships, visiting fellowships and mature awards tenable from January 1961, and the East African Governments have offered two scholarships, tenable at Makerere College, for which nominations have been requested from the United Kingdom. Pakistan, Ghana and Ceylon also announced offers of scholarships at the Commonwealth Education Conference, but no details are yet available. South Africa had offered a total of twenty scholarships tenable at any one time and five nominations from the United Kingdom had been requested. The Association of Universities of the British Commonwealth proposes to publish a full report of the work done under the Plan at the end of the first year of operation.

Advisory Committee on Nuclear Safety

AN Advisory Committee on Nuclear Safety has been appointed "To advise the Minister of Power and the Secretary of State for Scotland on any matters affecting the functions of those Ministers in relation to safety under the Nuclear Installations (Licensing and Insurance) Act, 1959, which may be referred to them by either of those Ministers or which in the Committee's opinion ought to be brought to the notice of either Minister, apart from any such reference". Its membership is as follows: Sir Alexander Fleck (*chairman*); Dr. T. E. Allibone, director of the Associated Electrical Industries Research Laboratory, Aldermaston; Mr. G. F. Bullock, general manager, Vulcan Boiler and General Insurance Co., Ltd., Manchester; Sir John Cockcroft, Master of Churchill College, Cambridge; Mr. Patrick Connor, Scottish Divisional Officer of the Amalgamated Engineering Union; Dr. S. C.

Curran, prin
Technology,
natural phil
Diamond, pr
ersity of Mar
aging direct
ment and E
Harris, profe
Mr. F. Hayt
General and
General Cour
search and Ec
(Manchester),
H.M. chief ii
J. M. Kay,
College of Sc
London ; Dr.
Research Cor
Harwell ; Mr.
tor of Factori
and Safety B
George McNa
of Housing a
Newell, manag
tries, Ltd., Wi
Mr. H. N. P
Register ; Col
Atomic Power
ham, member
Generating Bo
Research Coun
Atomic Energy

Agricultural P

THE Nation
Research Coun
Committee to
chemical contr
tion of America
of the Commit
Division of Biol
of several step
Council during
concern expres
chemicals to con
of the Committ
assistant to the
consin (chairma
of the Wildlife I
Gill, executive d
Forestry Foun
managing direct
Prof. E. C. You
of the graduate
G. C. Decker, er
Survey. Dr. W
Research Counc
tary of the Com

The Royal Anth

THE following
general meeting
stitute of Great
Memorial Medal
director of the B
Lister Institute ;
that can be made
awarded annually
since 1900 ; *The*
pological field wo
sity College of S

oyal College of Science and
of. P. I. Dee, professor of
rsity of Glasgow ; Prof. J.
hanical engineering, Univ-
P. T. Fletcher, deputy man-
ergy Authority, Develop-
oup, Risley ; Prof. J. E.
y, University of Bristol ;
of the National Union of
orkers and of the T.U.C.
s Jackson, director of Re-
iated Electrical Industries
r-General S. W. Joslin,
clear installations ; Prof.
nuclear power, Imperial
chnology, University of
, director of the Medical
ological Research Unit,
ough, H.M. Chief Inspec-
McLean, director, Health
Energy Authority ; Sir
chief engineer, Ministry
vernment ; Mr. R. E.
mperial Chemical Indus-
iddlesbrough, Yorkshire ;
ef surveyor to Lloyd's
by, managing director of
, Ltd. ; Mr. L. Rother-
f the Central Electricity
iam Slater, Agricultural
. Vick, deputy director,
tablishment, Harwell.

d Wild-life

of Sciences–National
ced the formation of a
e relationship between
ral pests and conserva-
ulations. The creation
ll function within the
lture, is the most recent
he Academy–Research
years in response to
quarters over use of
al pests. The members
ra L. Baldwin, special
he University of Wis-
. Gabrielson, president
nstitute ; Dr. Tom H.
Charles Lathrop Pack
George L. McNew,
Thompson Institute ;
f economics and dean
University ; and Dr.
linois Natural History
r, of the Academy–
s the executive secre-

stitute : Awards

made at the annual
Anthropological In-
reland : *The Huxley*
Dr. A. E. Mourant,
eference Laboratory,
s the highest award
ologist, and has been
ncil of the Institute
al Medal, for anthro-
C. Mitchell (Univer-
ern Rhodesia) ; the

Wellcome Medal of the Institute for 1959, jointly to Mrs. E. M. Chilver, director of the Institute of Commonwealth Studies, Oxford, and Dr. P. Kaberry (University College, London).

At the same meeting officers of the Institute for the session 1960–61 were elected as follows : *President*, Dr. Audrey I. Richards; *Vice-Presidents*, Dr. G. Caton Thompson, Prof. M. Fortes, Mr. I. M. Sieff ; *Honorary Secretary*, Dr. Marian W. Smith ; *Honorary Treasurer*, Sir George Beresford-Stooke ; and *Honorary Editors*, Mr. G. W. B. Huntingford and Mr. W. B. Fagg.

Zebra : a New Zero Energy Reactor

THE United Kingdom Atomic Energy Authority has decided to build a zero energy fast reactor at the Atomic Energy Establishment, Winfrith. The reactor has been named *Zebra* (zero energy breeder reactor assembly). The reactor has been designed to permit the study of the neutron physics of a wide variety of fuel assemblies containing uranium and plutonium. The assemblies under study will be built up by loading fuel elements into a steel matrix (approximately a cube of side 10 ft.). The fuel elements contain both fuel plates and plates of neutron-absorbing material : the latter will be used to simulate the nuclear properties of the coolant and structure material which would be required in a power reactor. *Zebra* will be operated at room temperature and the heat output from the nuclear reactions in the core will be kept very low so that no cooling system is necessary. It is planned to commission the zero energy reactor during 1962. *Zebra* will be used to obtain information that will be needed for the design of a prototype which is likely to be the next step in the development of the fast reactor by the Authority. The work at Winfrith will complement that carried out at the Dounreay Experimental Reactor Establishment.

The Diploma in Mathematics

THE Mathematical Association has now set up an Examinations Board to award a Diploma in Mathematics (Dip. Maths.). The printed regulations are to be available in the early autumn of this year, and it is expected that the first examination will be held at local centres in the British Isles in November 1961. The Diploma is intended for teachers who have not had the opportunity of reading for a degree which includes mathematics. Considerable interest in the proposal has been shown by the teacher-training colleges, the students of which might take the examination soon after completing their three-year course if they have taken mathematics as a special subject. Many of the technical colleges contemplate establishing part-time courses designed as a preparation for this Diploma.

A draft syllabus is now available from the Secretary of the Association at 29 Gordon Square, W.C.1. The examination will consist of four papers covering three separate schemes of work, and candidates will be required to pass in all sections, though reference on one occasion will be allowed in any one section. The first two papers are in pure mathematics, and these will form the core of the Diploma. The standard expected is that which might be reached by about a year of full-time study beyond the Advanced Level of the General Certificate of Education. The second section deals with mechanics and statistics. In this part, bearing in mind the special needs of women students, many of whom do none of this work at school, the standard will lie part-way between Ordinary and Advanced Level. It is regarded as essential that anyone teaching mathematics at any stage should have some competence in this part of the work. An interesting (and perhaps controversial) section is the third, which deals with the history and ideas of mathematics. Detailed history will not be required, but candidates will be expected to have a clear understanding of the origin and development of the various subjects and topics up to the end of the seventeenth century, with some awareness of subsequent developments. The purpose of the paper is to ensure that teachers will be able to illustrate and enliven their lessons by passing comment, or even by digression, about the great names and the fruitful periods in the subject. This could ensure that mathematics lessons of the future would cease to be, what they so often are to-day, a sequence of mechanical processes.

Radio and Electronics Engineering

THE Education Committee of the British Institution of Radio Engineers has prepared a report on the education and training of the professional radio and electronics engineer (Pp. ii+31. London: British Institution of Radio Engineers, 1960). The report defines the field of radio and electronics, and considers the qualifications required for professional competence in this field. After a brief reference to the Institution's own examination, the relevant educational facilities in universities, colleges of advanced technology and technical colleges are reviewed in some detail. Consideration is given to the radio and electronics content of university degree courses in physics and electrical engineering, in diploma in technology courses in applied physics and electrical engineering, and in courses for higher national diplomas and higher national certificates with endorsements. Reference is made to postgraduate work in radio and electronics in universities and colleges of advanced technology. Various forms of practical training are reviewed, and the report concludes with a group of general recommendations. It is advocated that there should be increased emphasis on radio and electronics in electrical engineering and in physics courses, and that there should be more new courses specifically designed to qualify for work in the radio and electronics field. There is an extensive bibliography followed by an appendix dealing with the training of technicians and craftsmen, and one compiling information about the proportion of radio and electronics work in existing courses. Two charts are given illustrating the scope of radio and electronics engineering, and the entrance requirements and basic structure of the main educational routes leading to professional, technician and craft qualifications.

The Royal College of Science and Technology, Glasgow

THE annual report on the one hundred and sixty-third session (1958–59) of the Royal College of Science and Technology, Glasgow, includes lists of titles of theses approved for the award of the degree of Ph.D., Glasgow, as well as those approved for the Post-graduate Diploma and for the Associateship of the College (Pp. 64. Glasgow: Royal College of Science and Technology, 1959). There is a further list of recent publications by members of the College, and brief reports from departments and the Glasgow School of Architecture refer to industrial reports prepared during the year by the Department of Civil, Mechanical and Chemical Engineering for the British Shipbuilding Research Association on natural circulation and heat transfer in water-tube boilers, and on the corrosion of water-cooled pistons, for the Cold Rolled Sections Association on the gusset plate strength of two-member in-line welded joints, and the collapse strength of uniformly compressed plates, and for the Motherwell Bridge and Engineering Co., Ltd., on a load-test of the Goliath crane at Hunstanton Nuclear Power Station.

Cancer of the Lung

THIS report has been issued of a study-group of experts from seven countries which met in Geneva during November 1959 to review existing knowledge of the ætiology of cancer of the lung and to suggest ways of improving it (Technical Report Series, No. 192: Epidemiology of Cancer of the Lung—Report of a Study Group. Pp. 13. Geneva: World Health Organization, 1960. 1 Swiss franc; 1*s.* 9*d.*; 0.30 dollar). The role of cigarette smoking in the causation of cancer of the lung, and of other factors such as air pollution, specific industrial causes, ionizing radiations, chronic pulmonary disease, and heredity were discussed. The study-group outlined a series of special studies designed to provide epidemiological information that will help explain the great increase in the incidence of cancer of the lung in some countries and furnish a basis for its control. They include studies of the reasons for geographical differences in the incidence of, and in mortality from, cancer of the lung; of its relative incidence in areas where the special histological classification suggested by Prof. L. Kreyberg, of Oslo, can be used; and of morbidity in countries where reliable statistics are not available. The study-group also made suggestions about the identification and intensive investigation of groups of people either exposed to an excessive degree or scarcely exposed at all to specific factors thought to have an influence on the disease, about the simultaneous study of multiple factors, and about genetic and experimental studies.

Collected Papers of the Rowett Research Institute

As in recent years, the "Summary" and "Subject Reviews", which are part of the annual volume, "The Collected Papers of the Rowett Research Institute", have been published separately and can be obtained from the Librarian, Reid Library, The Rowett Research Institute, Bucksburn, Aberdeen (5*s.*, post paid). This booklet gives a most useful and readable survey of the work of the Institute as embodied in the papers published during the academic year 1958–59. Some of the problems tackled and the results obtained are of practical importance to the agricultural industry, but many others bear on basic scientific issues, and so this summary should be of great use to a wide variety of scientists and agriculturists. Full references to all the papers published in the period are given. Many readers will find their appetites whetted for further information, and will be glad to learn that a limited number of reprints of the various papers are available for free distribution and particular ones may be obtained on application. The commendable practice has been continued of publishing two reviews on special topics in which work has been going on in the Institute for a number of years. On this occasion, the reviews are by Dr. G. A. Garton, on "Lipid Research at the Rowett Institute, 1951–59", and by Dr. G. A. Lodge, on "Experiments on the Nutrition of Sows". Both these reviews are

worthy succ
volumes of t

Scientific Re

UNDER the
Agency of th
Co-operation,
arrangements
into road saf
Laboratory,
July 12–15 in
of road resear
includes discu
responsibility
countries, po
means of ma
especially to
national basis
whether any r
tion are necess
from Austria,
Italy, the Ne
Switzerland, t
States; the U
two representa

The Advisory and Develop

THE Advisor
and Developm
Organization a
meetings for th
Combustion an
Propulsion Te
8–12, a seminar
the Istituto Lo
pulsion for Astr
October 1, Stru
tures and Mater
Dynamics Panel
(Istanbul); Oct
"Manned Ballist
(Istanbul); Oct
"Clinical Probl
"Space Flight P
Avionics Panel,
general assembly
nautical Researc
in Istanbul durin
can be obtained
Varenne, Paris V

Caroline Haslet Engineers

THE General
Memorial Trust
to two British w
study the trainin
women engineers i
to be made by th
been made to M
is head of the Mag
Research Laborat
lade, who is senio
Control Instrumen

The Electronic E

UNDER joint or
Council (London)
Association, the sc

se published in earlier
Papers".

oad Safety

ie European Productivity
for European Economic
onal meeting to discuss
ion in scientific research
ld at the Road Research
Langley, Bucks, during
illiam Glanville, director
. The provisional agenda
ogress of, as well as the
ty research in various
searches, and the best
the results of research,
workers, on an inter-
ll be asked to consider
nts for closer collabora-
s are expected to attend
nmark, France, Greece,
rway, Spain, Sweden,
gdom and the United
delegation will include
dical Research Council.

Aeronautical Research

Aeronautical Research
orth Atlantic Treaty
following schedule of
f 1960: August 24–26,
Panel on "Advanced
sadena); September
red by the Group and
enze e Lettere, "Pro-
enna); September 26–
terials Panel, "Struc-
; October 3–4, Fluid
ses of Wind Tunnels"
ght Mechanics Panel,
ons Systems Testing"
space Medical Panel,
tion Medicine" and
nbul); October 3–8,
(Istanbul). The tenth
ory Group for Aero-
ment will take place
Further information
D–NATO, 64 rue de

wards for Women

he Caroline Haslett
travelling exhibitions
s to enable them to
nt and prospects of
The awards, the first
on of the Trust, have
er, who at present
Section of the A.E.I.
, and Miss R. Wins-
r with Research and

sociation: Awards

the Radio Industry
ctronic Engineering
ing annual premiums

for articles on electronics now reaches its tenth year. Articles published during 1960 will be considered by the panel of judges early in the New Year, and six premiums of 25 guineas will be awarded. Further information can be obtained from the Electronic Engineering Association, 11 Green Street, London, W.1, to which also eligible articles should be submitted before the end of the year.

U.S. Record of Published Books

A NEW *American Book Publishing Record* is now being issued which collects all entries listed in the *Publishers' Weekly* during the previous calendar month and arranged according to the Dewey Decimal Classification; a combined author and title index is included (Vol. 1, No. 2, for the month ending March 1, 1960. Pp. 96. Subscription: 11 dollars for 12 monthly issues (U.S.A. 10 dollars). New York: R. R. Bowker Company, 1960). Books are defined as non-periodical publications of 49 pages or more, and books on all subjects are included as well as those printed abroad, but 'published' in the United States in the sense of being offered for sale there through a single designated agent.

Bibliography of British Journals and Newspapers

MR. F. ATKINSON, of the Hampstead Public Library, has prepared an admirable bibliography covering, as Mr. F. Williams points out in an introduction, every book of substance dealing with English newspapers and journalism during the most expansive period in their history (Library Association. Special Subject List No. 32: The English Newspaper since 1900. Pp. 31. London: Library Association, 1960). Nearly 400 entries are classified under a dozen headings, of which biography includes most (109), and no aspect of the Press is left uncovered.

Cytology and Cell Culture Genetics of Man

"A SYMPOSIUM on Cytology and Cell Culture Genetics of Man" has been published by the *Amer. J. Human Genetics* with the aid of funds from the National Institutes of Health, Public Health Service, U.S. Department of Health, Education and Welfare. Reprints may be obtained on request from Dr. Gordon Allen, Building 10, Room 2*N*208, National Institutes of Health, Bethesda 14, Maryland. The symposium is 42 pages in length and contains the following papers, originally presented in Pennsylvania on September 2, 1959: "The Chromosome Complements of Human Somatic Cells", by E. H. Y. Chu; "Human Cytogenetics: Its Present Place and Future Possibilities", by C. E. Ford; "Sexual Dimorphism in Interphase Nuclei", by M. L. Barr; "Some Systems for the Genetic Analysis of Mammalian Cells", by L. Sachs and M. Krim; and "Cell Cultures for Human Genetic Studies", by M. Fraccaro.

Royal Commission Awards for the Exhibition of 1851

THE following awards for 1960 have been announced. *Senior Studentships*: B. Brummer (Imperial College of Science and Technology), for research in physical chemistry at the Imperial College of Science and Technology; M. J. M. Leask (University of Oxford), for research in physics at Oxford; S. K. Malhotra (University of Oxford), for research in zoology at Oxford; D. J. Williams (University of Sheffield), for research in theoretical chemistry at Oxford. The Senior Studentships are of the value of

£800–£900 a year and tenable ordinarily for two years. *Overseas Scholarships :* M. H. Jericho (Dalhousie University), for research in physics at Cambridge; P. S. Simony (McMaster University), for research in geology at the Imperial College of Science and Technology; A. G. Moritz (University of Adelaide), for research in physical organic chemistry at Cambridge; D. St. C. Black (University of Sydney), for research in organic chemistry at Cambridge; G. D. Jones (University of Canterbury, New Zealand), for research in physics at Oxford; P. J. Herley (Rhodes University, Grahamstown), for research in physics at Cambridge; T. J. B. Webb (Trinity College, Dublin), for research in biochemistry at Cambridge; A. J. Walton (Trinity College, Dublin), for research in physics at Cambridge; P. S. Sarin (Delhi), for research in organic chemistry at Cambridge; A. Q. Sarker (Rajshahi), for research in theoretical physics at Birmingham. The Overseas Scholarships are of the value of £550–£650 a year and tenable for two or three years.

University News : Belfast

Dr. D. W. R. Mackenzie has been appointed to a lectureship in microbiology.

Birmingham

Dr. Stanley Mandelstam, at present assistant research physicist in the Department of Physics of the University of California, has been appointed to the newly established chair of mathematical physics within the Department of Mathematical Physics from October 1. Appointments to lectureships and research fellowships are as follows. *Lectureships :* Dr. R. W. Whitworth and Dr. A. B. Robbins (physics); Dr. J. R. Majer (chemistry); Dr. F. W. J. Teale and Dr. D. G. Walker (biochemistry); Dr. E. H. Creaser (microbiology); Dr. D. F. Gibbons (physical metallurgy). *Research fellowships :* A. H. M. Hoare (pure mathematics); J. S. Lilley (physics); B. Cockayne (physical metallurgy); E. N. Corlett (senior research fellow in the Department of Engineering Production).

Cardiff

Dr. S. P. Hutton, at present deputy director of the National Engineering Laboratory, East Kilbride, Glasgow, has been appointed professor of mechanical engineering.

Liverpool

The following appointments are announced. *Readerships :* R. L. Plackett (mathematical statistics); A. C. Shuttleworth (veterinary surgery); Dr. C. L. Smith (zoology). *Senior lectureships :* Dr. A. S. Aldred (electric power engineering); Dr. A. Bolton (civil engineering); Dr. H. W. Douglas and Dr. T. B. Grimley (inorganic and physical chemistry); Dr. V. H. Heywood (botany); Dr. J. F. Norbury (fluid mechanics); Dr. T. G. Richards (physiology); Dr. I. C. Geddes (anæsthesia); Dr. J. S. Scott (obstetrics and gynæcology).

London

The following appointments to readerships are announced: Dr. P. G. Saffman (mathematics, tenable at King's College); Dr. D. V. Ager (geology, tenable at the Imperial College of Science and Technology); Dr. M. Shepherd (psychiatry, tenable at the Institute of Psychiatry).

Oxford

Appointments to lectureships are as follows: D. F. W. Baden-Powell (prehistoric archæology); Dr. M. J. Kearsley (mathematics); Dr. H. R. Harré (philosophy of science).

Swansea

The following appointments to lectureships have been made for the session 1960–61: Mr. I. G. Evans (pure mathematics); Dr. H. T. Miles (physics); Dr. J. A. Schofield (organic chemistry). Dr. S. K. Zaremba has been appointed senior lecturer in pure mathematics.

Announcements

It has been announced that Prof. Adolf Butenandt (Munich), president of the Max-Planck Society, has been elected an honorary member of the Leopoldina German Academy of Science.

Dr. P. C. Spensley, a temporary assistant director of the Tropical Products Institute, has been appointed acting director of the Institute, until Mr. E. S. Hiscocks takes up duty towards the end of the year.

The Science Museum, South Kensington, has recently brought into operation a star-projector to demonstrate the daily motion of the stars and their appearance at different parts of the world and at different times of the year. The stars are projected on the inside surface of a hemispherical plaster dome 20 ft. in diameter. Demonstrations are given once daily, from Monday to Friday only.

The ninety-seventh meeting of the British Pharmaceutical Conference will be held in Newcastle during September 5–9. Further information can be obtained from W. K. Fitch, British Pharmaceutical Conference, 17 Bloomsbury Square, London, W.C.1.

The tenth Canadian High Polymer Forum will be held at the Alpine Inn, Ste. Marguerite, Quebec, during September 7–9. The Forum is sponsored by the National Research Council of Canada in co-operation with the Chemical Institute of Canada. Further information can be obtained from Dr. D. A. I. Goring, Canadian High Polymer Forum, Pulp and Paper Research Institute, McGill University, Montreal, Quebec.

The first International Symposium on "Cori's Ester and Phosphorylated Glucides" will be held during September 13–18 at the Museum of Science and Technology, Milan. Further information can be obtained from the Comitato Organizzatore del 1° Symposium Internazionale sull estere di Cori e sui glucidi fosforilati, Via Modica 6, Milano.

The Department of Scientific and Industrial Research is organizing a conference on "Ergonomics in Industry" during September 27–29 at the Connaught Rooms, Great Queen Street, London, W.C.2. Further information can be obtained from Miss H. M. Clay, Department of Scientific and Industrial Research, 14–18 Cornwall Terrace, Regent's Park, London, N.W.1.

Erratum. It is regretted that an announcement referring to the seventeenth International Congress of Pure and Applied Chemistry to be held in Munich during August 26–29 was inadvertently inserted in the July 2 issue of *Nature*. The announcement is incorrect.

DE T OF SCIENTIFIC AND INDUSTRIAL RESEARCH

RETURNS FOR 1959

THE repc
Industria
general theme
issue (p. 89), r
compared wit
£8,894,820 by
other sources £
was from o
£625,708 from
by the Natic
increase on 1
students amo
research stude
928 (including
advanced cour
these 251 were
fellowships, inc

Of the resear
biochemistry, I
lurgy, 753 in c
other engineeri
sciences, 190 i
The advanced c
distributed by
engineering, 37
logy and in ch
physics (14), f
chemistry (11)
ships.

Grants for sp
247 were new,
ended March 31,
77 in chemistry
mathematics, 16
work and inves
physics, 69 (tota
59 in technology
the individual g
£400,000 to the i
years from Aug
University of Liv
grants included
3–5 years from M
in the Universit
metals; £97,000
College of Scien-

uncil for Scientific and
or the year 1959, the
iscussed elsewhere in this
penditure of £10,059,376,
n 1958, and reduced to
ipts from industry and
dered, of which £405,514
ient departments and
,468 in all being received
Laboratory: the net
£536,907. Grants to
9,818, the number of
; being 2,144, of whom
TO awards) were new;
s numbered 271, and of
39 of the 49 research
TO awards.
254 were in biology and
. engineering and metal-
in electrical and 138 in
ilogy, 30 in the human
s and 431 in physics.
ships were fairly evenly
45 in physics, 44 in
es and 35 each in geo-
ering and metallurgy;
biochemistry (13) and
of the research fellow-

s totalled 390, of which
£3,542,861 in the year
hese 63 were in biology,
y and geophysics, 4 in
. 35 in low-temperature
the solid state, 20 in
38) in nuclear physics,
e human sciences. Of
the largest is that of
V. B. Skinner for three
for research at the
energy physics; other
of. A. B. Pippard for
a magnetic laboratory
lge for the study of
Butler, at the Imperial
ology, London, for 2

years from October 1, 1959, for equipment for the analysis of bubble-chamber films; £75,000 to Prof. R. Hanbury-Brown at the University of Manchester for 2½ years from January 1, 1960, for a new type of photoelectric stellar interferometer, and £60,820 over 3 years from April 1, 1960, to Prof. A. C. B. Lovell for research with the 250-ft. steerable radio telescope and another £52,000 over 4 years for its maintenance.

With the exception of fire research, expenditure on which decreased to £29,743 from £37,174 in 1958, hydraulics research (£90,768; £100,650 in 1958), water pollution research (£100,586 from £103,882) and, surprisingly, road research, which decreased by £25,751 to £535,062 (compared with £441,762 in 1957) although work on traffic safety problems has notably expanded, the net expenditure on all branches of the Department's work increased in 1959, though that on food investigation (£326,908), forest products (£139,965), Geological Survey and Museum (£338,404) and pest infestation (£95,642) was practically unchanged. The biggest increases were in headquarters administration, etc. (£436,190 from £377,905); National Physical Laboratory (£801,550 from £737,950); National Engineering Research Laboratory, £606,055 compared with £507,104 in mechanical engineering research in 1958. Expenditure on radio research was £193,681 compared with £159,398 in 1958, and, on the new Warren Spring Laboratory, which appears for the first time in the summary of expenditure, £397,413.

Annual grants to research associations amounted to £1,683,195 (£1,700,330 in 1958) and special grants to £88,570; contributions to European nuclear research remained at £1,100,000 and expenditure on headquarters overseas liaison increased from £85,583 to £92,137.

The report records an increase in staff of the Department to 5,506; but although net recruitment over the year was satisfactory, difficulties in recruiting certain categories of staff continued. The number of research associations has now reached fifty, and at the request of the Board of Trade and the Federation of British Industries, the service of technical digests has been restarted. The Overseas Liaison Division was merged with the Headquarters Information Division at the end of the year.

TH . COLLEGE OF SURGEONS OF ENGLAND

NEW LABORATORY BUILDING

IN order to unde
College of Surg
was formally op
reference must b
building which w
completed in 196

Rebuilding star
the site, where t
Museum formerly
of the Great Hall,

portance to the Royal
boratory block which
end of March, brief
e programme of re-
1952 and may be

th-eastern portion of
rt of the Hunterian
first phase consisted
rs of museums above

it. The second phase is the Nuffield College of Surgical Sciences, a residence for eighty postgraduate students, which faces Lincoln's Inn Fields immediately to the east of the old College buildings and to the north of the new phase I block.

The buildings recently opened lie behind the old College and are the westward continuation of phase I, the floor-levels corresponding exactly except that there is a fifth story in the new block, which accommodates the animal house. In general terms, it may be said that phase I is primarily a museum block, whereas the new building (phase IIIa) contains research laboratories and lecture and demonstration rooms.

The fourth floor is occupied by the Department of Anatomy, with a fine Dissecting Room at the western end and a Prosector's Room leading from it, in which anatomical teaching material is prepared. Running east from the Dissecting Room there is a corridor flanked by staff offices and research rooms where work is being done on the anatomy of conjoined twins, the nerve endings in the larynx, and in preparing material for electron microscopy. Research in this field is concerned with the structure of the nuclear cytoplasmic interface in normal and neoplastic cells; the electron microscopy of human gastric mucous membrane in relation to exfoliative cytology; and the electron microscopic changes produced in the prostatic epithelium of mice by hormonal stimulation.

At the western end of each story there is a large room, the size of the Dissecting Room, that on the third floor being used by the Departments of Physiology and Pharmacology as a demonstration room, with benches for experimental work. The research rooms on this floor belong to the Department of Ophthalmology, in which work is being done on the clinical applications of antibiotics in ophthalmology, with special reference at the moment to the possible exploitation of interferon in virus diseases of the eye; on the distribution and nature of refractive errors, especially on the optical components during growth; and on blindness, including both statistical and experimental studies. It has been established that the general pattern of retinal metabolism conforms to that of the brain, and work is being planned to seek for possible biochemical defects in the retina of rats and mice affected with hereditary degeneration of the retina.

It has been shown that sodium iodate, sodium fluoride, and a group of phenoxyalkanes can produce degeneration of the retina in the rabbit. Cysteine has been found to be effective in preventing the experimental degeneration induced by iodate and by iodoacetate, but is apparently ineffective against the phenoxyalkanes and fluoride. Work is proceeding to seek for other protective substances against both the experimentally induced lesion and spontaneously occurring blindness.

On the second floor of phase I is the main Museum of Pathology and some research rooms for the professor and his lecturers. This Department has now been able to extend into the new building, having a demonstration room at the west end and more laboratories in which at present work is being done on tissue culture and X-ray microscopy. The tissue culture work is designed to study the distribution of adenoviruses in the tonsils of normal persons in relation to age, and the incidence of virus infections of the lung. Organ culture is being carried out to assist the research already going on in the Department into lung cancer.

X-ray microscopy is being used to explore the possibilities of the method for elucidating the structure and constitution of cells and connective tissue, and to confirm by physical means some of the results obtained by histochemical techniques.

The first floor houses the Department of Dental Science, having the Odontological Museum at its western end. The research work of the Department is directed towards exploring the aetiology of pyorrhoea and dental caries. A morphological peculiarity of the interdental septum has been demonstrated whereby a trivial aberration of tooth eruption is liable to initiate a chronic ulcer between the teeth which progresses in some cases to the establishment of a pyorrhoea pocket.

On the biochemical side, research is proceeding into the amino-acid composition of enamel protein, and it has been shown that this protein is quite different from other skin keratins; and on the bacteriological side, a special study is being made of the organisms capable of living on enamel proteins.

A third problem engaging the attention of the Department is the determination of the earliest reaction of bone to metastatic deposits of carcinoma; and a study is also being made of salivary gland metabolism using radioactive tracers.

On the ground floor there are two committee rooms, a Fellows' Common Room, and an excellent lecture theatre to seat 140 students, a great asset to the College, which is, however, still short of lecture and demonstration room-space to meet all the requirements of its educational programme. The building of phase IIIb, which will complete the restoration of the College, is planned to make good these deficiencies.

THE ROYAL BOTANIC GARDENS, KEW

THE Students Day at the Royal Botanic Gardens, Kew, was held this year on May 7. Many universities, schools and training colleges were represented as well as members of a number of scientific societies. Altogether, about six hundred visitors were present. The exhibits this year were not restricted to the Herbarium but were spread over the various buildings and greenhouses at the north end of the Gardens.

Many of the Herbarium exhibits were concerned with the work of the taxonomist. Starting with the collection of plants in the field, there were demonstrations of drying and mounting leading to the ultimate naming and classification of the specimens. The work of the monographer was also demonstrated, with particular reference to the genus *Ficus* (figs), which includes nine hundred species.

A challenge to visitors was provided by an exhibit illustrating the classification of grasses. Two contrasting sets of specimens were displayed. In one, seven of the larger tribes were illustrated by herbarium specimens which were typical in respect of their inflorescences and spikelets. Contrasted with these were a number of non-typical examples from the same tribes, in which there were certain mutual resemblances. The compact spike-like inflorescence illustrated by *Chaetostichium minimum* in the Chlorideae, *Rhytachne rottboelloides* in the Andropogoneae and *Prionathium pholiuroides* in the Danthoneae were surprisingly similar. This apparent parallelism, however, was shown to be misleading, since diagnostic characters other than those of gross morphology are essential to the correct placing of a given species. The employment of other criteria such as the nature of

epidermal ha
and basic ch
instances, to
relating to th
Kew were als
the Library an
and periodical
Many of the
his assistants
although not
student of bot
large number
astonishing div
distribution co
teacher as well
Another gar
climbing in pla
other than tex
more popular
androgyna, for
as an example
would have gu
of attaining a h
the Arboretum
was devoted to
of certain see
Under natural
moist leafy med
germination.
stored, the re
aeration can be
seeds—acorns,
together with da
temperature of
for several mon
germination of
with. The seeds
stony endocarps
seeds when gath
sand in successi
Here they are ex
year or more, a
become sufficient
Another method c

y, type of starch grains
nbers has led, in some
ibal position. Exhibits
now being prepared at
he Herbarium, while in
ection of botanical books
t on the tables.
ayed by the curator and
of horticultural interest
cientific appeal to the
mple, the exhibit of a
axifraga illustrating the
, form and geographical
ve failed to impress the
t.
llustrating methods of
eries of living examples,
, although some of the
lso displayed. *Semele*
nown to most students
elopment, although few
climbing plant capable
The exhibit staged by
oncerning seed storage
f maintaining viability
us trees and shrubs.
seed is shed into a
normally remains until
ich are collected and
ons of moisture and
placing the collected
—in polythene bags
maintaining them at a
y can then be assured
lems involved in the
eeds were also dealt
antha and others with
o 'stratification'. The
d in boxes of damp
placed in the open.
elements for maybe a
the endocarps have
permit germination.
germination depended

on the principle of vernalization. A sample of *Malus* seed had been maintained at a temperature of 36° F. for sixty days and then subjected to two 1-sec. dips at 10-min. intervals in water at 165° F. The seeds then showed radicle development at an advanced stage and a batch of seed so treated had actually germinated within a few days.

An impressive exhibit displaying methods of vegetative propagation demonstrated the use of various growth-promoting substances in the quick establishment of cuttings. The formation of callus in treated and untreated examples was illustrated, and the methods used in propagation by leaf, root and stem cuttings were also demonstrated. A working mist-unit which automatically maintains a constant humidity in a propagating house was also on view.

The exhibit in the Fernerios was notable for a fine display of young sporophytes of the rare monotypic *Regnellidium diphyllum*, a member of the Marsiliaceae; few students could ever have seen living specimens of this interesting South American genus. In addition, there were examples of the early stages in the development of the fern sporophyte and an interesting demonstration of the vegetative propagation of species of *Selaginella* and *Lycopodium*. These genera, which are difficult or impracticable to raise from spores, are in most cases readily raised from leaf or stem cuttings.

In the Jodrell Laboratory a number of exhibits were displayed to illustrate the multifarious activities of its staff. Besides demonstrations of the methods used in preparing materials for microscopical examination, several examples were shown of commercial vegetable products which had either been adulterated with worthless material or were completely spurious.

Finally, mention should be made of the exhibit shown in the Herbarium, prepared and loaned by the British Council, consisting of forty-four panels illustrating the history and activities of the Royal Botanic Gardens, Kew. Intended primarily for displaying overseas, they were quite excellent in presentation and were universally admired.

F. BALLARD

INFLUENCE OF EDITORS

THE question
correcting an
on April 29 at a m
Council. Dr. G. E
tion) was in the
Dr. R. D. Key
a dual responsibil
reader. Many aut
a long historical in
a wearisome repe
the statistical ev
calculated incorre
that do not supp
formity to a stan
not be insisted on
the author should
an editor should
fierce in ensuring
published. Some
from an anonymou
cause resentment

editor should go in
nscript was discussed
cientific Publications
holme (Ciba Founda-

) said an editor has
uthor and (*b*) to the
nuscripts containing
a discussion that is
results. Sometimes
dequate, means are
author gives figures
ys. However, con-
presentation should
d in matters of taste
the last word. But
y; and he must be
f any data that are
the author a report
anonymity is apt to
iting personally can

often be much ruder and more effective without causing ill-feeling. As a university teacher, Dr. Keynes was concerned at the number of text-books and symposium volumes that bear the names of eminent scientists as editors, but in which the so-called editors have not really done any editing at all. The frequent contradictions in the different chapters are troublesome to student and teacher alike. Editorial interference may be objectionable, but editorial neglect is worse.

Dr. A. S. Parkes (National Institute for Medical Research) agreed that an editor had many responsibilities; but in the long run the author bears the full responsibility for every paper bearing his name. In particular, an editor should not rely too much on a referee, who may well have his own axe to grind, and who, being anonymous, has no right to try to insist on major alterations to someone else's paper. He recognized fully, from his own experience, that young authors can benefit enormously from the constructive criticism of more experienced writers; but papers should go through the moulding stage before they are sent for publication. The head of a department should see that all papers leaving it are in good shape and worthy to bear its name.

Prof. E. J. King (British Postgraduate Medical School) said that manuscripts written by scientists are often very poor, and heads of department cannot be expected to replace the experienced editor in the highly skilled task of revising for publication. Editing is a burdensome job, and most scientists are grateful to the editors who give their time to it. Editors should do as much rewriting as they think necessary. But an editor needs to be a diplomat: he must know how to effect a useful compromise without causing resentment.

Mr. A. L. Bacharach (*J. Nutrition*) said that the basic question is: How much should an editor do? Some scientists are glad to have their manuscripts revised, but others go so far as to assert that papers should appear just as they are written, even complete with grammatical errors. The purpose of publication is to spread new information, and a paper will do this only if the reader has confidence in the author. Grammatical errors, verbosity and repetition undermine the confidence of the reader and should be corrected. It is helpful if manuscripts go through a process of 'internal editing' within a department (not necessarily by the head) before they are sent for publication. In one department that had adopted this procedure for more than fifteen years, only one in some two hundred of the papers sent for publication had been rejected or returned for rewriting. An editor is entitled to make every alteration he thinks necessary to improve the clarity and intelligibility of a paper, so that it can be read with intellectual comfort. Those who resist such alterations are generally the bad scientists—the good ones are glad to have their papers improved.

Dr. R. K. Callow (National Institute for Medical Research) said that a part of the problem is that some scientists are completely blind to typographical, grammatical and logical errors and unable to understand the concern that others feel about them. In his experience, a journal in which an editorial board of scientists did most of the editing, and a staff editor did only sub-editing, achieved the happiest author–editor relationship. It was less satisfactory to have a system of refereeing in which the expression of opinion was limited ('suitable' or 'not suitable' for acceptance) and papers were altered by a staff editor to fit them into a stereotyped scheme for the concise recording of data.

Dr. I. Bush (Oxford) complained of over-zealous editors and laggard referees who hold up publications while making numerous changes, which are not of the first importance, in the manuscripts. Editorial requirements are so numerous and various these days that many otherwise conscientious authors do not take the maximum trouble in preparing their manuscripts since experience leads them to believe that, whatever they do, the editors will always raise a large number of objections or alternatives. He pointed out that Dr. Detlev Bronk had recommended a decrease in 'editorializing' in an article some years ago.

Dr. T. H. Osgood (U.S. Embassy) said that in his American experience, the insensitivity of some authors to shades of meaning lent credibility to the story told by a fellow editor that occasionally his letters of rejection took the form: "Dear Sir, Although your paper fills a much-needed gap in the literature, I regret that it cannot be accepted for publication". It was unfortunate that editors were, on occasion, forced to undertake the education of authors, but when it became known that the correction of errors and the questioning of editorial judgment involved considerable delay, authors took exceptional pains to present good manuscripts. In view of the normal anxiety of an author to see his paper in print, the threat of delay was the best weapon for ensuring the effectiveness of editorial influence. An editor who did his job well must expect to make one or two enemies every year.

Mr. F. Clark (*Biochemical J.*) described the work of a professional editor, whose services may be required for large scientific journals where much of the editorial work formerly done by the chairman and other members of the editorial board can be transferred to the editorial office.

Dr. G. E. W. Wolstenholme (Ciba Foundation) said it is difficult for scientists from abroad to understand the requirements of journals in another country. Some scientists whose papers are rejected are convinced that the editors have a personal grudge against them.

This short meeting had shown how helpful it could be for authors and editors to get to know each other: in that way many mutual difficulties could be ironed out.

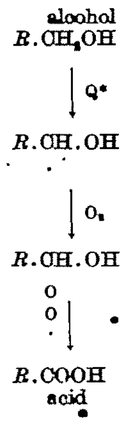
D. Richter

THE BRITISH RAYON RESEARCH ASSOCIATION

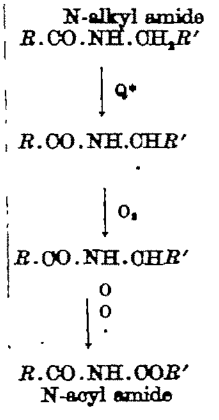
The annual open days of the British Rayon Research Association's Heald Green Laboratories at Wythenshawe were held during May 11–13. The total attendance was 900. Last year the work on 'fluid beds' and on vibration problems on spinning machinery was not demonstrated, but, because of the progress made, it was possible to give impressive demonstrations of both these aspects this year.

In the 'fluid beds', on which the Association has been working for the past few years, the bed material is small glass beads (dimensions 1 mm.–0·25 mm.) and the fluidizing agent is air. The particular virtues of fluid beds are: (*a*) that high rates of heat transfer can be achieved between a heat source in the bed and the material to be heated, for example, fabric or cord; (*b*) that the bed can be operated at high temperatures; and (*c*) that the temperature is uniform across the bed. Fabric or cord can either be introduced at the bottom and removed from the top of the bed (single-pass bed) or both entry and removal can be at the top (double-pass bed), in which case it is passed round an internal roller or similar device at the bottom. The problem is to achieve this with low cloth tensions. The current position is that fabrics can be passed through single-pass beds under a tension

of 2–4 lb. per
bed and under
tions in a dou
this developm
low for satisf
measurements
water from c
function of b
air per unit ar
data available
use as a dryin
reasons the r
dyeing of hydr
etc., and the h
other thermop
have received
year, and dem
technique to r
of nylon tyre-c
The problem
filament visco
crease-sheddin
spun-yarns ha
more difficult t
their surface is
which would r
example, to p
higher degree
these fabrics th
exploration of t
for example, ch
ture of treat
techniques of a
that there is
recovery and l
say, although i
of crease-recov
in abrasion resi
valueless. It c
treatments so
increase the 'y
region of elasti
a reduction in t
Two features
first one is the
tion of nylon.
studying the p
compounds, the
the same chemi
amides. With p
peroxides, it ha
product is that
with previous w



6-ft. path-length in the
6 lb. for the same condi-
uch effort has gone into
tensions are sufficiently
nt of cloth. Detailed
r and rate of removal of
have been made as a
e and rate of input of
e are therefore sufficient
analysis of its possible
r a number of practical
applications are the
uch as nylon, 'Terylene',
f tyre-cords of nylon or
s. These two aspects
ntion during the past
the application of this
nd to the heat-setting
n.
e fabrics of continuous
same visual degree of
btained on fabrics of
ved. The problem is
ese fabrics because, as
eye can detect creases
in spun-fabrics; for
lly acceptable fabric a
ary is necessary with
fabrics. A systematic
rying the parameters,
of treatment, tempera-
conditions, in known
e-resistance has shown
ation between crease-
resistance, that is to
obtain the high degree
he associated reduction
as to render the fabric
therefore, that all the
ed which appear to
he fibres, that is, the
simultaneously lead to
rain.
een investigated. The
rmo-chemical degrada-
as been approached by
oxidation of simple
es, which should show
in principle, as poly-
ensitizers, for example
hat the main reaction
e expected by analogy
s and ethers:



It has been conclusively shown that N-acyl amides are the primary product for a large range of N-primary alkyl amides. An initial study of the thermal oxidation, over the temperature-range 110–180° C., has shown that the major products from N-ethyl and N-propyl propionamide are again N-acyl amides, that is to say, thermal oxidation would appear to involve a specific hydrogen abstraction, namely from the carbon α to nitrogen, either in the initiation or propagation stage.

The second feature of nylon which has been studied is the structure of spherulites grown from the melt. Narrow-beam X-ray techniques have been used to study orientation, and it has been shown that the a axis of the unit cell lies along the radius in positively birefringent spherulites. The zig-zag extinction pattern shown in the polarizing microscope by some of these spherulites can be understood in terms of this orientation and a structure in which successive crystalline units along a radius show a progressive rotation (twist) around this radius with an optically resolvable pitch. The orientations in negatively birefringent spherulites and in spherulitic aggregates have also been studied. Further work is being carried out by electron microscopy in order to characterize the geometrical nature of the crystalline units from which the spherulites are formed.

An essential stage in the production of textile fibres is drawing, which brings about molecular orientation and an anisotropy in physical properties. Apart from previous work on cellulose film in the Laboratories, no attempts have been made to investigate the anisotropy of the mechanical properties, although the behaviour of fibres under lateral forces may well be as relevant to obtaining an understanding of the physical properties of yarns and fabrics as the axial tensile properties which are usually measured. Using polythene film (see *Nature*, 184, 600; 1959), measurements of the Young's modulus of strips cut at three angles ($\theta = 0°, 45°$ and $90°$) to the symmetry direction (direction of drawing) have been made. With increasing draw ratio at 20° C. the moduli at 0° and 90° to the axis of symmetry first decrease and then increase very markedly. This unexpected behaviour is not explicable in terms of a reduction in order, since density and molecular orientation (by X-ray measurements) increase monotonically with increasing draw ratio. Even more unexpected is the behaviour at $\theta = 45°$. In this case the modulus decreases smoothly as the draw ratio increases. This behaviour of polythene differs markedly from that of cellulose, for which some less-extensive data are available, but it is clearly of sufficient importance to justify the investigation of other polymers in a similar way.

Apart from these investigations, aspects of much other technological work were on show. Of particular interest to the textile industry were the different types of slub-catchers for removing slubs from yarn, a demonstration of the effect of spindle eccentricity on ring spinning frames on producing hairiness in yarns, and the effect of pirn winding tensions and humidity conditions on the production of weft bars in nylon fabrics.

The number of staff of the Laboratories is 230, comprising research staff, 80; laboratory and technical assistants, 57; engineering, drawing office and maintenance staff, 52; library and administrative staff, 32; canteen staff, 9.

L. A. WISEMAN

OCEANOGRAPHY OF LONG ISLAND SOUND

VOL. 17, Art. I, of the *Bulletin of the Bingham Oceanographic Collection** contains six papers on widely different aspects of the oceanography of Long Island Sound, with the emphasis on the cycle of organic production, and a guide for preparing figures written by the editor, Ynge H. Olsen, with James E. Morrow, research associate. The volume opens with an obituary notice of Eugene Harris, who had not fully completed the manuscript of his important contribution on the nitrogen cycle when he died. The senior author, Dr. Gordon A. Riley, completed it, and from the paper itself it is clear to all who wrestle with the problems presented by organic production in the sea that further contributions of high standard would have come from Harris had he lived.

The volume as a whole is a continuation of a series of seasonal studies, continued over a period of years, in the attempt to establish the various parameters, physical, chemical and biological, that seem to exert most influence on the production of plankton, and secondarily on the higher forms of life such as sand-eels and other fishes, in this area. Numerical values for the most important of these parameters having been established, the final approach to solution of the organic cycle is by the mathematical methods previously employed by Dr. Riley in studies of more strictly oceanic areas.

Marine biologists in Great Britain may gain a fair idea of the scope and importance of the work if it is said that it presents a close parallel to that carried out by Dr. Harvey and his co-workers of the Plymouth Laboratory in the coastal waters of the English Channel some twenty-five years ago. Long Island Sound is a more enclosed and more strictly coastal sea-area, with more extreme seasonal variation in such parameters as temperature and salinity, due partly to the climatic differences of an area on the eastern side of a continent. Moreover, the American workers began with all the advantages of the research and discussion that have accrued during the intervening years, with attendant improvements in technique; while the more-sheltered situation must have greatly assisted in the maintenance of wider and more prolonged seasonal coverage.

The general account given by Dr. Riley shows that the phytoplankton cycle is somewhat different from that observed off north-west Europe. A late-winter flowering dominated by diatoms such as *Skeletonema costatum* and *Thalassiosira nordenskiöldii* occurred, with its peak between January and March, in each of the years studied, that is, roughly one month earlier than the spring flowerings studied by European workers. Subsequent less-regular flowerings in May or June consisted predominantly of dinoflagellates. The phytoplankton of the western (enclosed) end of the Sound was so much greater than that near the open end that there the chlorophyll concentrations during post-flowering periods were as high as those representing flowerings at the eastern end. It was thought that relatively low-grazing intensity at the western end partly accounted for this great disparity. Autumnal flowerings were less regular than the others, but of very considerable magnitude. A fairly satisfying argument postulating increased stability of the surface layers as the prime factor promoting the richer autumnal outbursts is presented.

Harris's contribution established nitrogen as the most probable limiting factor among the essential nutrients in this area. As stated in Riley's general account, the relative poverty is shown by nitrogen/phosphate ratio of between 5 : 1 and 8 : 1 by atoms, between one-third and one-half the values found in the Atlantic area generally. It is pleasing to find Cooper's concept of the "anomaly of the phosphate/nitrate ratio" so useful in defining the nutrient characteristics of a region very different from most of those in which such work has been done before.

Harris showed further that ammonia was superior to nitrate and nitrite as a source of nitrogen for the phytoplankton studied in most instances, and not inferior to them in the remainder. In the discussion he developed a most interesting hypothesis to the effect that in strongly stratified surface waters, when nitrogen quantities are near minimal, but organic matter tends to a maximum near the thermocline, vertical zooplankton migrations may help to slow down depletion of the epithalassa in this respect, or even very slightly to increase the quantities available.

Riley and Schurr present a very detailed analysis of the various parameters affecting transparency of the waters as indicated by a fine series of Secchi-disk readings. Here I must confess to feeling rather unconvinced by the mathematical treatment of some of the more obviously inter-related physical factors influencing the maintenance of suspensoids in the upper layers, as wind stress, mean stability, tidal-current speed and depth. The time factor appropriate for the first two seems so uncertain that one doubts the adequacy of the statistically computed partial correlation coefficients to express these. This is not to query the correctness of the conclusions reached, where the possible effects of some of the 'unknowns' are quite fairly stated in more general terms.

A brief trenchant note by Riley on the particulate matter in the Sound shows that although the amount of detritus is exceptionally large its distribution seems to bear little direct relation to the phytoplankton cycle. From the seasonal imbalance between production and consumption it seems that some of it has a slow rate of degradation. Thus it may provide less-suitable food for the zooplankton than would seem probable from the evidence that the latter can assimilate more nitrogen than is to be found in the phytoplankton. The part played by organic detritus in a relatively shallow enclosed sea-area like the Sound, where local turbulence often churns up the bottom deposits, must be more complicated than it is in oceanic areas where it sinks out of the immediate circulation in the surface layers.

Peter J. Wangersky examined the carbohydrate content of water samples from the Sound throughout

---

* *Bulletin of the Bingham Oceanographic Collection*, Vol. 17, Article 1: Oceanography of Long-Island Sound. By Gordon A. Riley, Eugene Harris, Henry M. Schurr, P. T. Wangersky, Sarah W. Richards and R. Wade Covill. Guide for preparing Figures. By Y. H. Olsen and James E. Morrow, Jr. Pp. 153. (New Haven, Conn.: Peabody Museum of Natural History, Yale University, 1959.) 3.50 dollars.

one year's plaı
during a spring
(0 5–1·5 mgm.
dinoflagellate t
of magnitude I
pure cultures of
the material is
released : the :
more indicativı
production. I c
sentence : "Elu
dinoflagellates
task for pure c
[italic mine].]
likely to be n
present state c
concerning thes
certain about th
to extrapolate
existing in Na
field-work, whic
primary part of
The collection
Riley were studi
tion of earlier
of the twenty-
spawners. In w
of only one spec
in abundance.
caused mainly b
larly the anchov
six other species
greater abundan
the western part
eastern portions
that for summe
eggs did not ha
from small eggs
greater food sup
R. Wade Covi
stomach conten
sand-eels, *Ammod*

He found none present
and significant amounts
rds the end of a July
amounts were an order
found in bacteria-free
nism. He concludes that
almost as fast as it is
s present may even be
ilization than of small
gree with his concluding
e relationships between
acteria is *primarily* a
ues in the laboratory"
laboratory approach is
ely rewarding in the
(or lack of knowledge)
but if anything seems
t would be most unsafe
conditions to those
concomitant planned
ely be regarded as a

nd larvæ made by Dr.
. Richards in continua-
tland. The majority
roved to be summer
were taken, and larvæ
s americanus, occurred
in annual totals were
ndant species, particu-
tchilli mitchilli. Only
in large numbers. A
of species spawned in
han in the central and
ie year. It appeared
rge larvæ from large
age over small larvæ
hatched at a time of

detailed study of the
rval and post-larval
s, 3·2–23·1 mm. long.

Comparison with data from elsewhere showed fewer empty stomachs among the Long Island Sound material ; evidently the Sound provides good feeding for the young of this species. Copepods and their nauplii were the most important food organisms, but phytoplankton was also an important food, especially for the younger and smaller larvæ. It is shown that the larvæ must ingest a considerably greater quantity of food a day than can be deduced from direct examination of stomach contents for growth to continue.

Finally, the editors offer first-class advice and instruction regarding the production of the figures with which papers of this kind should be illustrated. No marine biologist can cavil at anything they have to say, for all the advice is excellent.

Is it not a little unjust to expect marine biologists to be good draughtsmen as well as possessing the wide range of professional knowledge and other semi-specialist skills that they must strive to attain in order to do their job well ? Many who are not so gifted are no wit inferior as scientists to those gifted with a natural facility for drawing. The number of research workers who can hope for the collaboration of a good illustrator is very limited, at least in Great Britain. Too much insistence upon a high standard of graphic presentation can thus lead to suppression of valuable results.

Another point which this, in itself unexceptionable, set of instructions impels one to raise is the need in marine biological papers for less size reduction of figures and more reference lines on graphs (which most editors seem to abhor). Such work often involves voluminous raw data, which for economic and other reasons are nowadays rarely published in full. Graphs from which the values really can be read off are therefore almost the last line of defence against destructive critics who make much of possible alternative arrays of the data, which on close examination are almost always found to be inferior to those selected by the individual who did the work.

T. John Hart

JR D. LITTLE RESEARCH INSTITUTE

THE annual
Little Resear
thirty-six publica
a considerable im
Institute's activi
operation, thoug
director, observe
in *Chemistry and*
more than £300,C
three contract re
and the research
Scientific and I
research in 1958
Arthur D. Little
An investigation
mers from derivati
four-year grant fr
of Agriculture, an
polymers is being
American compan
istry is being un
Energy Authority

59 of the Arthur D.
which includes a list of
during 1959, records
scale and scope of the
us its third year of
N. Woodward, its
m sponsored research
January 9, 1960, not
ively covered by the
tes in Great Britain
f the Department of
earch for sponsored
nveresk, Midlothian :
itute, 1960).
preparation of poly-
was initiated under a
d States Department
he bulk properties of
ored by British and
of aluminium chem-
ehalf of the Atomic
mistry and polymer-

ization of ethylene sulphide are being investigated for a European sponsor.

The work on the chemistry of sodium sucrates continued and has opened a new route for the preparation of a wide range of sucrose derivatives of potential value, including the sucrose fatty esters, although the problem of removing 'bound' ammonia from sucrates prepared in liquid ammonia has not been completely solved. In the work on the mechanism and kinetics of the formation of isotactic polymers, a new flow apparatus was built and the continuous-flow technique adopted to overcome the difficulty of preparing a reproducible Ziegler catalyst surface, and to afford some insight into the problem of making the polymer production process continuous. An improved model of the viscodensitometer was built and calibrated.

Work in the corrosion field was particularly fruitful, and 450 organic compounds were tested for inhibitory power using the rapid methods described in the previous report. Although the results did not establish any clear-cut correlation between chemical constitution and inhibitory power, they should assist the selection of compounds likely to be effective as inhibitors. Electrochemical methods of studying inhibition have also given interesting results, and the technique of studying inhibition in a flow apparatus with a controlled atmosphere has been considerably improved. Studies of the chemical modification of wood have been extended to include modification of blocks of sapwood specimens and of veneers with the view of assessing improved dimensional stability, and methods have been worked out for the routine evaluation of changes in the physical properties of veneer and whole-wood resulting from chemical modification, and a rapid screening technique for evaluating rot resistance properties of sawdust samples. Infra-red spectroscopy proved to be a particularly valuable method for examining comminuted wood samples.

POLYPEPTIDES OF THE HUMAN PITUITARY WITH DIRECT ACTION ON METABOLISM

By Dr. J. BORNSTEIN and DEIRDRE HYDE
Diabetic and Metabolic Unit, Alfred Hospital, Melbourne

THE observation by Baird and Bornstein[1], that residues of plasma following an acid solvent extract contained a fraction capable of inhibiting the uptake of glucose by rat diaphragm, led to the investigation of the human pituitary as a possible source of this material.

Acetone-dried pituitaries are extracted with a mixture consisting of ethanol, 4 vol.; *n*-butanol, 0·4 vol.; toluene, 0·4 vol.; and water, 1·0 vol.; hydrochloric acid to *p*H 1·5 for 5 hr. The supernatant is discarded, and the wet residue incubated for 4 hr. at 37° C. and then vacuum dried to remove all traces of solvents. The dry cake is pulverized and extracted with 0·1 *M* acetic acid. The extract is then ultrafiltered through 'Cellophane' at 40 lb. per square inch and the ultrafiltrate either freeze dried or precipitated with 15 volumes of absolute ethanol (dried over calcium oxide). The activity of this fraction (*P.U.F.*) is shown in Table 1.

The crude ultrafiltrate was added at a concentration of the equivalent of 1 gland/ml. of buffer.

The ultrafiltrate is then chromatographed on a column of 'Zeokarb 225*H*' or '*IRC* 120*H*', the column being developed with water, 0·1 *M* triethylamine acetate buffer *p*H 6, followed by 0·1 *M* triethylamine buffer *p*H 9·4. Three peaks are observed, the first fraction (HP_1) not absorbing on the column, the second (HP_2) being eluted with buffer *p*H 6 and eluting at *p*H 5·2–6·0 and the third (*BP*) at *p*H 9·4. The third peak (*BP*) has been inert in all systems and no further reference will be made to it. HP_1 and HP_2 showed opposite effects on glucose uptake by rat diaphragm, HP_1 producing acceleration and HP_2 inhibition (Table 2).

Table 1. Effect of Crude Ultrafiltrate on Glucose Uptake by Rat Diaphragm (2)

No. of preparations tested	No. of diaphragms	Glucose uptake in mgm./gm./hr.			
		Control	With *P.U.F.*	Diff.	*P*
6	36	4·54 *S.E.*	3·76 ±0·14	0·78 ±0·066	< 0·001

The inhibitory effect of fraction HP_2 has also been investigated in the following systems.

(*a*) The oxidation of U–^{14}C glucose by paired liver slices (Table 3).

(*b*) The incorporation of carbon-14 amino-acids into protein of rat diaphragm both *in vitro* and following pre-injection of animals.

The diaphragms of rats starved for 18 hr. were incubated in the presence of a protein hydrolysate of activity 1 μc./ml., total amino-acids 80 μgm./ml. and insulin 1 × 10^{-3} unit/ml. No glucose was added. In injection experiments 160 μgm. HP_2 was given subcutaneously 18 hr. before death and 160 μgm. HP_2 intravenously 30 min. before death. Protein was isolated according to the technique of Manchester and Young[4]. The results are shown in Table 4.

(*c*) Effect on the incorporation of ^{14}C-1-acetate into fatty acids and unsaponifiable lipids by liver slices both *in vitro* and following injection.

Liver slices taken from rats starved for 18 hr., paired in the case of *in vitro* experiments, and pooled in injection experiments, were incubated in the presence of ^{14}C-1-acetate 1 μc./ml., acetate concentration 300 μgm./ml., glucose concentration 2 mgm./ml. Where injection of animals was undertaken it was carried out as under *b*. The fatty acids and unsaponifiable lipids were recovered according to the technique of Hastings *et al.*[5]. The results are shown in Table 5.

The unsaponifiable lipids from this series show the same trend as in the *in vitro* studies, but the results are not statistically significant.

Table 2. Effect of Fractions HP_1 and HP_2 on Glucose Uptake by Rat Diaphragm

Peak	No. of preparations tested	No. of diaphragms	Concentration in μgm./ml.	Glucose uptake by rat diaphragm mgm./gm./hr.			
				Controls	$-HP_1$	Diff.	*P*
HP_1	4	18	20 *S.E.*	4·39 ± 0·26	5·46 ± 0·29	+ 1·07 ± 0·247	<0·01
HP_2	9	66	160 *S.E.*	4·72 ± 0·16	$-HP_2$ 3·32 ± 0·17	− 1·40 ± 0·126	0·001

No. of preparations tested	No. exps
4	11

Table 4. EFFECT OF
AMINO-ACI

No. of preparations tested	No. of diaphragms used
3	9
	(2)
	No. of ani
	Controls
4	15

All radioactive
Chicago D47 gas
thinness. Elect
shows that it beh
substance both
experiments, an
molecular weigh
hydrolysis yield
residues. The m
temperature of 6
rapidly destroyed

Discussion. Fr
like activity wher
has not been furt

Fraction HP_1,
have a general a
uptake by muscle,
synthesis by musc
tissue and probab
in the liver.

Although the e
animals are at pre

unts/mm./100 mgm. tissue recovered as $BaC^{14}O_3$			
	$+HP_1$	Diff.	P
	415 ±29·7	−61 ±14 9	0 01

NCORPORATION OF CARBON-14
F RAT DIAPHRAGM

unts/min./mgm. protein recovered			
	$+HP_1$	Diff.	P
6	1,537 ±143 3	−464 ±108 9	0 01
as above			
ounts/min./mgm. protein recovered			
	Injected	Diff.	P
	1,785 ±119 2	−537	0·01

counted in a Nuclear
l corrected to infinite
dy of fraction HP_1
antially homogeneous
d moving boundary
study indicates a
rity of 2,500. Acid
tely 19 amino-acid
le to freeze drying, a
in acid solution, but is

pears to have insulin-
rat diaphragm, but

s obtained, seems to
on inhibiting glucose
tion by liver, protein
cid synthesis by liver
cholesterol synthesis

iochemistry of living
lied, it cannot as yet

Table 5

No. of preparations tested	(1) *in vitro*—fatty acids					
	No. of expts.	Conc. HP_1 μgm./ml.	Counts/min./100 mgm. liver—fatty acids			
			Controls	$+HP_1$	Diff.	P
5	16	60 *S.E.*	589 ±51·6	334 ±40 4	−255 ±30 3	0 001
	(2) *in vitro*—unsaponifiable lipids					
			Counts/min./100 mgm. liver—unsaponifiable lipids			
6	16	60 *S.E.*	286 ±38	394 ±51	+108 ±31	0 01
	(3) following injection—fatty acids					
	No. of animals used		Counts/min./100 mgm. liver—fatty acids			
	Controls	Injected	Controls	Injected	Diff.	P
4	15	14 *S.E.*	529 ±32	381 ±35	−148	0·01

be said whether the material is actively diabetogenic in the same sense as growth hormone in suitable animals.

The relation of this apparently polypeptide fraction to the well-known similar effects of growth hormone following the injection of that substance is at present not known, but it is possible that it represents an active fragment split from the growth hormone molecule.

Again it is not possible to state whether this fraction is the same as that described by Baird and Bornstein[1], although there is considerable similarity in the technique of preparation.

Further work as to biological activity, molecular size and structure is in progress, and full details will be published elsewhere.

This work was supported by grants from the Australian National Health and Medical Research Council, Eli Lilly and Company and the Life Officers Fund of Australia and New Zealand.

[1] Baird, C. W., and Bornstein, J., *Lancet*, 1111 (1957).

[2] Park, C. R., Brown, D. H., Cornblath, M., Daughaday, W., and Krahl, M. E., *J. Biol. Chem.*, 195, 197 (1952).

[3] Bornstein, J., and Hartman, B., *Nature*, 176, 788 (1955).

[4] Manchester, K. W., and Young, F. G., *Biochem. J.*, 72, 136 (1959).

[5] Renold, A. E., Hastings, A. B., Nesbett, F. B., and Ashmore, J., *J. Biol. Chem.*, 213, 135 (1954).

IMMUNO-E HORETIC DIFFERENTIATION OF HAPTOGLOBINS
FRO ER GROUP-SPECIFIC INHERITABLE SYSTEM
IN NORMAL HUMAN SERA

By DR. JAN HIRSCHFELD

Department c
arolinska Institutet, Stockholm 60. State Institute for Blood Group Serology,
holm 60. State Bacteriological Laboratory, Stockholm

WITH the ai
least twent
can be characteriz
by means of a s
seems to give a bet

In Fig. 1, a sche
from magnified p
which are still uni

-electrophoresis[1,2] at
itating components
normal human serum
d technique, which
of the components[3,4].
of these components
given; precipitates
noted as α_1-globulin

I, II, etc., according to their electrophoretic positions in immuno-electrophoresis under the conditions employed.

At least two evidently independent group-specific systems have also been observed, whereby normal human sera can be divided into three groups depending on variations in electrophoretic position of the haptoglobin precipitates, as well as three further

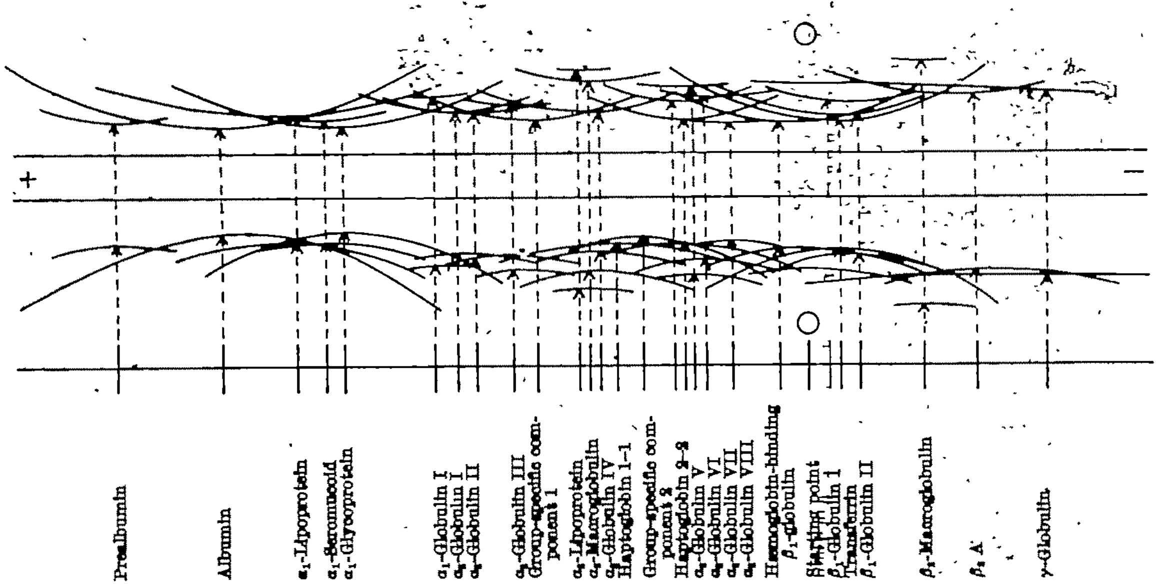


Fig. 1. Schematic representation of immuno-electrophoretic pattern of serum No. 2 (upper basin) and serum No. 4 (lower basin) after previous addition of hæmoglobin developed with different anti-human immune sera

groups depending on other precipitating components occupying different electrophoretic positions in different sera[4].

Both these group-specific systems occur in the α_2-globulin region, as characterized by immuno-electrophoresis, and the homozygotes in both systems have either a fast-moving or a slow-moving component which occupies very close electrophoretic positions. The haptoglobin homozygotes have a slightly slower electrophoretic mobility than the corresponding homozygotes characterizing the other group-specific system. These differences are, however, very subtle. The haptoglobin heterozygote (Hp 2-1) occupies an intermediate electrophoretic position between the Hp 1-1 and 2-2 precipitates, whereas the heterozygote of the other group-specific system gives a precipitate with two peaks if the electrophoretic separation is sufficiently prolonged, the two peaks corresponding to the fast- and slow-moving homozygotes respectively[4].

The haptoglobin precipitates can also be differentiated morphologically from the precipitates formed by the group-specific components, for they present different shapes of precipitate[3,5] and also occupy different positions between the antigen–antibody diffusion centres. Thus the Hp 1-1 precipitate shows an extended shape and is situated close to the antibody diffusion centre, whereas the Hp 2-2 precipitate is normally curved and situated closer to the antigen diffusion centre. The precipitates formed by the group-specific components 1 and 2, on the other hand, are identical with respect to shape of the precipitate (normally curved) and diffusion positions (close to the antibody diffusion centre). Their diffusion position is closer to the antibody diffusion centres than Hp 1-1 and Hp 2-2.

Addition of hæmoglobin will result in a slower migration of the haptoglobins, while the electrophoretic mobilities of other serum components (including the group-specific components) are evidently unaffected (Fig. 2). Also, the haptoglobin precipitates can be stained by means of a benzidine reagent, while no staining is obtained of the other group-specific precipitates if hæmoglobin is added to the sera[3].

By means of agar-gel electrophoresis[6], the electrophoretic position of the haptoglobins can also be localized and compared with the haptoglobin precipitate in immuno-electrophoresis (Fig. 2), whereas as yet no demonstration of the other group-specific components has been obtained with electrophoretic techniques other than immuno-electrophoresis.

It may be difficult to group human sera according to any of the group-specific components because of the number of other precipitating components, especially in the α_2-globulin region, some of which may also vary in different sera[7].

Either an immune serum has to be used, which contains as few precipitating antibodies against other components in the α_2-globulin region as possible, or the immune serum has to be absorbed. Immune sera, which can be used without absorption in haptoglobin grouping or grouping of the other group-specific components in human sera, have been found to be uncommon when rabbits are immunized with whole

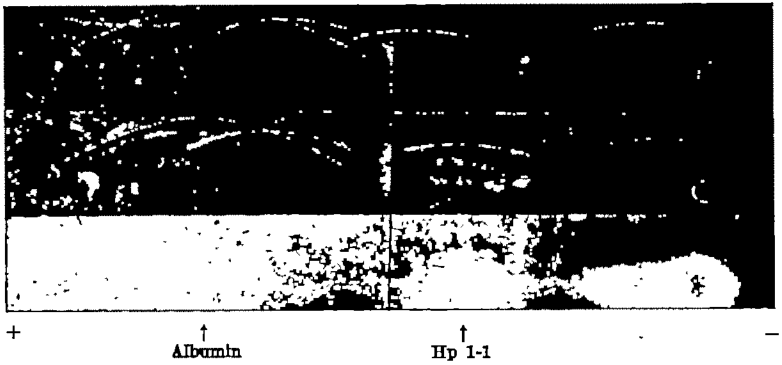
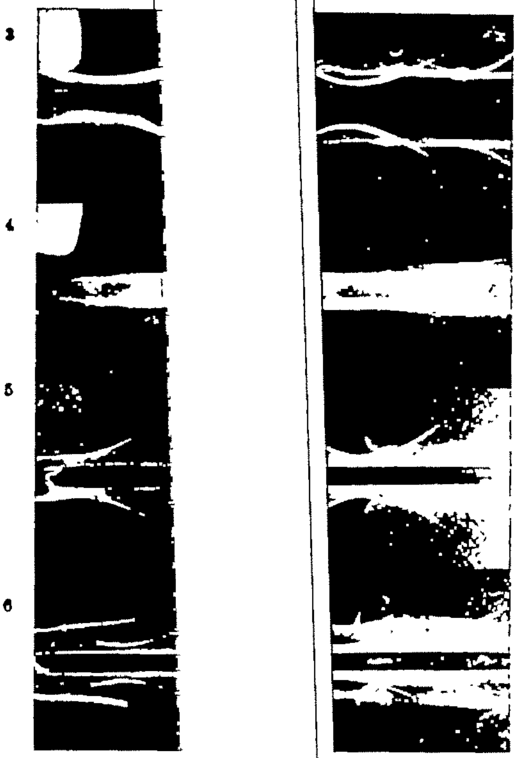


Fig. 2. Immuno-electrophoretic pattern of normal serum 4 before and after addition of hæmoglobin and agar-gel electrophoretic pattern of the same serum after addition of hæmoglobin and staining with benzidine (in order from above downwards)



Figs. 3–6. Immuno-el
basins) and serum Nc
O. 318.I (Fig. 3), and i
umbilical serum (Fig.
(Figs. 5 and 6). For f

n of serum No. 2 (upper
against immune serum
IV after absorption with
purified serum fractions
see text. The anode is

human sera. Am
prepared in rabbits
either with or wit
suitable for this pu
other hand, most of
antibodies against
specific component
several other comp
which partially ob
different sera. In F
pattern of two ser
globin groups devel
serum suitable for t
groups is shown, wl
tion the immuno-e
with immune sera sur
other group-specific
As further possib
specific components
grouping of human
sera to be studied r
these lines is in prc
technique are difficu
possibility of chang
or immunological prc
study. Finally, spe
used, but hitherto t
the haptoglobin prec
In the present cor
techniques will be pr
possible to demonstr
ents, provided that
which contains precip
components.

venty immune sera
g with human serum
s only a few sera
en found[7]. On the
tained precipitating
ins and the group-
antibodies against
α_2-globulin region,
ariations found in
uno-electrophoretic
o different hapto-
untreated immune
ion of haptoglobin.
evious communica-
pattern developed
monstration of the
ere demonstrated[4].
monstrating group-
utable for routine
purification of the
ted. Work along
results of such a
on account of the
in electrophoretic
components under
nethods might be
n results only for

simple absorption
ans of which it is
-specific compon-
erum is available
dies against these

It has been found that this is the case for most rabbit immune sera immunized with normal human serum, and that such antibodies are also demonstrable in commercially available immune sera (Behring-Werke, No. 1047 and Institut Pasteur No. 13).

The absorption technique employed was first published by Dray and Young[8] but has also been used in our laboratory[3–5]. It will be referred to as intra-basin gel absorption.

All experiments were carried out with the same two sera from evidently normal blood-donors and Fig. 1 also refers to these sera. Serum No. 2 belongs to Hp 2-2 and group-specific component 1 (fast), whereas serum No. 4 is of the type Hp 1-1, group-specific component 2 (slow). Further data of these sera have been given in a previous communication[4]. No changes in these sera have been observed in repeated bleedings of the blood-donors during a period of a year.

In Fig. 1, a schematic drawing is made of the immuno-electrophoretic pattern of these sera when developed with five different immune sera in different experiments. The schematic drawing is believed to demonstrate all components accurately from the original photographs. In this instance, hæmoglobin was added to the sera, which explains the slower electrophoretic position of the haptoglobin precipitates than in Figs. 3–6.

In Fig. 3 the immuno-electrophoretic pattern of these sera is shown when developed with an untreated immune serum which incidentally contained strongly precipitating antibodies only against the haptoglobins and α_2-macroglobulin in the α_2-globulin region.

This immune serum also gives strong precipitates with albumin, transferrin, β_1-globulin 1, γ-globulin as well as another component in the γ-globulin region, which appears only in very fresh sera and disappears after a few weeks, even when sera are stored in the deep-freeze[7] (not included in the diagram).

In Fig. 4, the immuno-electrophoretic pattern of these sera is shown after intra-basin gel absorption with umbilical serum[3–5]. Only the haptoglobin precipitates are shown in the α_2-globulin region.

Intra-basin gel absorption of the immune serum with equal amounts of properdin (1·2 mgm./ml.) and fibrinogen (20 mgm./ml.) gives only the haptoglobins, the group-specific components α_2-macroglobulin as well as α_2-globulin IV, which recently has been identified as the cœruleoplasmin precipitate, in the α_2-globulin region (Fig. 5).

Finally, by means of intra-basin gel absorption with equal amounts of properdin (1·2 mgm./ml.) and albumin (70 mgm./ml.) the group-specific components can be demonstrated, whereas the antibodies against the haptoglobins seem to have been effectively absorbed (Fig. 6).

The serum fractions used were supplied by Kabi, Ltd., Stockholm.

I acknowledge grants from Karolinska Institutet and Stiftelsen Thérese and Johan Anderssons Minne.

---

[1] Grabar, P., and Williams, C. A., *Biophys. Biochim. Acta*, 10, 193 (1953).

[2] Scheidegger, J. J., *Int. Arch. Allergy*, 7, 103 (1955).

[3] Hirschfeld, J., *Acta Path. Microbiol. Scand.* (in the press).

[4] Hirschfeld, J., *Acta Path. Microbiol. Scand.*, 47, 160 (1959).

[5] Hirschfeld, J., *Nature*, 185, 164 (1960).

[6] Hirschfeld, J., *Acta Path. Microbiol. Scand.*, 47, 169 (1959).

[7] Hirschfeld, J. (unpublished work).

[8] Dray, S., and Young, G. O., *Science*, 129, 1023 (1959).

CLEAVAGE OF HUMAN γ-GLOBULIN

By Dr. ROSA AUGUSTIN and BARBARA J. HAYWARD

Wright-Fleming Institute, St. Mary's Hospital Medical School, London, W.2

TWO communications appearing recently in *Nature*[1,2] prompt us to report briefly our own experiences with the 'spontaneous' and enzymatic cleavage of human γ-globulin and other serum components.

During attempts to distinguish reaginic from non-reaginic sera by micro immuno-electrophoresis[3] we observed variations in human sera which were unrelated to allergy. Four out of twenty sera stored at 4° C. for 5–8 years shared a pronounced post-γ-globulin component when tested against antiserum (rabbit) to whole human serum (*R*72) and a further ten sera of this batch had a suggestion of a post γ-globulin line. Out of thirty-four sera stored up to four months at 4° C. only one showed the beginning of a split in the γ-globulin line. Thus, the γ-globulin of serum as well as that of plasma[1] shows evidence of spontaneous splitting during prolonged storage. There were also great variations in the strength of the β_{1M}-globulin line, in the number and positions of the β_1-globulins, the α-globulins and the appearance of a pre-albumin line, most probably identical with Grabar's ρ (ref. 4). Many more sera contained ρ than post-γ-lines, and more sera giving weak β_{1M}-lines had ρ-lines than sera giving strong β_{1M}-lines.

Further, two γ-globulin preparations obtained by fractionating serum on diethylaminoethyl-cellulose[5] originally gave only one line when tested with either rabbit antiserum to whole human serum (*R*72) or with rabbit antiserum specific for γ-globulin only (*R*92). After only a few weeks at 4° C. immuno-electrophoretic patterns showed three partially related γ-globulin components very much like those observed by Grabar[4] and Škvařil[1] in some stored γ-globulin preparations. Like Škvařil[1], we followed up these leads by deliberate proteolytic digestions.

By fractionation on diethylaminoethyl-cellulose we succeeded in preparing immuno-electrophoretically pure water-soluble γ-globulins of a limited range of medium electrophoretic mobilities. These were digested with papain using 1 mgm. of the crystalline enzyme per 100 mgm. of protein. Drops of the digest were removed at intervals and immediately subjected to immuno-electrophoresis. Five- and 17-hr. samples (37° C.) were also dialysed in the cold against distilled water before electrophoresis, but patterns before and after dialysis were identical. Forking at both ends of the γ-globulin line was observed immediately after adding the papain, but a distinct post-γ-line formed rather earlier than the pre-γ-line.

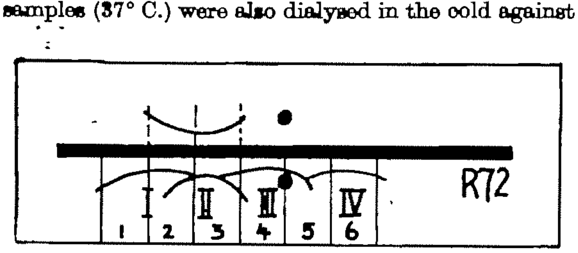


Fig. 1. Immuno-electrophoresis of a human γ-globulin fraction, undigested (top) and digested (bottom). For the Ouchterlony tests in Fig. 2 digests were electrophoresed in both the top and bottom halves; the gel in the top halves was cut into sections as indicated, the immuno-electrophoretic pattern in the bottom half being allowed to develop as usual to provide the key for the cut-out gel sections

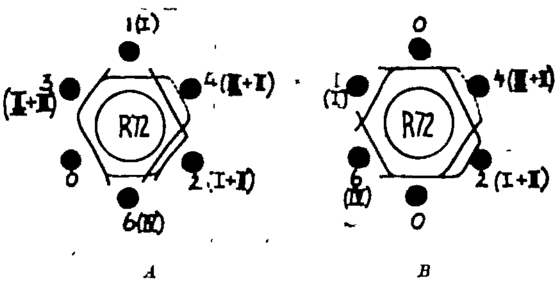


Fig. 2. Ouchterlony patterns obtained with γ-globulin digest fractionated by gel electrophoresis as indicated in Fig. 1. Arabic figures identify the gel sections while the roman figures in the brackets indicate the γ-globulin fraction in the particular gel section as identified by the immuno-electrophoretic pattern in Fig. 1. *O* = original undigested γ-globulin. *R*72 = rabbit antiserum to whole human serum

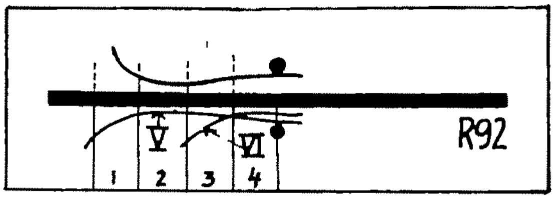


Fig. 3. Immuno-electrophoresis of undigested (top) and digested (bottom) whole human serum. *R*92 = rabbit antiserum to human γ-globulin only. For comparing the split products V and VI with those of Fig. 1, the gel was cut as indicated

There were three distinct components after 1 hr., the amounts of post-γ-globulin line (I) and especially the pre-γ-globulin line (III, Fig. 1) increasing at the expense of II during further digestion. A fourth component (IV) started to appear on the anode side after 4 hr. of digestion; Fig. 1 gives the picture obtained with *R*72 after 17 hr. No component IV could be seen when *R*92 was used to develop the pattern. The upper halves of the gel of three microscope slides were cut into six sections (as indicated in Fig. 1) immediately after finishing the electrophoresis and before the addition of the anti-serum, as in methods described previously[3]. The cut-out gel sections were filled into peripheral cups of Ouchterlony plates as indicated in Fig. 2. From the immuno-electrophoretic patterns it was already clear that both I and III were partially related to II, and that IV was partially related to III. This was confirmed in the Ouchterlony tests (Fig. 2), which further showed complete immunological identity between II and the undigested γ-globulin (Fig. 2*A*), and partial identity of I, III and IV with undigested γ-globulin (Fig. 2*B*). Further, I gave a reaction of non-identity with both III and IV (Fig. 2). Also, it can be seen (Fig. 2*A*) that I

gave a reaction o
elimination of an
in III through pr
Similarly, III ga
with II due to t
precipitation line
antibodies to the

Grabar[7] credits
evidence for fiv
determinants in
presented here ca
minimum of thre
III, and all three
product of III an
of III, for examp
IV appeared wit
lacked antibody t

Only two γ-glo
were obtained afte
when tested with
logically identical
no evidence of re

Testing of who
little attack on
4 hr. Then a pre-a
albumin was split
(from other eviden
the α-globulins.

The spontaneou
for prolonged per
components (*R*92).

tity with II after the
for the determinants
he line formed by III.
of identity (Fig. 2*A*)
that had passed the
that is, which lacked
specific for I.
d Burtin with having
ly seven) different
ulin. The evidence
ed by postulating a
, *A* on I, *C* + *B* on
IV may be a split
only one determinant
t *C*. No component
must therefore have

s (V and VI, Fig. 3)
stion of whole serum
oved to be immuno-
I above. There was
ed γ-globulin.
ts with *R*72 showed
than γ-globulin for
peared; after 17 hr.
ated fragments and
ion also occurred in

ulins in sera stored
wed more than two
ences (between the digestion of isolated γ-globulin and γ-globulin in whole serum) could be due to our isolated γ-globulins (of a limited range of mobilities) containing more of the determinants *B* and *C* than of *A*, while the amounts of those two sets of determinants may be more nearly equal in the whole γ-globulin range.

A digest of rabbit γ-globulin prepared according to Porter[8] showed no immunological similarities when compared with our digest from human γ-globulin; *R*72, *R*92, a sheep antiserum against whole rabbit antiserum and a rabbit antiserum (*R*89) against an ultracentrifugally enriched macroglobulin fraction (from a Waldenstron patient) were used in the Ouchterlony comparisons.

With normal human sera and with γ-globulin fractions isolated from them, *R*89 gave what looked like three parallel γ-globulin lines, a heavy line flanked by two weak ones. This is reminiscent of the two γ-globulin lines obtained by Goodman[2] with chicken antiserum and whole human serum and may mean that even the purest γ-globulin preparations isolated so far contain components other than γ-globulin, but with identical electrophoretic mobilities.

[1] Skvaril, F., *Nature*, 185, 475 (1960).
[2] Goodman, M., *Nature*, 185, 474 (1960).
[3] Scheidegger, J. J., *Int. Arch. Allergy*, 7, 103 (1955).
[4] Grabar, P., "Adv. in Protein Chemistry", 13, 1 (1958).
[5] Augustin, R., and Hayward, B. J., *Immunology*, 3, 45 (1960).
[6] Augustin, R., *Immunology*, 2, 230 (1959).
[7] Grabar, P., *Ann. Inst. Pasteur*, 97, 613 (1959).
[8] Porter, R. R., *Biochem. J.*, 73, 119 (1959).

FO EMAINS IN SOME BRITISH PARCHMENTS

By DR. M. L. RYDER

F cience, University of New England, Armidale, New South Wales

THE success ob
tion of parch
stimulated the ge
further work desc

The earliest sam
came from a collect
ing to Mr. T. H. G
samples of which
of the Department
of Leeds[2]. The onl
6 from this collecti
sixteenth centuries
the Public Record
Archives (via Dr.
Yorkshire and So
were supplied by M
of Leeds Central L
from Fountains Ab
and Sherburn in Elr
in this co-operation
disciplines; he ma
the samples were c
using dated parcl
while making sure
had been, or coul
sampled, and that
impaired. Court r
series of dated par

istological examina-
Dead Sea Scrolls[1]
on of material for

Table 1) dated 1193,
parchments belong-
thill, Bedfordshire,
by Dr. R. Reed,
dustries, University
ntury samples were
eenth, fifteenth and
by 5 samples from
n Canterbury City
rge collection from
Yorkshire samples
hen he was archivist
comprised samples
Manor of Hatfield.
was much interested
nistic and scientific
fort to ensure that
scientific value by
a known locality,
f a document that
written upon, was
nal value was not
hese requirements,
vailable which were almost certainly acquired locally, and in a court roll there is often a considerable area of unwritten parchment at the junction of membranes from which the required short strip about 1 cm. wide could be taken without spoiling its appearance. In addition, a sample was sometimes taken from the end of a sealing tag. In fact, all the Scottish samples were of this nature. These were supplied by Mr. J. H. Thornton, of Northampton College of Technology, and covered the fifteenth, sixteenth and seventeenth centuries.

The final parchments examined were 164 from the family documents of Captain Sir Hugh Rhys Rankin, Bart., of Bryngwyn, near Kington, Herefordshire. These ranged in date from 1743 to 1871, and all the 60 dated before 1800 were examined; but there were so few remains in the nineteenth century parchments that only three from each decade were examined. Most of this collection were from documents that had been drawn up in Hereford, but there were some from various parts of England and Wales. However, certainly as early as the seventeen-nineties, it was clear that the parchment had not necessarily been made locally; one parchment from Hereford, in fact, bore the name of a London stationer.

The parchments were treated in the following way: Sandison's softening fluid[3], 24 hr.; 70 per cent alcohol, 3 hr.; 90 per cent alcohol, 3 hr.; absolute alcohol, 5 min.; carbolic xylol (phenol 25 gm.,

Table 1. SPECIES OR WOOL TYPE IN PARCHMENTS, EACH SAMPLE BEING INDICATED BY ITS DATE

Key : —, unidentified ; f, fine ; f–m, fine to medium ; m, medium

Century	England (T. H. Gardner)	Public Record Office, London	Canterbury City Archives	Sherburn-in-Elmet	Hatfield, Yorks.	Fountains Abbey	Scotland	Hereford
12th	1193 m							
13th	1217 f 1244 — 1220 m 1274 ? Soay 1231 f–m 1297 f							
14th	Others not yet examined	1305 ? Soay 1337 see text and Fig. 2		1346 hairy 1365 hairy 1374 — 1376 f 1381 — 1386 — 1393 ? Soay	1328 f–m ? long 1338 —	1350 f 1350 f–m 1350 f–m 1350 hairy		
15th	Others not yet examined	1422 fat, and pigmented follicles ? calf 1462 m	1450–7 m ? long 1474 —	1402 f 1490— 1494 f–m 1496–98 —	1403 hairy (Fig. 1) 1431 —	1450 calf (book cover) 1495 —	1406 — 1452 — 1490 —	
16th	Others not yet examined	1527 hairy	1502 f–m ? down	1501 — 1505 f–m 1506 m 1507 — 1508 — 1511 f–m ? down 1513 m ? long 1514 — 1515 — 1516 — 1520 —	1540 — 1540 — 1540 —	1509 — 1511 f–m 1524 — 1535— 1537 f–m	1519 ? Soay 1529 — 1538 — 1539 — 1563 — 1574 ? Soay 1580 ? Soay 1584 — 1594 ? Soay 1597 ? Soay f–m	
17th	1659 m 1677 m 1687 —		1692 f (described by Ryder, ref. 1)	Otley, Yorks. (Leeds City Museum) 1689 m ? long			1603 ? Soay 1618 — 1621 — 1624 — 1661 ? Soay 1664 ? Soay	
18th	1700 — 1702 — 1736 m			Startforth, Yorks. (Leeds Central Lib.) 1727 goat				1743 hairy sheep or goat—2 hairy sheep—1 medium—11 (1 ? long, but all could be) f–m—1 m— 2
19th								1871

xylol 75 ml.), overnight, and then wax embedded *in vacuo* for 30 min. They were sectioned horizontally, that is, parallel to the original skin surface, and stained with sacpic stain[4].

Only one sample had a clear follicle grouping, whereas four of the Dead Sea Scroll samples[1] had clear groups. Even those with many well-preserved follicles or fibres did not show the follicle arrangement. The remains in the medieval parchments were on the whole less well preserved than those in the Dead Sea Scroll parchments, possibly owing to the wetter British climate, although many of the medieval parchments were of excellent quality. The seventeenth- and eighteenth-century parchments were on the whole of the worst quality, being the thickest, but showed most histological detail, for example, cell nuclei in follicle bulbs and surface scale patterns on the wool fibres. The nineteenth-century parchments were the thinnest, and contained the least number of remains.

The results are summarized in Table 1. Identification presented great difficulty because it had to be based mainly on individual follicles and fibres. The main criterion was the diameter of fibres and follicles, resulting in descriptions as fine, medium, and fine to medium wool, which gave no indication of breed. Sometimes, however, further information could be obtained from indications of follicle grouping and fibre-scale pattern, and suggestions of type, for example, down or long-wool, were added. A further difficulty was the likelihood that sheep of the past differed from those of to-day; for example, the mention of down sheep means that the sample had the appearance of this type, and not necessarily that the down type existed at that date. Hairy sheep were easily distinguished because of the presence of both coarse and fine fibres, the latter having a large latticed medulla (Fig. 1). They were distinguished

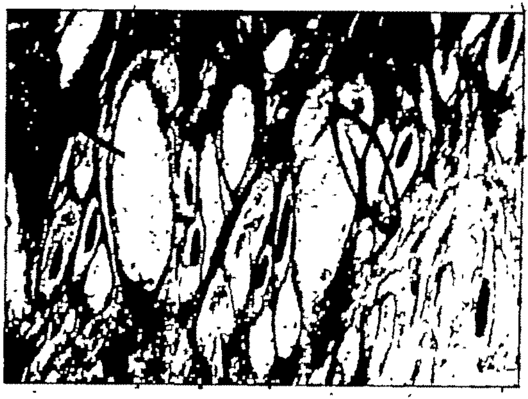


Fig. 1. Parchment, from hairy sheep; note coarse fibre with latticed medulla displaced from primary follicle, and fine fibres in secondary follicles. × 55

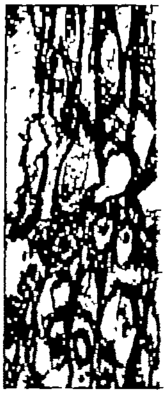


Fig 1. Parchment

from goats by the
medulla, and the s
aries in sheep.
Yorkshire, was i
pattern of the fib
parchment surfac
pigmented follicle
mented samples,
however, it was r
present in some of
those of the primit
and that these to
One sample from
1387 could not be
clear fibre remain
pigmented, as in t
not characteristic
than usually found

ibres. × 60 (see text)

e size of the latticed
r size of the second-
le from Startforth,
oat from the scale
emaining above the
ottish sample had
as with other pig-
nented calf. Later,
he pigmented fibres
les closely resembled
oay type of sheep[1,5],
een from the Soay.
ecords Office dated
though it had very
These were sparsely
the appearance was
medullæ were wider
being the size often

found in the goat, but lacking the latticed structure characteristic of wide medullæ, and the secondaries were larger than usually found in the goat. Many of the fibres had brush ends showing that they had been about to moult.

Hairy sheep were apparently present in all periods, whereas most of the fine-wool samples came from the medieval period, and most of the medium-wool samples came from the sixteenth century onward, those of the eighteenth century being the coarsest. The findings therefore support historical records which mention the extreme fineness of medieval wool, and also work which has shown evidence of an increased supply of long wool during the sixteenth- and seventeenth centuries[6]. There was evidence, however, of the existence of medium and fine-to-medium wool sheep in the Middle Ages that could have been the ancestors of the long-wool, the origin of which has recently been much discussed[6-8]. It is interesting that a suggestion of Soay sheep was found in Scotland, because it had been thought that the Soay type was widespread there until the eighteenth century.

I wish to thank all those mentioned earlier who provided the material for this work, which was carried out while I was a member of the staff of the Wool Industries Research Association, Leeds. I am grateful to Miss R. G. Jasper for technical assistance.

---

[1] Ryder, M. L., *Nature*, 182, 781 (1958).

[2] Burton, D., Poole, J. B., and Reed, R., *Nature*, 184, 533 (1959).

[3] Sandison, A. T., *Stain Tech.*, 30, 277 (1955).

[4] Auber, L., *Trans. Roy. Soc. Edin.*, 62, 191 (1952).

[5] Ryder, M. L., *Nature*, 183, 1831 (1959).

[6] Bowden, P. J., *Econ. History Rev.*, ii, 9, 44 (1956).

[7] Ryder, M. L., *Agric. History Rev.*, 7, 1 (1959).

[8] Ryder, M. L., "Sheep Breeds in History", in Year Book of the National Sheep Breeders' Assoc. (in the press).

-LIMB REFLEXES IN THE KITTEN

By Dr. STEN SKOGLUND

Institute of Anatomy, University of Uppsala

Velocity of Transmission c

and Spinal ptive Hindlimb

MALCOLM[1,2] s
prioceptive
natal development
in kittens. With r
reflexes, Malcolm s
partly medullated
nothing of the tim
He concluded that
the cord is monosy
chronous volley v
studied the proper
related the increas
skin nerve to the in
development. From
the peripheral nerv
the kitten are not
rate of conduction,
sated for by the de
This conclusion has
who presumed tha

ansmission of pro-
xes and the post-
ation and inhibition
conduction of these
iny fibres are only
lucting[2], and says
s in the reflex arc.
l transmitted over
it is a single syn-
discharge. Hursh[3]
g nerve fibres and
f conduction of a
h of the leg during
dded that, so far as
the movements of
e of the decreased
r is nicely compen-
of the nerve path.
xtended by Lloyd[4].
ssion through the

spinal cord is not slower in the new-born animal than in the adult.

It will here be shown that both the peripheral conduction and the central transmission of proprioceptive hind-limb reflexes are slower in the new-born kitten than in the adult animal, until the kitten reaches the age when it can walk and stand on its hind-legs. Furthermore, it is concluded for several reasons that the spinal transmission of proprioceptive reflexes is monosynaptic.

Experiments have been performed on kittens from 60 different litters, most of them ranging in age from 1 to 45 days. They were either decerebrated and spinalized or anæsthetized with nembutal intraperitoneally (35 mgm./kgm. body-weight). Various hind-limb nerves were dissected free for stimulation and recording, and after laminectomy either all dorsal or all ventral roots from *LII* and downwards were severed for recording or stimulation. This preparation has been used both for determining the velocity of conduction and the spinal transmission of proprioceptive reflexes as well as their reaction to antidromic and tetanic stimulation, and their facilitation and inhibition. Furthermore, the Renshaw feedback and the impulse-flow from sense organs in the muscle have been studied. Here only the development of the time relationships in the proprioceptive hind-limb reflexes will be considered.

At birth, the velocity of conduction of the fastest muscle afferents varies in different litters and animals from 8 to 12 m./sec., which means a time of conduction of around 3–4 m./sec. from, say, the gastrocnemius muscle to the spinal cord, the distance varying from 3·5 to 4·5 cm. When the kitten is well able to support its body-weight on the hind-legs, the velocity of conduction of the fastest muscle afferents has increased to about 30 m./sec. At the same time the distance has increased to 5–8 cm. from the gastrocnemius, which means a time of conduction of around 3 msec. This velocity of conduction is normally attained at an age of 18–25 days postnatally.

The ventral roots and muscle efferents are developed earlier than the dorsal roots and muscle afferents, having a velocity of conduction that is 2 m./sec. faster in the new-born animal. When the efferents have achieved a velocity of about 30 m./sec., there appears a later wave in the neurogram on stimulation at ten times threshold for the biggest efferents. This wave has been found to correspond to the gamma-efferents in the adult nerve.

On stimulating a muscle nerve or a dorsal root and recording on the central end of the cut ventral root, a rather synchronous potential is obtained in the new-born kitten (Fig. 1). With increasing age the reflex time is seen to diminish, so that, at a velocity of peripheral conduction of 30 m./sec., it is about the same as that of the monosynaptic potential in the adult animal[5-7]. Such a long reflex time as that in the new-born kitten does not immediately suggest that it is mediated by a two-neuron arc. The flexor behaviour of the animal[8] suggests rather that the reflex is polysynaptic and directed to the flexors. This possibility can be immediately ruled out, for on stimulating the dorsal roots and recording on the muscle nerves, or both stimulating and recording on the muscle nerve, a reflex with the same central delay can be recorded on both extensor and flexor nerves. Thus, so far its identity with the monosynaptic reflex is clear. In Fig. 2 the reflex time on stimulating the dorsal and recording on the ventral root has been plotted against velocity of conduction in the muscle afferents (circles). Subtracting the time of conduction in the dorsal and ventral roots gives the curve with half-filled circles. Measurements on spinal cord sections in a new-born kitten have shown that the intraspinal conduction path to the ventral horn cells amounts to 2 mm. in *S* 1. Plotting the time of conduction in the dorsal root collaterals kept at a constant length of 2 mm. against velocity of conduction in the muscle afferents, the velocity of intraspinal conduction being assumed to be a third of that for the adult animal gives the filled circles. From these curves is seen that, with a synaptic delay of 0·5–0·8 m./sec.[9], there would be no time for more than one synapse. The velocity of conduction in the thin dorsal root collaterals might be even slower in the new-born kitten than the calculated value, and the conduction path is somewhat longer than 2 mm. at the later stages of development, which would shift the filled circles to the right, as the time of intraspinal conduction from the ventral horn cells to the surface of the cord, here not calculated, will do. It is thus concluded that the reflex is mediated by arcs of two neurons already in the new-born animal, the long reflex-time being due to the slow velocity of conduction, although a somewhat longer synaptic delay than in the adult animal might be at hand.

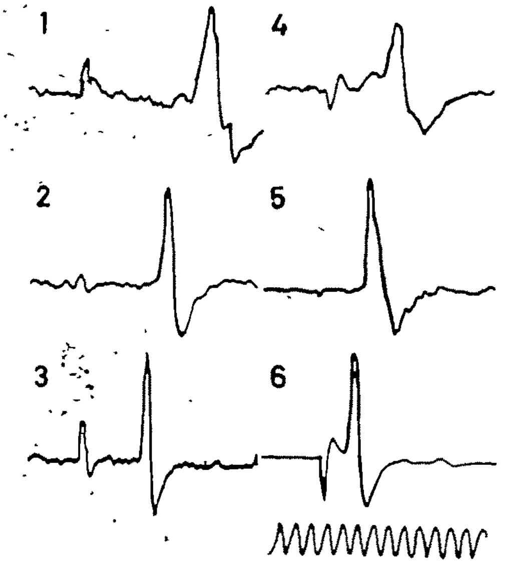


Fig. 1. Reflex potential recorded on the central end of the cut ventral root in three different experiments, (1), (2), (3), on stimulation of the gastrocnemius nerve in the popliteal fossa, afferent nerve path 4 7 cm., 5 4 cm. and 6·8 cm., respectively; (4), (5), (6), on stimulation of the cut dorsal root *S* 1, (1) and (4) from 1-day old kitten, (2) and (5) from 12-day old kitten, (3) and (6) from 28-day old kitten. Time, 1,000 c./sec. Note shock artefacts appearing one under the other

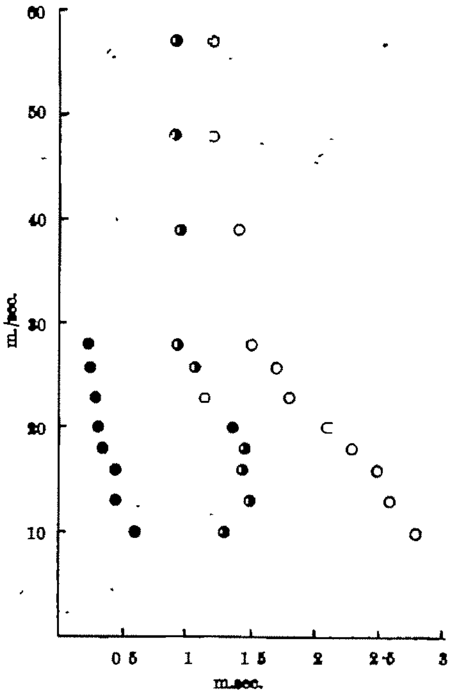


Fig. 2. Reflex-time on stimulation of the dorsal root and recording on the ventral root *S* 1 plotted against the velocity of conduction of the muscle afferents in 11 experiments (circles). The central reflex-time plotted against velocity of conduction of the muscle afferents in the same 11 experiments (half-filled circles). Time for dorsal root collateral conduction plotted against velocity of conduction of the muscle afferents up to 28 m./sec. (filled circles). For further explanation see text

From these experiments it is seen that the stretch reflex loop approaches the same time relationships

as in the adul
conduction h
the eighteent
has earlier bee
tonic stretch r
time.

[1] Malcolm, J. L.,
(1953).
[2] Malcolm, J. L., in
104 (Acad. Pr
[3] Hursh, J. B., *A*
[4] Lloyd, D. P. C.,
Fulton (W. B.
[5] Eccles, J. C., an
[6] Renshaw, B. B.,
[7] Lloyd, D. P. C.,
[8] Skoglund, S., K
(1959).
[9] Skoglund, S., *U*

Propert

In a series o
tors[1–3] have sh
elicited either
pulls on a m
called tonic t
which can be e
potentiation.
about by the
endings drivin
set up a state
potentiation[1,2]
synaptic pathw
for its slow co
to prevent the
tion. Thus po
develops simu
synergists.

Experiments
1–45 days of a
munication.

The first thi
synaptic reflex
longer recover
To obtain the re
between the s
eliciting the ref
or three reflex p
ones. The refle
more frequently
of motoneuron
shock to the v
within 100 mse
the long recove
central reflex-ti
the velocity of
afferents has re
reflex shows ab
adult animal.

Applying a su
muscle afferents
with a frequenc
in the adult ani
tiation[3] (see Fig.
completely for a
tion, the time va
in the same ma
the potential r
latency up to 3
30–50 msec. it

the velocity of peripheral
m./sec., which occurs on
lfth day postnatally. It
decerebrate rigidity and
in the hind-limbs at that

nt. Physiol Congr., Montreal, 586

he Developing Nervous System".
, 1955).
, 140 (1939).
ysiology", seventeenth edit., 57,
ladelphia and London, 1955).
J. Physiol., 89, 43*P* (1937).
, 373 (1940).
, 293 (1943).
hället i Uppsala Årsbok, 3, 75

1–2, 92 (1959).

wo-Neuron Arc

s, Granit and collabora-
t-tetanic potentiation[4,5]
stimulation or repeated
certain motoneurones
h a series of impulses,
eight of the post-tetanic
se events are brought
ion of the nuclear bag
uencies high enough to
ilitation or post-tetanic
e shown that the mono-
n has properties, except
h the cord, which seem
ilitations of long dura-
ntiation is lacking and
h facilitation between

performed on kittens
in the preceding com-

en eliciting the mono-
kitten is that it has a
in the adult animal[6].
ize, up to seven seconds
sary. When usually
1 second, the first two
gger than the following
bserved if it is elicited
Testing the recovery
after an antidromic
ws complete recovery
is thus concluded that
formity with the long
ic in character. When
luction for the muscle
c., the monosynaptic
covery time as in the

anic stimulation to the
mes from 3 to 30 sec.
npulses/sec. is not, as
y post-tetanic poten-
e potential disappears
ec. after the tetaniza-
ration and frequency
dult animal[6]. When
an increased central
during a period of
1 the control latency,

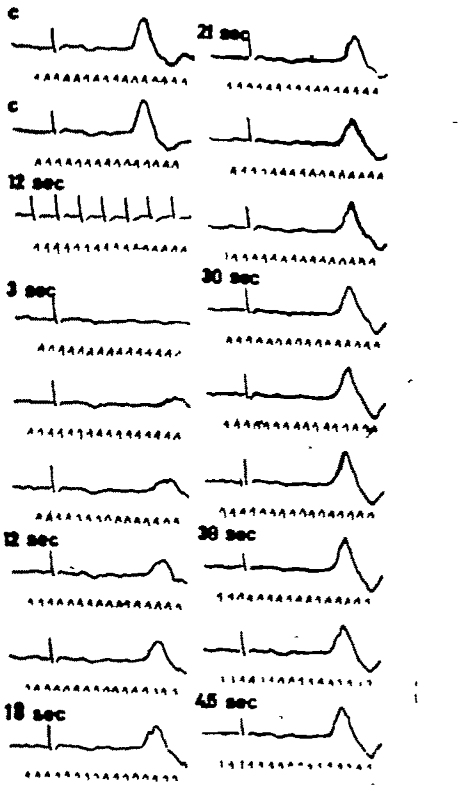


Fig. 1. Monosynaptic reflex elicited from the nerves to the gastrocnemius muscle and recorded on the ventral root *S* 1 in a 1-day-old kitten. Two controls, c, followed by a 12 sec. supramaximal tetanic stimulation at a frequency of 400 imp./sec. After that, the reflex is tested every third second. Further explanations in text. Time, 1,000 c./sec.

the potential being restored somewhat earlier (see Fig. 1).

With advancing age the increase of latency after tetanization, as well as the time required before latency and the height of the potential have resumed their control value, diminish. When the velocity of peripheral conduction has exceeded 20 m./sec., the first signs of a post-tetanic potentiation appear in response to a short tetanus, a long tetanus still setting up an increase of latency and diminution of the potential for quite a considerable time.

Post-tetanic potentiation is well developed when the conduction velocity of the muscle afferents has reached 30 m./sec. 18–25 days postnatally. At this stage of development short tetani also give facilitation of potentiation[1].

These experiments have provided information on the postnatal development of the dorsal root collaterals and events concerned with post-tetanic potentiation. Here, however, I wish to stress only the simultaneous development of post-tetanic potentiation and other adult features of the monosynaptic pathway on one hand, and decerebrate rigidity and tonic stretch reflexes[7,8] on the other.

[1] Granit, R., *J. Physiol.*, 131, 32 (1956).
[2] Granit, R., Henatsch, H.-D., and Steg, G., *Acta Physiol. Scand.*, 37, 114 (1956).
[3] Granit, R., Phillips, C. G., Skoglund, S., and Steg, G., *J. Neurophysiol.*, 20, 470 (1957).
[4] Larrabee, M. G., and Bronk, D. W., *J. Neurophysiol.*, 10, 139 (1947).
[5] Lloyd, D. P. C., *J. Gen. Physiol.*, 33, 147 (1950).
[6] Eccles, J. C., and Rall, W., *J. Neurophysiol*, 14, 353 (1951).
[7] Skoglund, S., Kungl. Vetenskapssamhället i Uppsala Årsbok, 3, 75 (1959).
[8] Skoglund, S., *Uppsala Läkaref. förh.*, 1–2, 92 (1959).

LETTERS TO THE EDITORS

PHYSICS

Effect of Specular Reflexions on the Radiation Flux from a Heated Tube

A QUESTION of some importance that arises in problems of radiational transfer of energy in an enclosure is this: If ε is the emissivity, and hence also the absorptivity, of the surface, in what manner is the fraction $(1 - \varepsilon)$ of the incident radiation that is not absorbed returned to the enclosure? In most investigations on the radiation from the inside of a uniformly heated cylinder it is assumed that the whole of this fraction is diffusely radiated according to the cosine law[1]. The alternative case where the whole of this fraction is specularly reflected does not seem to have been investigated. This case also is of interest, since it can be secured in practice by suitably polishing the wall surface, and secondly since it lends itself to a more precise and elegant theoretical treatment than the corresponding case of perfectly diffuse reflexion.

Consider, for example, the flux of radiation that issues from the mouth of a cylinder, open at both ends, the temperature of which is kept uniform over its whole length. In order to evaluate the flux one may adopt a method somewhat similar to that used by Berman, Simon and Ziman[2] for calculating the effect of specular reflexions of thermal phonons of long free path from the walls of a cylindrical crystal on its thermal conductivity at low temperatures—though these authors were concerned, unlike here, with transport of energy under a gradient in temperature. The flux can be readily shown to be equal to:

$$F_L = \sigma T^4 \sum_{r=0}^{\infty} \varepsilon^2 (1 - \varepsilon)^r \int_0^L \mu\left(\frac{h}{r+1}\right) dh \qquad (1)$$

where:

$$\mu(h) = \pi\left[h - \frac{2h^2 + D^2}{2(h^2 + D^2)^{1/2}}\right] \qquad (2)$$

σ being Stefan's constant, L the length of the tube and D its internal diameter.

When the tube is long, that is, when $L \rightarrow \infty$, the expression for the flux reduces to:

$$F_\infty = \sigma T^4 \varphi(\varepsilon) \int_0^\infty \mu(h') dh' \qquad (3)$$

where:

$$\varphi(\varepsilon) = \sum_{r=0}^{\infty} \varepsilon^2 (1 - \varepsilon)^r (r + 1) \qquad (4)$$

is the factor by which the corresponding expression for the ideal case when the walls of the tube are black has to be multiplied in order to take into account the defect of actual ε from unity and the consequent occurrence of specular reflexions.

It can be readily seen that:

$$\varphi(\varepsilon) = \varepsilon^2[1 + 2(1 - \varepsilon) + 3(1 - \varepsilon)^2 + \ldots] = 1 \qquad (5)$$

That $\varphi(\varepsilon)$ is independent of ε and is equal to unity, as though the direct radiations only were involved and they corresponded to those of a black body, is significant. It can be further seen that $\int_0^\infty \mu(h) dh = \frac{1}{4}\pi D^2$, which is just the area S of the mouth of the tube, and that $F_\infty = S\sigma T^4$, which is just the radiation that one would expect from a black body of this area.

The equivalence of the flux from the mouth of the cylinder to the radiation from a black surface holds for all directions over the 2π solid angle.

When the other end of the tube is closed, the flux from the mouth includes, in addition to F_L, two more terms, F_L' and F_L'', relating to the radiations that originate from the side walls and are reflected from the end wall, and those that originate from the end wall, respectively:

$$F'_L = \sigma T^4 \sum_{r=0}^{\infty} \varepsilon^2 (1 - \varepsilon)^{r+1} \int_L^{2L} \mu\left(\frac{h}{r+1}\right) dh \qquad (6)$$

$$F_L'' = \sigma T^4 \sum_{r=0} \varepsilon^2 (1 - \varepsilon)^r \xi\left(\frac{L}{r+1}\right) \qquad (7)$$

where:

$$\xi(L) = \frac{1}{4}\pi[2L^2 + D^2 - 2L(L^2 + D^2)^{1/2}] \qquad (8)$$

With $\varepsilon = 0{\cdot}75$, the flux issuing from the mouth of a tube of length $5D$, closed at the other end, is short of that from a black body by about 1 per cent. In the alternative case of perfectly diffuse reflexion, even though the flux along some directions may approximate even more closely to that from a black surface, the total flux over all directions is considerably short of it, and remains so however much the cylinder may be extended.

E. S. KRISHNAN

National Physical Laboratory,
New Delhi 12.
March 3.

---

[1] See, for example, Buckley, H., *Phil. Mag.*, **4**, 753 (1927).

[2] Berman, R., Simon, F. E., and Ziman, J. M., *Proc. Roy. Soc.*, A, **220**, 171 (1953).

Gamma Irradiation of Lead Silicate Glass

GLASSES exposed to gamma radiation darken due to the trapping of electrons in defects. Much work has been done by Seitz and others on colour centres produced in alkali halides by irradiation. Glass has also been studied by many workers, and it is well known that the intensity of the colour produced in glass fades in the dark and that this process is accelerated by increase in temperature or by exposing the glass to light. The present work was undertaken to investigate the mechanism involved in the darkening of glass, and the recovery in the dark with time, in an attempt to obtain better understanding of the structure of glass. A lead silicate glass of weight percentage composition PbO–80, SiO_2–20 was chosen because of the simplicity of its chemical composition (approximately $PbO.SiO_2$). Such glass might be expected to provide a simple absorption spectrum after irradiation. Rectangular blocks of glass 1 cm. × 1 cm. × 3 cm. cut from a single

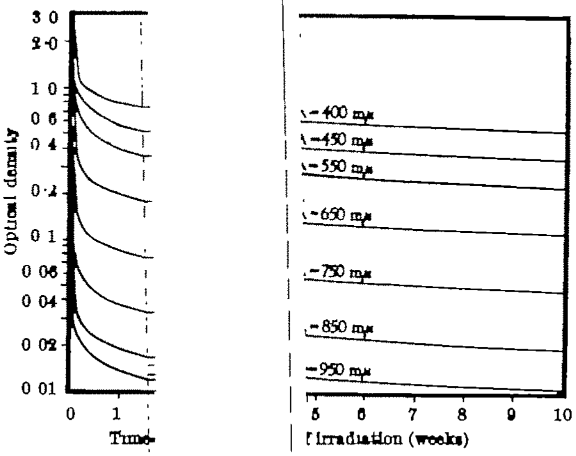


Fig. 1. Change
with time for various wave-
10^{4} rads

block of glass
and polished
Since it was
of various dos
rads, use was r
facility at the
Harwell, this
providing larg
Pairs of gla
ously so that e
tion of the tim
in steps of 10
difference in c
and an unirra
Fig. 1 shows th
after completic

n. × 3 cm. faces ground
parallel.
tudy the effect on glass
adiation from 10^{4} to 10^{8}
nt fuel-element radiation
Research Establishment,
nly facility capable of
asonably short times.
re irradiated simultane-
he same dose. By varia-
, the dose was graduated
0^{4} and 10^{8} rads. The
between an irradiated
was measured directly.
ptical density with time
iation for a dose of 10^{8}

rads. The optical density decreased rapidly immediately after removal from the radiation facility, and the rate of fading became smaller as time progressed. Similar curves obtained for other doses within the range studied had the same form.

The effect of increasing dose on optical density at different wave-lengths after certain periods of fading was studied. It was found that as the glass was irradiated, the number of colour centres increased rapidly at first with increasing dose, apparently approaching a saturation value. Complete saturation was not achieved, however, since for doses higher than 10^{6} rads the variation between optical density and dose was linear. The explanation suggested for this is that there are two processes involved: trapping of electrons in defects existing in the glass prior to irradiation; and creation of defects of the same type during irradiation. These induced defects can then trap electrons to produce the same type of colour centre. The filling up of defects already existing is complete at about $10^{5\cdot5}$ rads, but there is no evidence to suggest departure from non-linearity between the concentration of induced defects and dose up to 10^{8} rads.

The absorption spectra of the irradiated samples show three absorption bands at approximately 1·7 eV., 2·3 eV., and 3·3 eV. If it is assumed that these absorption bands are Gaussian in shape, it is possible to separate the full absorption curve into three component parts shown as dotted lines in Fig. 2. Further work is in progress and will be reported elsewhere.

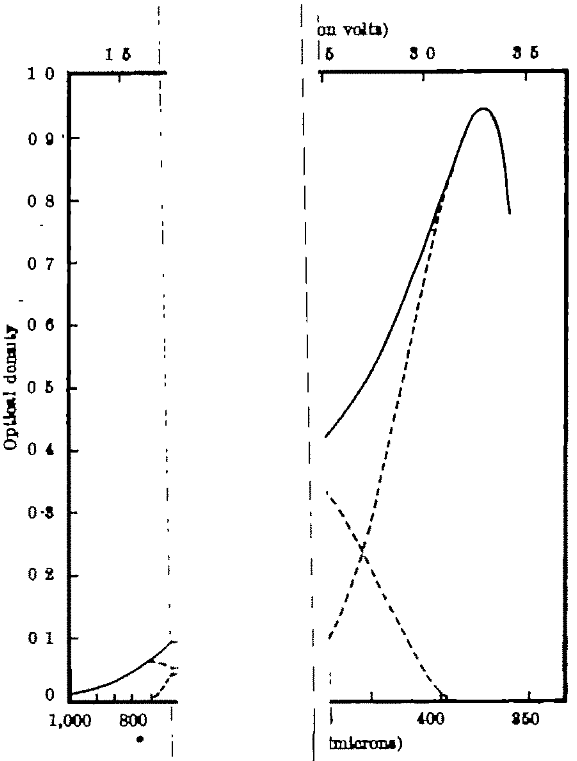


Fig. 2. Absorptio
iated glass; dose 10^{8} rads.
radiation

R. S. BARKER
D. A. RICHARDSON
E. A. G. MCCONKEY
R. RIDDIER

Research Laboratories,
Pilkington Brothers, Ltd.,
St. Helens, Lancashire.

Ultrasonic Velocities in Aqueous Electrolyte Solutions

IN a recent communication, Mr. S. V. Subrahmaniam[1] has reported measurements of ultrasonic velocities in aqueous solutions of cadmium iodide and mercuric chloride. I have made a detailed investigation of the variation of ultrasonic velocities in a number of aqueous solutions of electrolytes with concentration and temperature. The electrolytes that show the rather unusual behaviour of decreasing sound velocity with increasing concentration are the following: (1) cadmium bromide, (2) cadmium iodide, (3) zinc iodide, (4) strontium iodide, (5) lead acetate, (6) uranyl chloride, and (7) uranyl nitrate. The detailed results were published[2,3]; the conclusions reached in those studies are as follows:

(1) While in general sound velocities in electrolyte solutions are greater than that of water and increase with increasing concentration at all temperatures the experiments on the above-mentioned electrolytes reveal the opposite type of behaviour, that is, a decrease in sound velocity with increasing concentration, the values being always less than that of water.

(2) It is also a striking feature that the velocity decrease is always associated with the presence of heavy ions like Pb^{++}, I^{-}, U^{++}, etc., so it is probable that a correlation exists between the two factors. It

as been suggested by Barthel[4] that in the case of eavy ions the velocity of Brownian motion is much ess and this may result in a decrease in velocity, Brownian motion being regarded as one of the factors hat contribute to the sound velocity.

(3) It is noteworthy, however, that the adiabatic ompressibilities are quite normal in all these cases, eing always less than that of water at all concenrations and temperatures.

(4) One more striking feature is that in spite of the nomalous variation in sound velocity a linear variaion of apparent molar compressibility with square oot of concentration is found in all cases as predicted by the Debye–Hückel theory.

(5) The slopes of the apparent molar compressibility versus square root of concentration curves and the values of apparent molar compressibility at infinite dilution do not show any marked correlation with decrease in velocity with increasing concentration.

(6) On the other hand, these properties seem to be related more to the state of dissociation of the electrolytes and the existence of complex ions.

The above work was carried out at the Indian Institute of Science, Bangalore, India, under the direction of Prof. R. S. Krishnan, head of the Physics Department, and I thank him for his kind interest and encouragement.

C. G. Balachandran*

National Research Council,
Ottawa.

* Post-doctorate Fellow on leave from the Central Building Research Institute, Roorkee, India.

[1] Subrahmaniam, S. V., *Nature*, 186, 371 (1960).

[2] Balachandran, C. G., *J. Indian Inst. Sci.*, 37, 27 (1955).

[3] Balachandran, C. G., *J. Indian Inst. Sci.*, 38, 1 (1956).

[4] Barthel, R., *J. Acous. Soc. Amer.*, 26, 227 (1954).

Perceptual Anomalies associated with a Single Contour

In the course of an investigation into the basis of 'complementary images'[1] evoked by patterns of near-parallel lines, I have observed some striking phenomena which, together with some confirmatory tests that they suggested, indicate that a single contour can be sufficient to excite a complementary image.

Two 300-W. projectors were focused on a screen at a distance of 1 metre. One of these, *A*, projected a plain bright field, while the other, *B*, projected a bright field with a black disk 10 cm. in diameter in the centre. By means of a rotating circular mask with two 10° apertures on opposite sides, these images were presented alternately, at intervals *AB* and *BA*, which could be varied by raising and lowering the axis of the mask. When the time-interval *AB* was about 30 per cent of the total cycle the following phenomena were observed. (1) Fine radial spokes extended about 2 cm. inwards from the edge of the dark disk. These were sharpest and brightest at the circumference, becoming more diffuse towards the centre. There were about 40 of them when viewed at 1 metre; (2) the disk appeared to be in continuous rotation of variable speed; (3) the disk gave the impression of slow continuous expansion; (4) the background was rather brighter and the disk considerably darker in the neighbourhood of the edge.

When the interval *AB* was 50 per cent of the cycle: (1) the radial effects were broader in appearance; (2) rotation was seen as before; (3) the disk remained constant in size; (4) the disk again appeared dark, but there were no variations in brightness towards the edge.

When the time-interval *AB* was increased to 70 per cent of the cycle: (1 The strongest radial effects were now on the outside of the disk and were described by most observers as spiky, but the disk showed diffuse internal rays. Again when viewed at 1 metre the effects extended about 2 cm. from the edge; (2) rotation was seen as before; (3) the disk now gave a compelling impression of continuous contraction; (4) the background was much brighter in the neighbourhood of the edge whereas the disk appeared uniform and considerably brighter than previously and was olive in hue.

With simultaneous presentation of *A* and *B* the disk was again of an olive shade and both this and its background appeared much brighter than in the other cases. Pattern and movement, however, were scarcely visible.

In all cases Fechner colours and 'stroboscopic' patterns[2] associated with flashing light (but unrelated to the pattern of the disk) were frequently noticed.

The phenomena were strongest for frequencies in the range of 15–25 cycles per sec. but persisted to some extent through the range of 5–40 cycles per sec.

Corresponding effects were observed using a bright disk on a dark ground and using a single straight edge, and again when a negative of the disk pattern was substituted for the plain field.

The effects were the same whether one or two eyes were used. The presentation of the plain field to one eye and the disk to the other, however, gave no comparable results.

In view of the apparent relation between these phenomena and the complementary image, a series of tests were undertaken to find out whether other methods used to evoke complementary images[1] might also be effective with a single circular contour.

As might have been expected, no convincing complementary pattern was seen as an after-image, though a few subjects have reported a very faint radial pattern. A more effective technique was found in altering the pattern brightness cyclically about once per sec., when at times a radial pattern could be seen clearly.

Simple stroboscopic illumination was also found to give unconvincing results with a single contour. When, however, flashing light was superimposed on a bright continuous image, corrugations could be seen on the darker side of the contour.

The movement seen in spatio-temporally random visual 'noise'[1] appeared more organized at the contour, although this effect was not comparable in magnitude to that produced by patterns of many lines.

Double flash stimulation of the type described above has also been found more effective in producing vivid and continuous complementary images of more complex patterns. The reason for this is not yet understood. It seems, however, that any theory of the complementary image must now account for its production at a single contour.

J. P. Wilson

Department of Physics, King's College,
University of London,
Strand, W.C.2.

[1] MacKay, D. M., *Nature*, 180, 849, 1145 (1957).

[2] Smythies, J. R., *Brit. J. Psych.*, 50, 106, 305 (1959).

Ultra-Vio Mol

THE ultra-
water has b
They found
of 200 mμ anc
as far as the l
In view of t
try of aqueo
200 mμ, this
together with
The spectra o
on a Hilger
silica prism tr
At wave-len
be essential t
from oxygen,
this region[5].
instrument se
continuously
during measur
caution led to
Golding[6] being
be observed a
a thermostatt
Hilger high-tr
cells. Correct
applied to all
The spectra
shown in Fig
50° C. are sho
were derived f
H_2O and D_2O,
calculated on t
for the exchan

which have bee
As can be see
differences in
HDO and D_2O
the spectra are
The shape of
with the previ

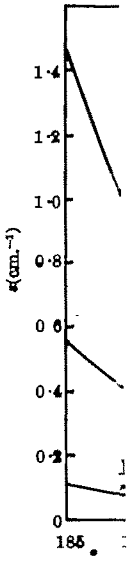


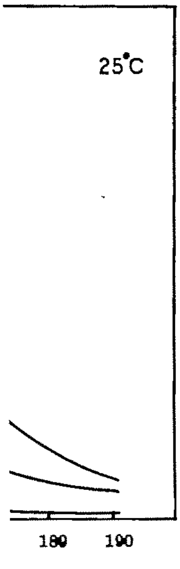
Fig. 1.

ion Spectra of the HDO and D_2O

ion spectrum of liquid
by various workers[1-4].
m begins in the region
h decreasing wave-length
ement at 180 mμ.
erest in the photochemis-
wave-lengths less than
as been re-investigated
olecules HDO and D_2O.
materials were measured
ispek' equipped with a
wn to 185 mμ.
195 mμ, it was found to
entire optical path free
ng strong absorption in
one by modifying the
ptical system could be
oxygen-free nitrogen
ure to observe this pre-
ar to those reported by
order that spectra could
peratures, we have used
ge in conjunction with
-mm. and 1-cm. silica
tered light have been
es measured.
and D_2O at 25° C. are
orresponding spectra at
The spectra of HDO
ra of a 1 : 1 mixture of
of HDO present being
e equilibrium constants

⇌ 2HDO

Urey[7].
tra, there are significant
n coefficients of H_2O,
wave-length, and also
endent on temperature.
of H_2O is in agreement
work, but the value of



DO and D_2O at 25° C.

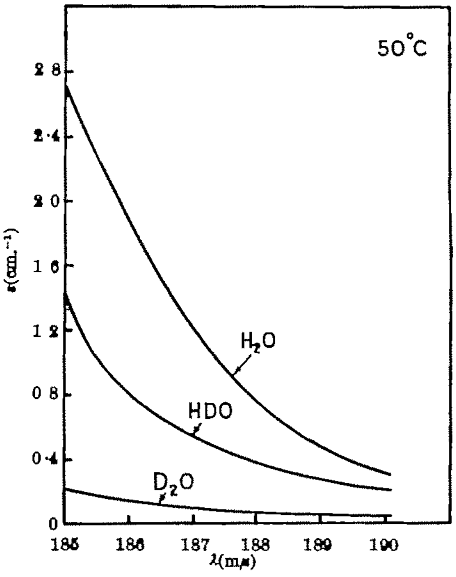


Fig. 2. Spectra of H_2O, HDO and D_2O at 50° C.

1·46 cm.⁻¹ for ε for water at 185 mμ at 25° C. is higher than the previously reported value of 1·2 cm.⁻¹ (ref. 8). This we consider to be due to the greater accuracy of the method and to the substantial correction for scattered light at this wave-length. The values for the absorption coefficients of H_2O, HDO and D_2O will be of use in the interpretation of results of photochemical investigations of systems containing these species.

The observed dependence on temperature has been noted by Golding[6]. We have investigated this effect in several systems in which hydrogen-bonding is known to be present.

We have found that the dependence on temperature in such systems is much more pronounced than in those where hydrogen-bonding is not present, as the following typical results show:

Absorbing molecule	λ(mμ)	T° C.	D (1 cm.)
Methanol	220	3	0·186
Methanol	220	25	0·253
Hexane	220	3	0·120
Hexane	220	25	0·140
Carbon tetrachloride	260	3	0·76
Carbon tetrachloride	260	25	0·92

We consider that the effect of temperature on the reported spectra can be interpreted in terms of the degree of hydrogen-bonding present. The presence of such bonds may lower the transition probability of the optical electrons.

M. Ito[9] has discussed a similar effect in the spectra of organic molecules.

JACK BARRETT
A. L. MANSELL

Department of Science,
Hatfield Technical College,
Herts.

---

[1] Tsukamoto, *Rev. d'Optique*, **7**, 89 (1928).
[2] Kohler, *General Electric Review*, **39**, 232 (1936).
[3] Goodeve and Stein, *Trans. Farad. Soc.*, **27**, 393 (1931).
[4] Klevens and Platt, *J. Amer. Chem. Soc.*, **69**, 3055 (1947).
[5] Pearse and Gaydon, "The Identification of Molecular Spectra".
[6] Golding, *Nature*, **186**, 308 (1960).
[7] Urey, *J. Chem. Soc.*, 562 (1947).
[8] Barrett and Baxendale, *Trans. Farad. Soc.*, **56**, 37 (1960).
[9] Ito, *J. Mol. Spec.*, **4**, 106 (1960).

Drs. Barrett and Mansell imply that the ultra-violet absorption spectra of water reported by me[1] were due to failure to flush the optical path by oxygen-free nitrogen.

The normal spectrophotometric precautions for work in this difficult region were observed. The sample space and detector optics of the Beckman *DK2* were scavenged with dry oxygen-free nitrogen. The monochromator of the instrument involves only one beam path, and the double-beam chopping is external to this unit. This monochromator is factory-sealed, and was not flushed with nitrogen. The effects of stray light, scattered light and band-width were investigated.

Stray light (inherent in the instrument) and scattered light (inherent in the solvent) may be ignored (less than 1 per cent) below the following readings of optical density:

Wave-length	186 mμ	188 mμ	190 mμ	195 mμ
Maximum optical density for error < 1 per cent	0·5	0·6	1·2	2·0

The band-width can be kept to less than 0·3 mμ down to 185 mμ. By partially closing the sample shutter (equivalent to a fixed absorption), the deviation at the extreme end of the instrument from the fixed optical density reading can give a measure of the stray light figures, which are very dependent on the slit-widths as shown at 185 mμ.

Band-width	0·35 mμ	0·42 mμ	0·52 mμ	0·7 mμ
Percentage stray light	1	6	14	30

Flushing the instrument with dry nitrogen and bubbling nitrogen or hydrogen through the water sample for 12 hr. made no visible alterations to the spectrum. Reversing the sample and reference cells produced an exact mirror image of the spectrum. The spectrum did not come from the matched cells, since heating the reference cell to about 70° C. also had no effect on the spectrum. These precautions show that the water spectrum was real and not inherent in the Beckman *DK2* or in the various gases in the water and the instrument.

The water spectrum was shown to obey Beer's law by varying the path-length using a number of cells.

Path-length (cm.)	Optical densities		
	188·0 mμ	189·5 mμ	191·0 mμ
1	0·260	0·230	1·180
2	0·520	0·460	0·360
3	—	0·690	0·540

Concentrated sulphuric acid has no peaks in this region, and on adding water to the acid the water peaks suddenly appear.

In an experiment, two matched cells filled with water were placed in sample and reference beams, and the instrument gave a straight I_0 line. When solutes were added to the sample cell, the reported water spectrum[1] appeared, promoted by the presence of solute. This cannot be due to an instrument characteristic.

An extensive investigation of the Beckman *DK2* double-beam spectrophotometer suggests that the water spectrum at 190 mμ is real. A more detailed paper will be published shortly interpreting the results.

R. M. Golding

Dominion Laboratory,
Department of Scientific and Industrial Research,
Wellington, New Zealand.

---

[1] *Nature*, 186, 808 (1960).

CRYSTALLOGRAPHY

Crystal Structure of 9 : 10-Dimethyl-1 : 2-benzanthracene

As part of an investigation into Daudel and Pullman's theory[1] of the connexion between the carcinogenic activity of benzanthracene derivatives and their structure, we have made an accurate determination of the crystal structure of 9 : 10-dimethyl-1 : 2-benzanthracene. It is a potent carcinogen, unlike its parent, 1 : 2-benzanthracene, the structure of which we have reported previously[2].

All X-ray data were collected from a good crystal, about 0·3 mm. on an edge, grown by cooling from amyl acetate. Basic data are: $a = 7 \cdot 62$ Å., $b = 8 \cdot 62$, $c = 21 \cdot 11$, space group $P2_1nb$, $Z = 4$ molecules/cell, $d_{\text{calc.}} = 1 \cdot 23$. (The alternative space group *Pmnb* would lead to an impossibly high density unless all atoms lay in the planes $x = 1/4, 3/4$; this would cause the $0kl$, $2kl$, $4kl$, . . . reflexions to be essentially identical, and the $1kl$, $3kl$, $5kl$, . . . likewise. In fact these reflexions are similar but not identical.) Of the 1,647 independent reflexions observable with copper $K\alpha$ radiation, 347 were photometered from integrated Weissenberg photographs, 1,134 were estimated by eye from ordinary Weissenberg photographs, and the remaining 166, which were too weak to measure, were given intensities of half the minimum that could have been measured. No corrections for absorption were made.

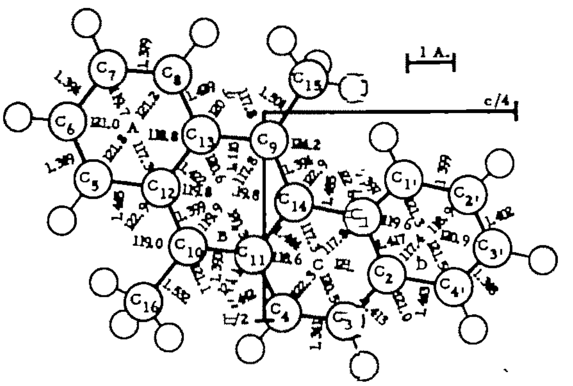


Fig. 1. The a-axis projection of 9 : 10-dimethyl-1 : 2-benzanthracene. The numbers give 3-dimensional bond-lengths and angles

The approximate structure was found from considerations of packing and by fitting a few critical reflexions. The refinement was done by least squares, using the programme *NY XR*1 on the *IBM* 704 to minimize the function $R' = \Sigma w_H (F_H^{\text{obs.}} - K'|F_H^{\text{calc.}}|)^2$. All 1,647 reflexions were included. The weights w_H were set equal to min. $(1, 100/F_H^{\text{obs.}2})$. The parameters refined were K', plus x, y, z, and B for each of the 20 carbon atoms. The hydrogen atoms were included, but were simply moved in conformity with the carbon skeleton. Table 1 and Fig. 1 show the results. The final values of the conventional discrepancy R and R' were 13·5 per cent and 1,261. The average standard deviations for atom position, C—C bond-length, C—C—C bond-angle, and temperature factor B are 0·003 Å., 0·011 Å., 1·2° and 0·14 Å.^{2}.

If the bond-lengths of the 23 C—C bonds are converted into bond orders by the use of Pauling's curve, it is found that they range from order 1·01, for the

Table 1. Fina

or 9 : 10-Dimethyl-1 · 2-benz-
ene

	Co-ordinat		Co-ordinates (Å.)			
	x		x	y	z	B
C_1	0·2479	0	·889	2·174	2·063	4·08
C_2	0·3266	0	488	3·360	2·558	4·73
C_3	0·4034	0	074	4·305	1·687	5·53
C_4	0·3959	0	017	4·135	0·259	5·04
C_5	0·2436	0	·856	1·375	−3·600	5·98
C_6	0·1909	0·	·455	0·194	−4·115	6·79
C_7	0·1579	−0	203	−0·901	−3·289	6·62
C_8	0·1842	−0	408	−0·792	−1·929	5·11
C_9	0·2447	0	865	0·583	0·098	3·69
C_{10}	0·3228	0	455	2·779	−1·623	4·35
C_{11}	0·3279	0	498	2·931	−0·242	4·01
C_{12}	0·2660	0	027	1·568	−2·179	4·37
C_{13}	0·2332	0	777	0·452	−1·333	3·86
C_{14}	0·2708	0	064	1·859	0·623	3·54
C_{15}	0·2436	−0	856	−0·675	0·918	4·68
C_{16}	0·3745	0	854	3·925	−2·559	6·61
C_1'	0·1444	0	101	1·394	2·913	4·53
C_2'	0·1275	0	·971	1·704	4·272	6·09
C_3'	0·2175	0	657	2·816	4·782	6·70
C_4'	0·3093	0·	357	3·632	3·969	6·08

C_{16}—C_{16} bond,
(The average b
fact that after
32 pairs of val
the 23 C—C bo
The molecule
down out of th
C_{15} up by abou
C_{15} and C_1' to g
We are grate
for Cancer Res
supplying a sm
the U.S. Public
Business Machi

e C_3–C_4 (K region) bond.
·39, agreeing with the
e C—H bonds there are
to be distributed over
e of 1·39 pairs per bond.)
Ring D has been bent
by about 20°, and atom
istortion permits atoms
ay from each other.
Creech of the Institute
hase, Philadelphia, for
pure material, and to
e and the International
for financial grants.

E. R. Johnson
Univ
Phila

). Sayre*
. H. Friedlander†
Medical Physics,
sylvania,
nsylvania.

* Present address
500 Madison Avenue

usiness Machines Corporation,
w York.

† Present address
Co., 202 North Canc

n-Ramo-Wooldridge Products
Hills, California.

[1] Daudel, R., and Pu

d. Sci., Paris, 221, 201 (1945).

[2] Friedlander, P. H.

ature, 178, 999 (1956).

Crystal Str
Fc

he High-Pressure
Ice III

At the sugges
undertaken a s
polymorphs of
bearing upon th
line arrangeme
temperature an
will be pertinen
liquid water an
bond.

In addition t
pressure (ice I,
polymorphs (ice
of 2,000 atmosp
covered by Tam
investigation by
data for ice II a
these two forms
available. The
ice II and ice II
hedral character
molecules, which
in these substan

inus Pauling, we have
y of the high-pressure
heir intrinsic interest,
lity of different crystal-
arying conditions of
e results of this work
d, to the structure of
getics of the hydrogen

stable at atmospheric
l ice Ic, cubic), six ice
at pressures upwards
own; they were dis-
Bridgman[2]. An X-ray
ive powder diffraction
d led to structures for
ta have hitherto been
ven by McFarlan for
ate the expected tetra-
bonding by the water
to the conclusion that
r molecules are disso-

ciated, their tetrahedral character is lost, and the protons lie midway between the oxygen ions. These conclusions are not in harmony with modern ideas on the nature of molecular structure and of intermolecular forces.

We have built equipment for making the high-pressure ice polymorphs and extracting them for X-ray study, utilizing Tammann's discovery that these substances can be held metastably at atmospheric pressure if maintained at liquid-nitrogen temperature. A small sample of water is confined in a cylindrical chamber closed by movable pistons and loaded by means of a hydraulic press. The temperature and pressure of the sample and its volume can be measured, and the phase transitions observed directly as discrete changes in volume. The press can then be submerged in liquid nitrogen, and the sample expelled, by means of the hydraulic press, into a liquid-nitrogen bath.

From samples prepared in this way we have obtained both X-ray powder diffraction and single-crystal data. The samples under X-ray examination were cooled continuously in a stream of nitrogen gas at − 190° C.

Our powder data for ice II and ice III disagree with McFarlan's data for the same substances. Our data for ice III are in fairly good agreement with McFarlan's data for ice II, for the larger spacings, whereas our data for ice II correspond to neither of McFarlan's sets of powder data. Because of these disagreements, we have checked carefully the identification of our ice II and ice III samples. They satisfy all the conditions of formation, stability and metastability given by Tammann and Bridgman (with the exception of the fact that our ice II does not, in experiments to date, transform rapidly to ice V on rising temperature). We have so far found no polymorph giving powder data in agreement with McFarlan's data for ice II.

Single-crystal data for ice III show that this polymorph is dimensionally cubic but symmetrically tetragonal, with $a \simeq c = 6{\cdot}80$ Å. The space group is $P\,4_12_12$. The density calculated on the basis of 12 molecules in the unit cell is $1{\cdot}14_1$ gm.cm.$^{-3}$, in satisfactory agreement with the value $1{\cdot}13_6$ gm.cm.$^{-3}$ obtained by extrapolating to zero pressure the ice III density values determined by Bridgman over the range 2,000–3,500 atmospheres, and correcting for thermal contraction by assuming that the average thermal expansion coefficient of ice III is the same as that of ice I over the temperature-range −20° to −190° C. Consistent with the space group and density, no other number of molecules in the cell is possible.

On rotation and precession photographs, the intensities of 45 separate reflexions have been measured, in the region $\sin\theta/\lambda < 0{\cdot}5$ Å.$^{-1}$. In addition, 13 intensities on rotation photographs correspond to superimposed pairs of reflexions, the separate intensities of which cannot be assigned without upper-level precession data not at present available. 61 additional reflexions in the region $\sin\theta/\lambda < 0{\cdot}5$ Å.$^{-1}$ have intensities too faint to observe.

It is possible to build a reasonable structure for ice III by placing 8 oxygen atoms in general positions and 4 oxygen atoms in special positions, as follows:

$$8\ O_{\text{I}} \text{ in } 8a:\ x, y, z;\ \ldots;\ \text{with } x_{\text{I}} = 0{\cdot}095,\ y_{\text{I}} = 0{\cdot}30,\ z_{\text{I}} = 0{\cdot}29$$

$$4\ O_{\text{II}} \text{ in } 4b:\ x, x, 0;\ \ldots:\ \text{with } x_{\text{II}} = 0{\cdot}392$$

The x and y parameters were also derived independently from the $hk0$ Patterson projection (13 independent reflexions only), and refined roughly by means of the (001) Fourier projection. Without systematic refinement of the parameters on the basis of the three-dimensional data, the overall agreement of calculated and observed intensities is good enough to indicate that the structure is correct. The residual $R = \Sigma|\sqrt{|F_o|^2} - \sqrt{|F_c|^2}|/\Sigma\sqrt{|F_o|^2}$ is 0·26 for the 45 observed reflexions. The calculated intensities of 13 reflexions chosen at random from among those unobserved are all weaker than the limit of observation.

In the ice III structure, each oxygen atom is surrounded by four others at distances of 2·73–2·90 Å., and the co-ordination polyhedra are approximately tetrahedral. The O_I oxygen atoms form fourfold spirals parallel to the c-axis. These spirals are linked together by the O_{II} atoms, each of which forms bonds to O_I atoms in four separate spirals. The arrangement is satisfactorily interpreted in terms of hydrogen-bonding, and the tetrahedral character of the water molecule is approximately retained, no hydrogen bond deviating by more than 15° from a tetrahedral direction.

The arrangement of oxygen atoms in ice III is very similar to that of the silicon atoms in silica K (keatite), a recently discovered[4] high-pressure polymorph of SiO_2. It is interesting, and certainly not unexpected, that the structural relationship between the silica and ice polymorphs, already known for ice I—tridymite and ice Ic—cristobalite, should be found to extend to the high-pressure forms. The tendency for the Si—O—Si bond angle in the silica polymorphs to be about 140° should, however, lead to a destabilization of the corresponding ice polymorphs, in which the hydrogen bonds would be correspondingly bent.

This work has been supported by the National Science Foundation. The detailed experimental methods and results will be published elsewhere.

W. BARCLAY KAMB
SANKAR K. DATTA

Division of the Geological Sciences,
California Institute of Technology,
Pasadena, California.

---

[1] Tammann, G., *Ann. d. Phys.*, 2, 1 (1900).

[2] Bridgman, P. W., *Proc. Amer. Acad.*, 47, 441 (1912); *J. Chem. Phys.*, 3, 597 (1935); 5, 964 (1937).

[3] McFarlan, R. L., *J. Chem. Phys.*, 4, 60 and 253 (1936).

[4] Keat, P. P., *Science*, 120, 328 (1954). Shropshire, J., Keat, P. P., and Vaughan, P. A., *Z. Krist.*, 112, 409 (1959).

CHEMISTRY

Excited Electronic States of Lithium and Sodium Molecules

THE electronic spectra of the alkali metal molecules are of interest for several reasons: for example, (1) Li_2 is sufficiently simple to be the subject of quantitative wave-mechanical calculations[1,2], and (2) these spectra may be expected to be somewhat similar to that of H_2, for which reliable analyses of many systems are now available[3,4]. Furthermore, the excited singlet *ungerade* states of the alkali metals are readily accessible, since they may be observed in combination with the ground states at $\lambda > 2300$ Å. It is therefore surprising that for Li_2 and Na_2 only the lowest excited singlet states, $A\ ^1\Sigma^+_u$ and $B\ ^1\Pi_u$, have been well characterized[5]: several systems at shorter wave-lengths have been reported[5,6], but the vibrational analyses of some of these are uncertain, and only for the system C—X of Na_2 has a rotational analysis been attempted[7].

We have now examined the C—X systems of Li_2 and Na_2, using photographs taken in absorption in first and third orders respectively of a 6·5 m. grating spectrograph. Previous vibrational analyses are confirmed, but rotational analysis of some twenty bands of each system shows that the upper states of both systems are in fact both $^1\Pi$ and presumably, since the C—X systems appear to be quite strong, $^1\Pi_u$. The earlier rotational analysis[7], which led to the conclusion that $C(Na_2)$ was $^1\Sigma^+_u$, is incorrect.

At wave-lengths shorter than the C—X systems, there are many further bands, and rotational analyses of several of these have also been made. A long $v' = 0$ progression established the vibrational numbering in the D—X system of Na_2: this again proves to be $^1\Pi_u - {}^1\Sigma^+_g$. In Li_2, the D—X system is also $^1\Pi_u - {}^1\Sigma^+_g$, but it has not yet proved possible to determine an unambiguous vibrational numbering for this system. The present results are summarized in Table 1.

Table 1

	State	T_e	ω_e	$\omega_e x_e$	B_e	$10^3\ \alpha_e$
$^7Li_2$	$D\ ^1\Pi_u$	< 34,140	~ 205	—	0·465	—
	$C\ ^1\Pi_u$	30,549	237·9	2·23*	$0·5075_6$	$9·6_4$†
Na_2	$D\ ^1\Pi_u$	33,440	110	0·5	0·1185	1
	$C\ ^1\Pi_u$	29,393	117·3	$0·5_3$	$0·1231_3$	$0·8_4$

* + 0·060 $(v + \frac{1}{2})^3$
† + $0·00018_4\ (v + \frac{1}{2})^2$

The energies of dissociation of these states are of considerable interest, and in the case of the C states of Li_2 and Na_2, quite definite lower limits can be given. Considering first Li_2, the state $B\ ^1\Pi_u$ is known to correlate with Li(2s) + Li(2p), so that the lowest excited atom pair to give $C^1\Pi_u$ is Li(2p) + Li(2p), with $E_A = 29,808$ cm.$^{-1}$. Taking[8] $D_e''(Li_2) = 9,185$ cm.$^{-1}$, $D_e'(C) \ngtr 8,445$ cm.$^{-1}$. By analogy, however, with the absorption spectrum of H_2, it might be expected that the strong absorption systems of Li_2 would be $(2s\sigma_g np\pi_u)\ ^1\Pi - {}^1\Sigma^+_g$, so that it is perhaps more probable that state C correlates with Li(2s) + Li(3p), with $E_A = 30,925$ cm.$^{-1}$. If this is so, $D'_e(C) = 9,560$ cm.$^{-1}$. In either case, the energy of dissociation in state C is not very different from that in the ground state.

For $C\ ^1\Pi$ in Na_2, the lowest possible atomic states are Na(3s) + Na(3d), with $E_A = 29,173$ cm.$^{-1}$. Thence, with[8] $D_e''(Na_2) = 6,215$ cm.$^{-1}$, $D'(C) \ngtr 5,995$ cm.$^{-1}$. However, it seems more probable that what is observed here is $4\ p\pi_u - 3s\sigma_g$ rather than the partly forbidden transaction $3d\pi_u - 3s\sigma_g$. In the former case, $E_A = 30,270$ cm.$^{-1}$, and $D'(C) = 7,090$ cm.$^{-1}$.

It is more difficult to reach a definite conclusion about the $D\ ^1\Pi_u$ state of Na_2. Bands may readily be followed up to $v' = 13$ at about 34,840 cm.$^{-1}$ above the minimum in the ground-state but this is not high enough to rule out the possibility that $C^1\Pi_u$ is $(3s\sigma_g + 3d\pi_u)$ and that D is $(3s\sigma_g + 4p\pi_u)$. If, however, it is accepted that the correlation for state C is $(3s\sigma_g + 4p\pi_u)$, then state D may be correlated with $(3s\sigma_g + 5p\pi_u)$, to give $D\,(D) = 7,815$ cm.$^{-1}$. In this case, states B, C, D form a Rydberg series of states $(3s\sigma_g np\pi_u)^1\Pi_u$, and we may obtain an approximate value for the ionization potential of Na_2 as follows:

State

B
C
D

Thus the ion
Since the ioniz
implies that D
2,150 cm.$^{-1}$ or
very surprising
pointed out to
that Li$_2^+$ is mor

Physical Chemi
University

[1] James, J. Chem. P
[2] Arai and Sakamot
[3] Dieke, J. Mol. Sp
[4] Herzberg and Hov
[5] Herzberg, "Molec
of Diatomic M
[6] "Données Spectros
edit. by Rosen
[7] Sinha, Ind. J. Phy
[8] Evans, Jacobson,
55, 83 (1955).
[9] James, J. Chem. P

Initial potential

40,610
39,313
39,300

l (Na$_2$) ~ 39,300 cm.$^{-1}$.
(Na) = 41,450 cm.$^{-1}$, this
r than D(Na$_2$) by about
At first sight, this is a
t, as Prof. Coulson has
l calculations[9] indicate
i$_2$ by about 1,200 cm.$^{-1}$.

R. F. BARROW
N. TRAVIS
C. V. WRIGHT

y,

).
, 28, 32 (1958).
(1958).
, 37, 636 (1959).
olecular Structure, I. Spectra
k, 1950).
t les Molécules diatomiques",

an, J. Res. Nat. Bur. Stand.,

Infr

THE effect of
solvents on infr
been considere
constant and p
example, Caldo
Williams[2]). A
seem to be to
solution interac
At infinite d
energy is give

$$E_{1S} = E_1$$

where L_1, L_2 an
and molal volu
and $\Delta \bar{H}_1$ is the
dilution. The v
in the absence
amounts to the
to form a hole
Fig. 1 is a p
quency shift, $\frac{\Delta\nu}{\nu}$
solution in vari
and Williams[2].
from the Intern
acetonitrile and
from the data o
no change with
approximation).

where K is a con
acetone. Becau
possible to demo
solutes other th
generally true th
in the same mo

ncy Shifts

nd solution in different
quencies has previously
changes in dielectric
association effects (for
son[1], and Bellamy and
ental approach would
s to the actual solute-

ate-solution interaction
mately by:

$$\frac{V_1}{V_2}\Big)^{n} L_2 - \Delta \bar{H}_1\Big] \quad (1)$$

ne internal latent heats
d solvent respectively,
eat of mixing at infinite
s with the solvent, but
e taken to be $\frac{2}{3}$ (this
at the energy required
to its surface area).
inst the fractional fre-
yl group in acetone in
reported by Bellamy
f $\Delta \bar{H}_1$ were obtained
Tables[4] except those for
which were calculated
ok[5] at 45° C. assuming
(this may be a poor
a fair approximation:

$$(2)$$

5·4 × 10³ cal./mole for
data it has not been
lidity of equation 2 for
but if the relation is
ifts for different groups
e rectilinearly related.

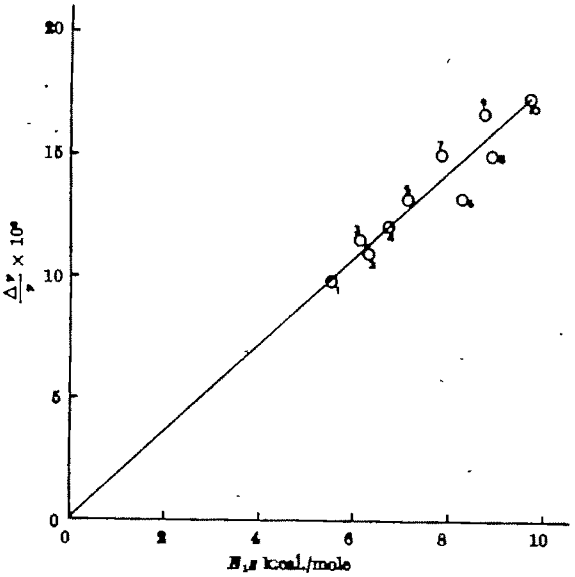


Fig. 1. Variation of frequency shift of acetone carbonyl group in different solvents with solute-solution interaction-energy. The solvents are: 1, ether; 2, carbon tetrachloride; 3, carbon disulphide; 4, benzene; 5, acetone; 6, acetonitrile; 7, chloroform; 8, nitromethane; 9, ethanol; 10, methanol

Such a relationship has been shown to exist for a number of molecules (for example, Bellamy, ref. 6).

It is evident from consideration of the frequency shifts on liquefaction that the value of K is different even for the same group in different molecules; this is presumably connected with the way in which the interaction energy is distributed among the degrees of freedom as well as with differences between the force constants of the bonds.

If equation 2 is found to be generally valid, the much-discussed question of what proportion of the frequency shift is attributable to non-specific interactions can be considered in terms of the extent to which pure dispersion energy contributes to the latent heats and heat of mixing.

R. S. NORRISH

The Distillers Co., Ltd.,
Research and Development Department,
Great Burgh, Epsom, Surrey.

[1] Caldow, G. L., and Thompson, H. W., *Proc. Roy. Soc.*, A, 254, 1 (1960).

[2] Bellamy, L. J., and Williams, R. L., *Proc. Roy. Soc.*, A, 255, 22 (1960).

[3] Bellamy, L. J., and Williams, R. L., *Trans. Farad. Soc.*, 55, 14 (1959).

[4] "International Critical Tables" (McGraw-Hill, New York, 1929).

[5] Brown, L., and Fock, W., *Austral. J. Chem.*, 10, 417 (1957).

[6] Bellamy, L. J., "The Infra-red Spectra of Complex Molecules", second ed., 404 (Methuen, London, 1958).

Two Highly Selective Solvents for Gas-Liquid Chromatography Analysis of C_2–C_6 Hydrocarbons

IN the course of a systematic investigation of polar stationary liquids for gas-liquid chromatography at a column temperature of 30° C., it was found that dimethyl sulphoxide (CH_3SOCH_3, b.p. 189° C.) and sulpholane (tetramethylene sulphone, $(CH_2)_4SO_2$, b.p. 284° C.) are very suitable for the analysis of complex C_2–C_6 hydrocarbon mixtures. Under the conditions used (see below), columns charged with firebrick impregnated with these solvents have the following properties:

(1) Compounds of closely similar boiling point but different molecular type show widely different retention volumes. Relative corrected retention volumes (*n*-paraffin = 1·00) for (hypothetical) compounds with b.p. 30° C. are given in Table 1. For comparison data on the solvents dimethylsulpholane and squalane have been included, and retention volumes for one type of chlorinated compound are given.

Table 1. RELATIVE CORRECTED RETENTION VOLUMES FOR COMPOUNDS WITH b.p. 30° C.

Homologous series of compounds	Solvent			
	Dimethyl-sulphoxide	Sulpholane	Dimethyl-sulpholane	Squalane
2,2-Di-me-alkanes	0·8	0·86	0·81	0·96
2-me-alkanes	0·9	0·95	0·89	1·00
n-Alkanes	(1·00)	(1·00)	(1·00)	(1·00)
1-Alkenes	2·0	2·1	1·7	1·00
trans-2-Alkenes	2·2	2·1	1·8	1·00
2-me-1-Alkenes	2·45	2·4	1·9	1·00
cis-2-Alkenes	2·5	2·5	1·9	1·00
Unbranched cycloalkenes	2·5	2·4	1·9	1·3
1,3-Alkadienes	6·5	5·9	3·7	1·00
1-Cl-alkanes	11·0	11·7	6·4	0·77
1-Alkynes	15·3	11·7	6·4	0·69

(2) The separation efficiency is high. In the range of relative corrected retention volumes (*n*-butane = 1·00) up to 10·0, the average height equivalent to a theoretical plate is 1·5 mm. for dimethyl sulphoxide and 1·7 mm. for sulpholane (sample size of gaseous component < 0·1 ml.).

As a result of these two properties, the following compounds having closely similar boiling points are completely separated: ethane–ethylene–nitrous oxide–carbon dioxide–acetylene, and *iso*butene–1-butene. The resolution of 2-methyl-pentane (b.p. 60·3° C.) and 2,3-dimethylbutane (b.p. 58·0° C.) is nearly complete and comparable to that achieved by *iso*quinoline[1].

(3) Owing to the low solubility of paraffins and olefins, the time of analysis is short. Complex mixtures of hydrocarbon gases up to and including *cis*-2-butene can be analysed in 25 min. A complete separation of the 13 paraffins from methane to *n*-hexane is effected in 35 min.

(4) The solvents do not react with unsaturated compounds. When acetylenic compounds with active hydrogen atoms are determined, however, glass or stainless steel tubing is required as they react with copper in the presence of dimethyl sulphoxide. For sulpholane, copper tubing can be used.

(5) The volatility of dimethyl sulphoxide is not negligible, which causes retentions to decrease gradually. From the vapour pressure at 30·0° C.[2] it is calculated (for conditions specified below) that about 1,000 l. of carrier gas are required to make the loss of weight exceed the still allowable value of 5 per cent. As the liquid phase is mainly stripped off in the first section of the column, a regular replacement of this section will dispose of this problem. The operating conditions were:

	Dimethyl sulphoxide	Sulpholane
Column length	14·4 m.	18·0 m.
Internal diameter	6 mm.	
Packing	C-22 firebrick, 50/80 mesh	
Weight ratio solvent/solid support	30 : 70	
Hydrogen flow-rate	5·0 l./hr.	4·0 l./hr.
Column temperature (air bath)	30·0° ± 0·1° C.	

The commercial solvents were distilled before use; the colourless products had the following properties:

	Dimethyl sulphoxide	Sulpholane
Boiling point	61° C. at 6 mm. mercury	168·4° C. at 31 mm. mercury
Melting point	18° C.	27° C.
$n_D^{30\cdot00}$	1·47475	1·48168
Density (gm./ml.) at 30·00° C.	1·09036	1·26120

Thanks are due to Dr. G. W. A. Rijnders for his interest in this investigation and to Messrs. J. D. Kommer, H. J. Bogaard and N. v.d. Hoed for their co-operation in the experimental work.

A. VAN DER WIEL

Koninklijke/Shell-Laboratorium,
Amsterdam
April 20.

---

[1] Zlatkis, A., *Anal. Chem.*, 30, 332 (1958).

[2] Douglas, T. B., *J. Amer. Chem. Soc.*, 70, 2001 (1948).

Gas-Solid Chromatographic Separation of Hydrocarbons of High Molecular Weight

THE deactivation of highly active polar sites on activated alumina with water to give a satisfactory column packing for the gas chromatographic separation of C_1–C_4 hydrocarbons at room temperature has been reported[1]. An extension of this work has shown that alumina can be similarly deactivated with inorganic bases and salts added in aqueous solution, the water being removed by subsequent heat treatment. At low degrees of deactivation, retention volumes for aromatic hydrocarbons can be varied relative to aliphatic hydrocarbons according to the extent of deactivation. However, the amount of sample required (~100 µgm.) to obtain a response from a flame-ionization detector suggests that considerable irreversible adsorption takes place. The most promising application appears to be at the highest degrees of deactivation (lowest activity-levels, when irreversible adsorption is much reduced) for the separation of high-molecular weight hydrocarbons.

Fig. 1 shows the separation of C_{15}–C_{23} *n*-paraffins using an alumina (initial surface area 180 m.²/gm.) preheated for 70 hr. at 750° C. to reduce surface area and to which was added 40 per cent by weight of sodium hydroxide.

Fig. 2 shows the separation of $C_{[illegible]}$–$C_{[illegible]}$ *n*-paraffins on the same column with the temperature ranging

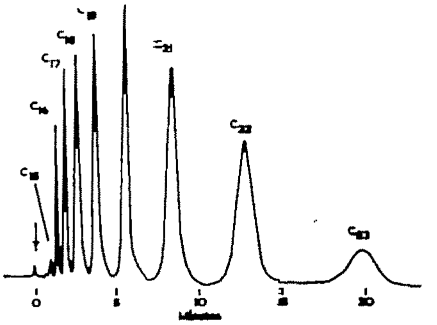


Fig. 1. Separation of refined paraffin wax. Column packing, 100 parts by weight alumina + 40 parts by weight sodium hydroxide; column dimensions, 3 ft. × ¼ in. outside diameter; column temperature, 250° C.; sample size, ~ 10 µgm.; detector, flame ionization; carrier gas, 75/25 hydrogen/nitrogen (50 ml./min.)

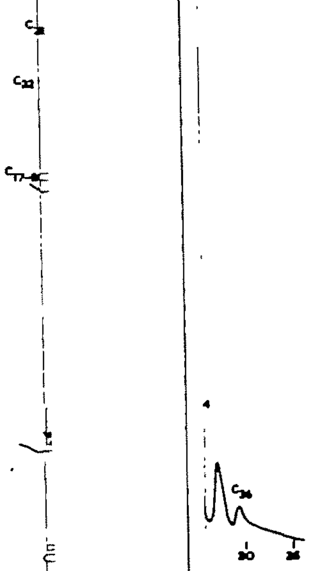


Fig. 2. Separation
column tem

wax. Detail as Fig. 1, but
om 320° to 390° C.

from 320° to 39
base-line drift is
in operating tem
Eglinton *et al.*[2]
tive detector pe
molecular weigh
temperatures ; f
gas-liquid colum
higher molecula
response of the
phase and/or i
limitation does n
an inorganic co
The present inv
retention volume
of the final modif
of high sensitivit
of operation can
n-paraffins greate

riod of 20 min. The
e detector with change

hat the use of a sensi-
omatography of high
at reduced operating
H_{74} at 228° C. With
of this principle to
ounds is limited by
carry-over of liquid
ion products. Such
lumina modified with
as sodium hydroxide.
imed at reduction in
reduction in activity
that the combination
and high temperature
r rapid separation of

C. G. Scott
D. A. Rowell

Lobitos Oilfiel
Ellesmere P
Cheshire.

---

[1] Scott, C. G., *J. Inst*
[2] Eglinton, G., Haml
Chem. and Indust

9).
, R., and Raphael, R. A.,

Microanalytic n of Steroids by Ga graphy

The applicatio
graphy to the m
has been recogni
goal. The chief
the problem aris
stable liquid phas
perties of steroid
silicones and pol
high temperature
for many steroids
even at elevated

partition chromato-
separation of steroids
ime as an attainable
ractical advances in
ture of the thermo-
y known and the pro-
reases, thermostable
be used at relatively
stribution coefficients
avour of these phases

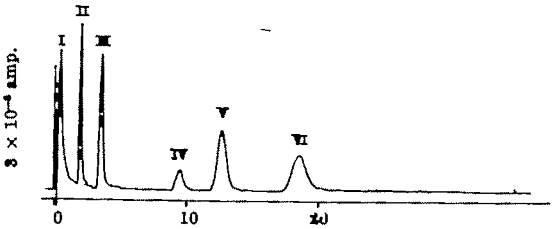


Fig. 1. Chromatographic separation of 50 μgm. total of steroid sample, as 5 per cent solution in benzene. Column temperature, 270° ; argon pressure, 25 p.s.i. ; column size, 100 cm. × 2 mm. ; argon ionization detection system. Compounds are I, solvent and androstane ; II, androstan-17-one ; III, cholesterol methyl ether and cholestanol methyl ether ; IV, cholestanone ; V, androstan-3,17-dione ; VI, Δ⁴-androstene-3,17-dione

An alternative to the use of non-polar phases lies in exploring the separating properties and retention times for thermostable polar phases. We have worked with an ethylene glycol–*iso*phthalic acid polyester (E. I. du Pont de Nemours, Inc.). The column packing was prepared by a solution technique[1] with a 10 per cent chloroform solution of the polyester and 60–80 mesh acid-washed 'Celite 545'. The coated 'Celite', containing 20 per cent (w/w) of stationary phase, was vibration-packed in a glass U-column (100 cm. × 2 mm.) and was conditioned briefly at 200°. A Lovelock argon ionization detector was used.

The separation of a synthetic mixture of steroids is shown in Fig. 1. Analyses within a temperature-range of 220–280°, with argon flow-rates of 50–100 ml./min., showed column efficiencies of 1,400–1,800 theoretical plates. No separation was observed for cholesterol methyl ether and cholestanol methyl ether in any circumstances, but androstane-3,17-dione and Δ⁴-androstene-3,17-dione had widely different retention times. There was no evidence of decomposition of any of these compounds ; but this point must be studied in greater detail and particularly with respect to derivatives of hydroxyl-substituted compounds. The thermal stability of the column was relatively good ; there was almost no 'bleed' at 200–220°, and thermal breakdown required several days at 280°.

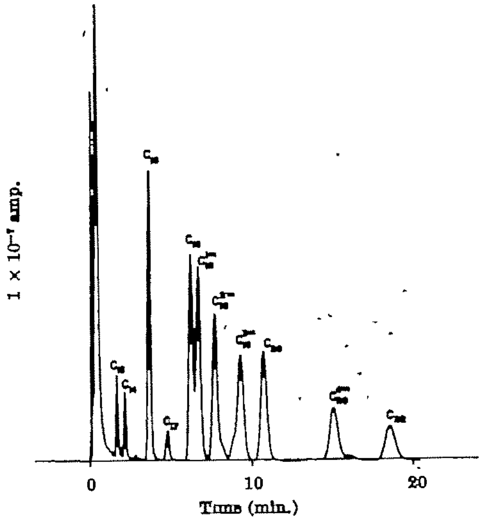


Fig. 2. Chromatographic separation of mixture of methyl esters of long-chain fatty acids. Column temperature, 230° ; argon pressure, 14 p.s.i. ; column size, 180 cm. × 4 mm. ; argon ionization detection system

Present knowledge of the properties of polyester phases is largely based on their use in lipid work for the separation of fatty acid methyl esters; this use is based on the observations of Lipsky and Landowne[3], Orr and Callen[4] and Craig and Murty[5]. Fig. 2 shows an array of fatty acid esters separated on an ethylene glycol–*iso*phthalate polyester column. The column may be useful for examinations of mixtures of very long chain compounds since the C–24 level may be reached in a few minutes if desired, but it is not likely to be useful in quantitative work because of the failure to separate completely methyl stearate and methyl oleate (oleate/stearate separation factor = 1·07).

For steroid separations, as with fatty acid esters, it is likely that both non-polar and polar phases will find specific applications. The present investigation provides an example of a polar phase suitable for steroid work.

C. C. SWEELEY
E. C. HORNING

Laboratory of Chemistry of Natural
Products,
National Heart Institute,
Bethesda, Maryland.

[1] This effect is reflected in the data of Eglinton, G., Hamilton, R. J., Hodges, R., and Raphael, R. A., *Chem. and Indust.*, 955 (1959); the retention time for cholestanone in a 46-in. column at 220° with an 'Apiezon' *L*-phase was just under 4 hr. Other laboratories have observed shorter retention times under different circumstances (Lipsky, S. R., private communication).

[2] Horning, E. C., Moscatelli, E. A., and Sweeley, C. C., *Chem. and Indust.*, 751 (1959).

[3] Lipsky, S. R., and Landowne, R. A., *Biochim. Biophys. Acta*, 27, 666 (1958). Lipsky, S. R., Landowne, R. A., and Godet, M., *ibid.*, 31, 336 (1959).

[4] Orr, C. H., and Callen, J. E., *J. Amer. Chem. Soc.*, 80, 249 (1958).

[5] Craig, B. M., and Murty, N. L., *Canad. J. Chem.*, 36, 1297 (1958).

Analysis of Solubility Data to estimate Small Amounts of Chain Fracture during the Cross-linking of Rubber

IN a communication[1] on methods of estimating chain fracture during the cross-linking of rubber by high-energy radiation, we mentioned that a quantitative analysis of solubility data was not attempted because results did not conform with a theoretical relationship derived by Charlesby and Pinner[2]. This relates the sol fraction (S) after dose R with the fracture and cross-link densities (p and q, respectively) and includes as a parameter the number average degree of polymerization before irradiation (u). This relationship (1) applies only for a polymer with a random molecular weight distribution and for the case where fracture and cross-linking are random and proportional to the dose. Hayden[3] has recently reported results which apparently do conform with this relationship. These are now contrasted with our previous results in order to emphasize some limitations concerning the general utility of this method for estimating small ratios of fractures to cross-links.

$$S + S^{\frac{1}{2}} = pq^{-1} + (quR)^{-1} \qquad (1)$$

Most of our samples of rubber were taken from the same source as Hayden's and apparently only differed in having been initially masticated to lower molecular weight; they were also irradiated under similar conditions. The linear plot reported by Hayden and represented in Fig. 1 was defined by results obtained after doses of up to about 15 M.rads.

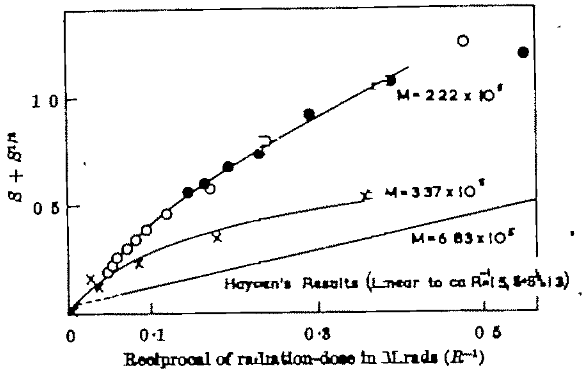


Fig. 1. Curves of $S + S^{1/2}$ against reciprocal dose for various rubbers irradiated with 4-MeV. electrons. Dose-rate of order 10^4 rads/min. M values represent initial number average molecular weight

It can be seen that in addition we obtained results at higher doses which do not lie on a straight line, but instead curve towards the horizontal axis. In these circumstances the significance of Hayden's linear extrapolation from his results to the $S + S^{\frac{1}{2}}$ axis and his estimation of the ratio of fracture to cross-links, pq^{-1}, as 0·05 is open to doubt.

The discrepancy between our results and simple theory is not surprising because it seems certain that such samples of rubber do not have a random molecular weight distribution[4]. This is, of course, generally the case for most samples of polymer, and it is significant that similar analysis of solubility data has usually been applied to estimate relatively high values of pq^{-1} of about 0·3. In such cases a random distribution might well be formed through random fracture during irradiation, and relationship (1) would then be applicable to solubility measurements made after sufficiently high doses. The average number of fractures per initial molecule may be calculated from the expression $6 \cdot 25 \times 10^{17}\, RG(F)MN^{-1}$, where $G(F)$ is the number of fractures for a dose of 100 eV., equal to 0·04 in Hayden's experiments, N the Avogadro number, and R and M are as defined previously. Then in the dose-range of from about 0·8 to 15 M.rads, in which he found a linear relationship between $S + S^{\frac{1}{2}}$ and R^{-1}, the corresponding average number of fractures per molecule would only be 0·02–0·43. This small amount of fracture would have relatively little effect on the molecular weight distribution[5] and therefore Hayden's rubber, unlike ours, either approximated to a random distribution before irradiation or his interpretation of the intercept obtained by linear extrapolation is unjustified. Current measurements indicate that the first of these alternatives is unlikely. For example, a rubber of number average molecular weight 5×10^5 had a ratio of weight to number average molecular weights closer to 1 rather than to the value of 2 characteristic of a random distribution (Allen, P. W., and Bristow, G. M., unpublished work).

In summary, we emphasize that in order to estimate small values of pq^{-1} from solubility measurements it is important to obtain data after sufficiently high doses and also to consider whether the assumption of a random molecular weight distribution is justified in order that relationship (1) may properly be applied.

Samples were irradiated at Wantage Radiation Laboratories (Atomic Energy Research Establishment) and we thank Dr. R. Roberts and members

of the Techno
kind co-operati

British Rubber
4
W

ation Group for their

L. Mullins
D. T. Turner
search Association,
oad,
City.

[1] Mullins, L., and Tu
[2] Charlesby, A., and
[3] Hayden, P., *Natur*
[4] Angier, D. J., and
[5] See Bovey, F. A.,
and Synthetic E

rs, 183, 1547 (1959).
. *Roy. Soc.*, A, 249, 367 (1959).
)
Polymer Sci., 28, 265 (1958).
onizing Radiation on Natural
4 (1958).

Structu
acrylic Acids

In previous pr
and β-pivaloyl-a
means of their sp
This work has
methyl-β-acrylic
isomerism and
preparations use
of acid (5) also
resonance) have

(1) β-Formylacryl
(2) β-Acetylacrylic
with a
(3) β-Pivaloylacry
(4) β-Pivaloylacry
(5) α-Methyl-β-ace

The ultra-viol
had end-absorpt
at about 220 mμ
ever, more or l
with increasing
245 mμ, which u
development of t

he β-formyl-, β-acetyl-
were investigated by
ra-violet and infra-red.
d to comprise the α-
regard to *cis–trans*
lic structure for the
d spectra (in the case
the nuclear magnetic
following structures :

C. : cyclic, *cis*
125° C. : *trans* (probably
-open acid)
° C. : cyclic, *cis*
° C. : *trans*
p. 98–101° C. : cyclic, *cis*

ompounds (1) and (3)
d (4) had a maximum
The former had, how-
r at 240 mμ, which
d to a maximum at
on disappeared. With
t 245 mμ a maximum

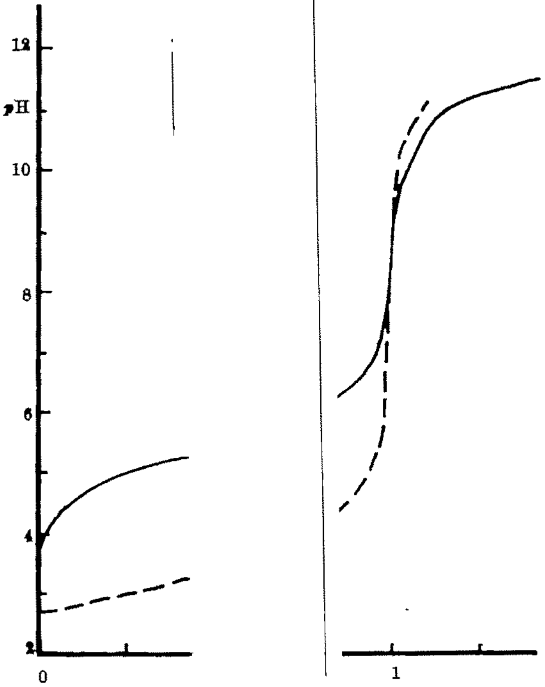


Fig. 1. Titration
(a) cyclic cis acids, (
0·1 N sod

oxide
ompounds given in text,
ds dissolved in water with
olume about 20 ml.

or a shoulder appeared at about 320 mμ, indicating a ketonic group. Thus, the ring in these cases should be opened by neutralization. Now, the compound (5) has shown the same behaviour.

Regarding the cyclic formula one could expect compounds with this structure to have acidic properties, and therefore it seemed worth while to compare these two categories by means of titrations and *p*H determinations. Fig. 1 gives in short the results; curve (*a*) refers to the cases (1), (3) and (5), that is, the cyclic *cis* structure, and curve (*b*) to the cases (2) and (4), that is, the (open) *trans* structure. Evidently, this seems to be a complementary method for determining the structure, and it follows that the pK_a values about 5·5 and 3·5 respectively characterize the curves. Back-titration gives the same curves. As from the ultra-violet spectra it must be concluded that the ring opens upon neutralization, it evidently is—if not instantaneously but very rapidly—closed upon acidification. Thus, it seems evident that the maximum at 245 mμ refers to the open *cis* form, which has been proposed previously.

A further report, also including nuclear magnetic spectra for these compounds, will be given elsewhere with a more detailed discussion.

Nils Hellström

Institute of Organic Chemistry,
Royal Agricultural College,
Uppsala 7.
Jan. 29.

[1] Hellstrom, N., *Ann. Roy. Agric. Coll. Sweden*, 22, 297 (1955).
[2] Hellström, N., *Nature*, 179, 589 (1957).
[3] Hellström, H. N. E., *Ann. Roy. Agric. Coll. Sweden*, 23, 519 (1957).
[4] Hellström, N., *Acta Agric. Scand.*, 8, 285 (1958).
[5] Hellstrom, N., and Gronowitz, S., *Ann. Roy. Agric. Coll. Sweden*, 25, 363 (1959).
[6] Jones, E. R. H., Shen, T. Y., and Whiting, M. C., *J. Chem. Soc.*, 48, 763, 766 (1951).
[7] Buchta, E., and Satzinger, G., *Chem. Ber.*, 92, 449, 468 (1959).

BIOCHEMISTRY

Occurrence of Keto-Acids in Blood Serum and Urine of Cattle in Comparison with Man, Horse, Sheep and Dog

In connexion with metabolic disorders occurring in cows, such as parturient paresis and acetonaemia, an investigation concerning the keto-acids occurring in blood serum and urine was started. Several authors have carried out work in this field concerning man. Keto-acids are converted into 2,4-dinitrophenylhydrazones, after which they are separated by means of paper chromatography. The 2,4-dinitrophenyl hydrazones are reduced by hydrogen to amino-acids and identified as such. In this way Cavallini *et al.*[1], El Hawary and Thompson[2], Markees[3], Biserte and Dassonville[4] and De Schepper *et al.*[5] showed that the following α-keto-acids occur in human blood : α-ketoglutaric acid, pyruvic acid, α-keto*iso*caproic acid, α-keto*iso*valeric acid and α-keto-β-methylvaleric acid. Moreover, it was shown that pyruvic acid predominates in human blood and α-ketoglutaric acid in human urine[4].

Applying De Schepper's method[5] the keto-acids of bovine serum were converted into 2,4-dinitrophenyl hydrazones and separated by means of chromatography, as well as by electrophoresis combined with evaporation at 6 V./cm. at *p*H 11·7. After reduction with hydrogen and platinum oxide as a catalyst, the amino-acids obtained were examined both by electro-

Table 1. A COMPARISON OF THE KETO-ACIDS IN BLOOD AND URINE OF CATTLE, SHEEP, DOG, HORSE AND MAN

Blood	Cattle	Sheep	Dog	Horse	Man (own estimations)	Man (see ref. 5) (per cent)	Man (see ref. 4)
Oxaloacetic acid	0 – +	0 – +	–	0 – +	0 – +		0
α-Ketoglutaric acid	+ +	+ +	+ +	+ +	+ –	35–65γ	+
Glyoxylic acid	+ – + +	+	0 – +	+	0 – +		±
Pyruvic acid	+ + + +	+ + + +	+ + + +	+ + + +	+ + – +	280–900γ	+ +
Succinic semialdehyde	+ +	+ – + +	+	+ – + +	+ – – +		+(a)
α-Ketoisovaleric acid	+	0 – +	+	0 – +	+		
α-Ketoisocaproic acid } α-Keto-β-methylvaleric acid }	+ +	+	+ +	+	+ +	930–1,900γ	+ +
Urine							
Oxaloacetic acid	+	+	0 – +	0 – +	0 – + +		0
α-Ketoglutaric acid	+ +	+ +	+ +	+ + +	+ + + + +		+ + + +
Glyoxylic acid	+ + + +	+ + + +	+ + +	+ +	+		0
Pyruvic acid	0 – +	+	+ +	+ +	+ +		+ + +
Succinic semialdehyde	+ +	+ +	+	+	+		+(a)
α-Ketoisovaleric acid	–	0 – +	0 – +	0 – +	0 – +		–
α-Ketoisocaproic acid } α-Keto-β-methylvaleric acid }	0 – +	–	–	–	0 – +		–

phoresis at pH 4·7 and by two-dimensional chromatography in different solvents. The following amino-acids were formed: aspartic acid (in small quantities), glutamic acid, alanine (much), valine and *iso*-leucine, γ-aminobutyric acid and glycine. From this it follows that besides the keto-acids mentioned before, succinic semialdehyde and glyoxylic acid occur in bovine blood as well.

As succinic semialdehyde, so far as we know, has not hitherto been found to occur in human blood, and glyoxylic acid only occasionally[4], identical experiments were made with human serum. It appears that it contains succinic semialdehyde as well as glyoxylic acid. Bovine urine, after preliminary purification, was investigated in the same way. The most striking result was the high content of glyoxylic acid. Moreover, bovine urine contains oxaloacetic acid and succinic semialdehyde. As the observations made by Biserte[4] on human urine were different, the latter was examined in the same manner. It appeared that now α-ketoglutaric acid showed the highest value, followed by pyruvic acid and finally succinic semialdehyde, oxaloacetic acid and glyoxylic acid. These results are in accordance with Biserte's findings.

As there was this remarkable difference between the contents of glyoxylic acid in human and bovine urine, the serum and urine of a few other animals, namely, sheep, horse and dog, were examined. The results are shown in Table 1. The intensity of the spots, coloured by interaction with ninhydrin, of the amino-acids produced by reduction is indicated by the number of + signs.

From Table 1 it appears that the serum contents of keto-acids in man and in the various animals show only slight differences; the urine, however, varies considerably.

This investigation has shown that: (*a*) Human serum and urine contain succinic semialdehyde in addition to the α-keto-acids already found. Glyoxylic acid occurs in small quantities in human serum as well as in urine. (*b*) Serum of cow, sheep, horse and dog contains the same keto-acids as human serum, and in almost the same quantities. (*c*) Bovine and sheep urine contains, compared with human urine, a far greater quantity of glyoxylic acid, whereas the latter contains more α-ketoglutaric acid.

Details of the methods used will be published in full with the results of an investigation on the keto-acids in the rumen of cattle. I am greatly indebted to Miss W. Klazinga and Mr. H. Vreman and Mr. C. G. van der Kamp for experimental assistance and Mr. W. D. Brands for making the necessary equipment.

C. J. G. VAN DER HORST

Laboratory of Veterinary Biochemistry,
State University of Utrecht,
Biltstraat 172,
Utrecht.

---

[1] Cavallini, D., and Frontali, N., *Nature*, 164, 792 (1949).

[2] El Hawary, M. F. S., and Thompson, R. H. S., *Biochem. J.*, 53, 340 (1953).

[3] Markees, S., *Biochem. J.*, 56, 703 (1954).

[4] Biserte, G., and Dassonville, B., *Clin. Chim. Acta*, 1, 49 (1956).

[5] De Schepper, P., Parmentier, G., and Vanderhaeghe, H., *Biochim. Biophys. Acta*, 28, 507 (1958).

Formation of a New Metabolite of Epinephrine and Norepinephrine in Liver and Kidney

IN previous work it was found that after the injection of norepinephrine and epinephrine in rats, a new metabolite of these compounds was excreted in the urine[1]. Axelrod *et al.*[2] have isolated recently from the urine of rats a metabolite of epinephrine and norepinephrine, which they have identified as 3-methoxy-4-hydroxy phenyl glycol. We have found that after the intravenous infusion in cats of a mixture containing both norepinephrine-7-^{3}H and epinephrine-1-^{14}C, a similar compound was found in the liver and kidney of this animal.

In these experiments, 10 ml. of 4·5 × 10^{-4} M solution of norepinephrine-7-^{3}H and epinephrine-1-^{14}C with a ^{3}H : ^{14}C activity ratio of 5 : 1 were infused during a period of 30 min. into the femoral veins of untreated cats and cats pretreated with iproniazid phosphate. At the end of the infusion period the animals were killed and the organs were removed and quickly frozen. The tissues were homogenized in saline and then deproteinized by the addition of 0·4 N perchloric acid according to the procedure of Ake Bertler *et al.*[3]. The water layer at pH 2 was extracted four times with ethyl acetate. This ethyl acetate fraction was then chromatographed in chloroform–acetic acid–water (2 : 1 : 1) overnight. The run-off was then chromatographed in *iso*propyl alcohol–aqueous ammonia–water (8 : 1 : 1) over a period of 12 hr. In this procedure 3,4-dihydroxymandelic acid remained on the paper in the chloroform–acetic acid–water system and the run-off contained 3-methoxy-4-hydroxymandelic acid.

Table 1. TRITIU
HYDROXYMANDELIC
FROM LIVER AND K

ACTIVITY OF 3-METHOXY-4-
UTRAL METABOLITE ISOLATED
USED WITH NOREPINEPHRINE-
HRINE-1-^{14}C

Compound	/^{14}C	Kidney c.p.m. per 1 gm. tissue ^{3}H	Kidney c.p.m. per 1 gm. tissue ^{14}C	^{3}H/^{14}C
3-Methoxy-4-hydroxymandelic acid	3/1	1,200	360	3·3/1
Neutral metabolite	5/1	520	165	3·1/1

In cats untre
gram develope
showed in addi
hydroxymande
The mobility o
than the mobil
acid. In cats t
peaks were not
The fast-mov
as a neutral co
ethyl acetate fr
of 1–8. This c
from its mobilit
appeared to be
for 3-methoxy-
be the same as
This shows that
norepinephrine
tion as 3-metho
The chromat
compound that
similar to that c
In the butanol
of this compou
of 3-methoxy-4
private comm
phenylacetaldeh
be a common
mandelic acid an
The fact that th
3-methoxy-4-hy
compound indi
precursor.
The finding t
3-methoxy-4-hy
methoxy-4-hydr
demonstrates th
action of monoa
epinephrine. O
we conclude tha
liver and kidn
hydroxyphenyl g
This work wa
Public Health S

New York Unive
and Seton Ha
Je

[1] Goldstein, M., Fried
press).

[2] Axelrod, J., Kopin,
86, 576 (1959).

[3] Bertler, A., Carlsso
44, 273 (1958).

[4] Bush, I. E., Biochem

iazid the final chromato-
and kidney extracts
sence of 3-methoxy-4-
her radioactive peak.
as found to be greater
oxy-4-hydroxymandelic
oniazid, however, these

emonstrated to behave
it was extractable into
phase in the pH range
readily acetylated and
'C' solvent system[4] it
nce. The ^{3}H : ^{14}C ratio
lelic acid was found to
l compound (Table 1).
mpound is formed from
ne in the same propor-
mandelic acid.
viour of the neutral
ated was found to be
hydroxyphenyl glycol.
system, the R_F value
al with the R_F value
l glycol (Axelrod, J.,
3-Methoxy-4-hydroxy-
lated by Axelrod[1] to
3-methoxy-4-hydroxy-
hydroxyphenyl glycol.
^{3}H : ^{14}C was found for
acid and the neutral
oth have a common

eated with iproniazid
glycol as well as 3-
id were not detectable
ounds arise from the
m norepinephrine and
ne evidence given here,
mpound isolated from
l with 3-methoxy-4-

part by United States

M. GOLDSTEIN
S. B. GERTNER

f Medicine,
Medicine,

ndler, G., *Experientia* (in the

. D., *Biochim. Biophys. Acta*,

en, B., *Acta Physiol. Scand.*,

Levels of Pyridine Nucleotides in Liver Poisoning

Gallagher and Simmonds[1] have shown that rats are protected against the lethal effects of carbon tetrachloride by prophylactic treatment with precursors of pyridine nucleotides. Such treatment was found also to protect against the loss of pyridine nucleotides from liver cells and to prevent necrosis of liver cells after dosing with carbon tetrachloride[2,3]. Rees, Spector and Sinha[4] found that the administration of 'Phenergan' (10-(2-dimethylamino-*iso*propyl) phenothiazine hydrochloride) to animals poisoned with carbon tetrachloride protects the liver cells against necrosis. In the present investigation we examined the effect of treatment with 'Phenergan' on the pyridine nucleotides of liver cells in carbon tetrachloride poisoning. The work was also extended to other liver poisons such as thioacetamide and dimethyl nitrosamine.

Table 1. EFFECT OF 'PHENERGAN' ON THE LEVELS OF PYRIDINE NUCLEOTIDES IN THE LIVER IN RATS POISONED WITH CARBON TETRACHLORIDE

Treatment	E_{340} absorption
Nil	1·26
'Phenergan'	1·40
Carbon tetrachloride	0·65
Carbon tetrachloride + 'Phenergan'	1·13

Rats were killed 24 hr. after poisoning with carbon tetrachloride (1·25 ml./kgm. body-weight). 'Phenergan' dosing was at 0 and 6 hr. following poisoning (25 mgm. and 12·5 mgm./kgm. body-weight respectively). The E_{340} reading is corrected to 10 mgm. fat-free dry weight of liver extracted with 5 ml. 5 per cent w/v trichloracetic acid solution.

Table 1 shows that the administration of 'Phenergan' to rats poisoned with carbon tetrachloride prevented largely the fall in the level of pyridine nucleotide which followed the action of carbon tetrachloride alone. As was shown by Rees and Sinha (ref. 5, and unpublished work) the hepatotoxic agents carbon tetrachloride, dimethyl nitrosamine and thioacetamide lead to a different chronological pattern of leakage of liver enzymes into the blood stream. Consequently we determined the level of pyridine nucleotides in the liver and the serum at different times during the course of poisoning to determine the time relationships of the change.

Table 2 shows that as early as 5½ hr. after the administration of carbon tetrachloride there is a considerable fall in the E_{340} of the acid extracts of liver homogenates, but at this time there is no fall in the mitochondrial E_{340}. However, 10½ hr. after administration of carbon tetrachloride the mito-

Table 2. LEVELS OF PYRIDINE NUCLEOTIDES IN LIVER AND SERUM FOLLOWING POISONING OF RATS WITH CARBON TETRACHLORIDE, THIOACETAMIDE AND DIMETHYL NITROSAMINE

Treatment	Time (hr. after poisoning)	E_{340} Liver homogenate	E_{340} Mitochondria	E_{340} Serum
Nil	—	1·26	0·55	0·54
Carbon tetrachloride	5·5	0·97	0·55	—
	9	—	—	0·90
	10·5	0·82	0·34	—
	20	0·78	0·33	—
Thioacetamide	5·5	1·30	0·54	—
	9	—	—	0·62
	10·5	1·17	0·50	—
	20	1·18	0·59	—
Dimethyl nitrosamine	5·5	1·16	0·54	—
	9	—	—	0·66
	10·5	0·86	0·39	—
	20	0·68	0·40	—

Rats were dosed with carbon tetrachloride, 1·25 ml./kgm. body-weight; thioacetamide, 200 mgm./kgm. body-weight, and dimethyl nitrosamine, 100 mgm./kgm. body-weight. The E_{340} reading is corrected to 10 mgm./fat-free liver-weight for the liver homogenate, to 1 mgm. nitrogen for the mitochondria and to 1 ml. of serum. In all cases extraction of the tissues was made with 5 ml. 5 per cent w/v trichloracetic acid solution.

chondrial-levels had also fallen. This is in good agreement with the data on the leakage of enzymes from the liver in carbon tetrachloride poisoning. Rees and Sinha[4] have shown that at 6 hr. there is loss from the liver of cytoplasmic isocitric dehydrogenase and malic dehydrogenase and that the loss of mitochondrial enzymes occurs later, at about 12 hr. Consequently it appears that the initial effect of carbon tetrachloride is on the cell membrane, leading to a leakage of cytoplasmic constituents, and that mitochondrial damage occurs later in the course of the poisoning. In the case of thioacetamide poisoning, no fall in the E_{340} of either liver homogenates or mitochondria is observed during the 20-hr. course of the poisoning (Table 2). This is in contrast to the enzyme leakage from the liver cells and mitochondria, and suggests that the effect of carbon tetrachloride and thioacetamide on semi-permeable membranes may be different. Finally, dimethyl nitrosamine does not affect the E_{340} of either the liver homogenate or mitochondria at 5½ hr., but the E_{340} of both is depressed by 10½ hr. (Table 2). This finding agrees with the observed time relationships of the leakage of cytoplasmic constituents (Rees and Sinha, unpublished work) but indicates that pyridine nucleotides are lost from the mitochondria at a time when glutamic dehydrogenase is not leaking. This again suggests a type of damage to the semi-permeable membrane different from that occurring with the other two poisons.

Measurement of the serum E_{340} values at 9 hr. (Table 2) after poisoning with each of the above agents showed that there is a rise in the E_{340} following carbon tetrachloride poisoning, no change in the case of thioacetamide and a smaller rise in the case of dimethyl nitrosamine. These results are in good agreement with the levels of pyridine nucleotides in the livers of animals poisoned with each agent.

This work has shown that treatment with 'Phenergan', like pretreatment with precursors of pyridine nucleotides, maintains normal levels of pyridine nucleotides following carbon tetrachloride poisoning. However, it is probable that whereas the pyridine nucleotide precursors maintain this level by stimulating replacement of the nucleotides lost as a result of carbon tetrachloride poisoning, 'Phenergan' appears to act by preventing the leakage of pyridine nucleotides and of enzymes across the mitochondrial and cell membranes.

This investigation also shows that the loss of pyridine nucleotides from liver cells subsequent to carbon tetrachloride poisoning is an early event in the course of the poisoning and is not simply a result of necrosis of liver cells. The results with dimethyl nitrosamine and thioacetamide indicate that the three hepatotoxins have different effects on the semi-permeable membranes. In the case of carbon tetrachloride there is a loss of cytoplasmic and mitochondrial enzymes as well as cytoplasmic and mitochondrial pyridine nucleotides. Dimethyl nitrosamine leads to a loss of cytoplasmic enzymes but not of mitochondrial enzymes, and to a loss of pyridine nucleotides from both. Finally, thioacetamide, although leading to a loss of both cytoplasmic and mitochondrial enzymes, does not lead to the loss of cytoplasmic or mitochondrial pyridine nucleotides. Thus it appears that at least two types of membrane damage can occur, one leading to a loss of enzymes only (for example, thioacetamide), and the other to the loss of pyridine nucleotides only from the mitochondria, as in dimethyl nitrosamine, while a combination of these effects or a more general third group leads to the loss of both as in carbon tetrachloride poisoning.

C. H. GALLAGHER
K. R. REES

McMaster Laboratory,
Commonwealth Scientific and
Industrial Research Organization,
Parramatta Road,
Glebe, Sydney,
and
Department of Chemical Pathology,
University College Hospital Medical School,
London.

[1] Gallagher, C. H., and Simmonds, R. A., *Nature*, **184**, 1405 (1959).
[2] Gallagher, C. H., *Aust. J. Agric. Res.* (in the press).
[3] Gallagher, C. H., *Aust. J. Exp. Biol. Med. Sci.* (in the press).
[4] Rees, K. R., Spector, W. G., and Sinha, K. P., *J. Path. Bact.* (in the press).
[5] Rees, K. R., and Sinha, K. P., *J. Path. Bact.* (in the press).

Isolation of a δ-Lactone Compound from the Leaves of *Clitoria marina* Linn.

THE plant *Clitoria marina* Linn. belongs to the Papilionaceae sub-group of Leguminosae, and is distinguished from *Clitoria ternatea* Linn. by its light-blue to almost white flowers. The leaves of the plant are used in medicine in India. A systematic chemical examination of the leaves has therefore been undertaken, and isolation of a δ-lactone compound from the alcoholic extract of the leaves has been achieved.

Sun-dried and powdered leaves were exhaustively extracted with 80 per cent ethyl alcohol in a Soxhlet for 36 hr. The extract was filtered hot, the filtrate reduced to half its original volume under reduced pressure and kept at 0° for 10 hr. when a solid substance settled down. The solid was separated, boiled with a large excess of ethyl alcohol, filtered and the filtrate again kept at 0° for 3 hr. The separated solid was refluxed with ethyl alcohol and a little activated animal charcoal and filtered hot. The filtrate on cooling deposited a white amorphous substance, m.p. 92° (yield 0·1375 per cent on dry weight basis). Further purification did not alter the melting point, and the purity of the product was established by chromatographic examination.

The substance was insoluble in water, cold ethyl alcohol, chloroform, petroleum ether and ether; but sparingly soluble in hot ethyl alcohol, benzene, pyridine and ethyl acetate. It did not decolorize bromine water or alkaline potassium permanganate and gave no acetyl derivative. It also did not reduce Fehling's solution and did not give tests for the presence of a keto group. It was found to be lævo-rotatory. Found: C, 78·95; H, 12·82 per cent, mol. wt. (Rast) 386; $C_{26}H_{50}O_2$ requires C, 79·18: H, 12·69 per cent, mol. wt. 394.

The bromo-derivative of the substance prepared by the usual bromination procedure was obtained as a pale yellow powder m.p. 80°. It was soluble in benzene, chloroform and ether. Found: Br, 16·65 per cent. $C_{26}H_{49}O_2Br$ requires Br, 16·84 per cent. On treatment with freshly distilled hydrogen iodide (b.p. 126°), an ash-coloured product, m.p. 68°, was obtained. Found: I, 24·00 per cent. $C_{26}H_{51}O_2I$ requires I, 24·33 per cent.

The methyl ester of the substance prepared by usual esterification procedure gave a white amorphous powder, m.p. 74°, soluble in ether and chloroform.

Found: C, 76
requires C, 76·
ester on acetyla
m.p. 71°. Fo
OAc, 9·25 per
H, 11·90; OA
Treatment w
acid and alkalir
gave two oxida
and a dibasic
acid, m.p. 75°.
mol. wt. 314.
76·92; H, 12·
glutaric acid,
6·92 per cent,
$C_6H_{10}O_4$: C, 4
respectively.
stance with hy
methyl alcohol
On the basis
compound has
in preference t

CH$_3$(C

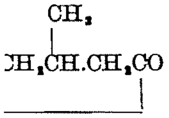
This fact is fu
dibasic acid ob
is a derivative
acid. The sub
bromide and
4-bromo-*n*-pent
methyl-4-iodo-*n*
spectively. On
methyl ester of
acid, which fur
n-pentacosano
I am gratefu
N. K. Chowdh
investigations.

Chemistry
Pharmacologica
Medical Col

Hydroxy
Ter

It is well
sources have
(T_s), at which
water or in 0·
values of fish-s
to 57° C., accor
environment[1],
value of about
source. By an
acid analyses,
been correlated
the collagen; t
the lower the v
considered to
forming hydro
The data of ref
using the mean
quoted. These

5 per cent. $C_{27}H_{54}O_3$
per cent. The methyl
ite amorphous product,
; H, 11·80 per cent;
O_4 requires C, 74·53;
t.
ed nitric acid, chromic
ermanganate separately
n each case, a fatty acid
s identified as archidic
·20; H, 12·66 per cent,
alue for $C_{20}H_{40}O_2$: C,
. wt. 312, and β-methyl
ound: C, 49·40; H,
Calculated value for
per cent, mol. wt. 146,
of the amorphous sub-
e, hydrogen iodide and
slow rate.
ndings, the amorphous
a δ-lactone structure
.



$$\overset{CH_3}{|}$$
H$_2$CH.CH$_2$CO

d by the nature of the
xidation product which
d and not of succinic
atment with hydrogen
ide yielded 2-methyl-
, $C_{26}H_{51}O_2Br$, and 2-
acid, $C_{26}H_{51}O_2I$, re-
the substance gave the
ydroxy-*n*-pentacosanoic
thyl-4-hydroxymethyl-
ion.
N. Wahi and to Prof.
interest during these

A. SINHA

,

OGY

the Shrinkage
f Collagen

ollagens from various
hrinkage temperatures
contract abruptly in
line solution. The T_s
ange from about 35° C.
ean temperature of the
lian collagen has a T_s
arently irrespective of
of the complete amino-
ge temperatures have
roxyproline content of
ount of hydroxyproline
. 1). Hydroxyproline is
collagen structure by
ween molecular chains.
plotted by us in Fig. 1
shrinkage temperature
resented by circles and

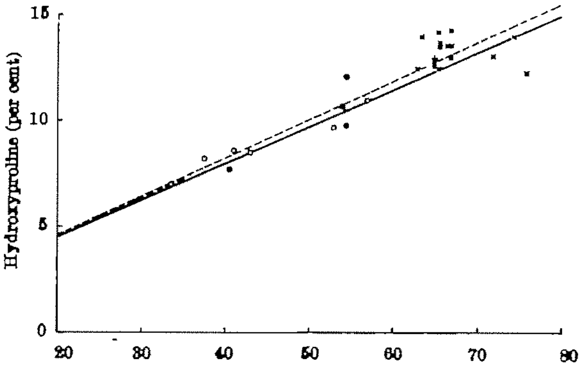


Fig. 1. ○, Fish skin collagen; ×, human dermal collagen; +, rat tail tendon; ●, cattle hide

include the additional values, hydroxyproline = 12·0 per cent and 13·0 per cent for cattle hide and rat tail tendon respectively. The continuous straight line in Fig. 1 has been fitted by the method of least squares to these data on the assumption that the relation between hydroxyproline and T_s is linear.

Also included in the graph are the data of Hall and Reed[2], who determined the T_s versus hydroxyproline content of human dermal collagen. Hall and Reed concluded from their experiments that there was no correlation between hydroxyproline and T_s. However, as can be seen from Fig. 1 their data fall in their appropriate position with respect to the line drawn to the circle data, and it is clear why no correlation could be seen from their data alone—the range of hydroxyproline was too narrow. It is interesting and significant to find collagen from such widely differing sources following such a simple relation, which supports Takahashi's[1] and Gustavson's[3] original contention.

If the data of Takahashi and Hall and Reed are together fitted by a least-square method the dotted line in Fig. 1 is obtained. Its close proximity to the first line again shows the close correlation in behaviour of different collagens.

If the dotted line in Fig. 1 is accepted as valid then it is possible to make some speculations about the biological implications of a below-normal hydroxyproline content in human collagenous structures. For example, it has been reported by Bowes, Elliott and Moss[4] and others[4] that the hydroxyproline content of fibrinoid tissue from rheumatic fever patients and in rheumatoid arthritis was lower than in normal tissue. They quoted a value of 8·3 per cent for fibrinoid tissue which, according to Fig. 1, would give the collagen a T_s value of 40° C. As 40° C. is close to normal blood temperature and could be reached during a fever it is suggested that these rheumatic effects are the result of a structural breakdown due simply to temperature. It is not necessary that the actual T_s values be reached for, as Weir[5] has shown, shrinkage is a rate process, and given sufficient time shrinkage will occur at temperatures about 5° C. below the instantaneous shrinkage temperature (our T_s). Furthermore, if the structure happens to be under tension, then the denaturation process is likely to be accelerated (although the T_s will be increased owing to the fact that extra tension has now to be generated in order to overcome the applied tension before contraction can take place). This idea has been discussed extensively by us elsewhere[6] and applied to the phenomena of 'heart murmurs'. This stress mechanism could be a factor in explaining the predominance of rheumatic complaints in the joints.

Finally, it has been reported by Briscoe and Loring[7] that the hydroxyproline content of the collagen of human lung increases with age. If this increase applies to collagenous structure generally, then it would appear that the body has a built-in defence mechanism for resisting denaturation, and only the young would be vulnerable to immediate effects of body temperatures higher than normal. In support of this view there is evidence, for example, that the high temperatures associated with rheumatic fever are more damaging to young patients than to adults. On the other hand, since the process of denaturation is rate-controlled, the time factor becomes important in the manifestation of rheumatic symptoms when the effect of temperature higher than normal is not involved. Thus where the hydroxyproline content is close to normal but slightly below it, many years would elapse before denaturation was complete, and this is a possible explanation of the fact that rheumatism is predominantly a disease of the adult.

In other words, if for hereditary or other reasons the increase of hydroxyproline (presumably by conversion of proline to hydroxyproline) with age does not occur (or the increase is slower than normal) then the individual concerned is likely to become a rheumatic. The above views may explain why many symptoms are common to both rheumatoid arthritic and rheumatic fever patients, for example, cardiac lesions, swelling and pain in joints. In both cases collagen has been denatured.

In this communication we have only considered the denaturation of collagen as a function of temperature. It is realized that other denaturation mechanisms occur; these will be discussed in a later publication.

This work was supported in part by the National Institute of Health, U.S. Public Health Service, through Grant No. *H*–3039.

B. J. RIGBY

Wool Research Laboratories,
Commonwealth Scientific and
Industrial Research Organization,
Ryde, New South Wales.

J. D. SPIKES

Division of Biology and Medicine,
United States Atomic Energy Commission,
Washington, 25, D.C.

[1] Takahashi, T., quoted in "The Chemistry and Reactivity of Collagen", by Gustavson, K. H., 224 (Academic Press, Inc., New York, 1956).

[2] Hall, D. A., and Reed, R., *Nature*, 180, 243 (1957).

[3] Gustavson, K. H., *Nature*, 176, 70 (1955).

[4] Bowes, J. H., Elliott, R. G., and Moss, J. A., in "Nature and Structure of Collagen", edit. by Randall, 199 (Butterworths, London, 1953).

[5] Weir, C. E., *J. Amer. Leather Chem. Assoc.*, 44, 108 (1949).

[6] Rigby, B. J., Hirai, N., Spikes, J. D., and Eyring, H., *J. Gen. Physiol.*, 43, 265 (1959).

[7] Briscoe, A. M., and Loring, W. E., 136th Meeting Amer. Chem. Soc., Sept. 13–18, 1959.

Effect of Electronarcosis on Oxygen Consumption and Carbon Dioxide Output

IN assessing changes of vital function during electronarcosis, we measured oxygen consumption and carbon dioxide output in an experiment in rabbits. The measured values were considered an important index for the evaluation of metabolic changes during electronarcosis.

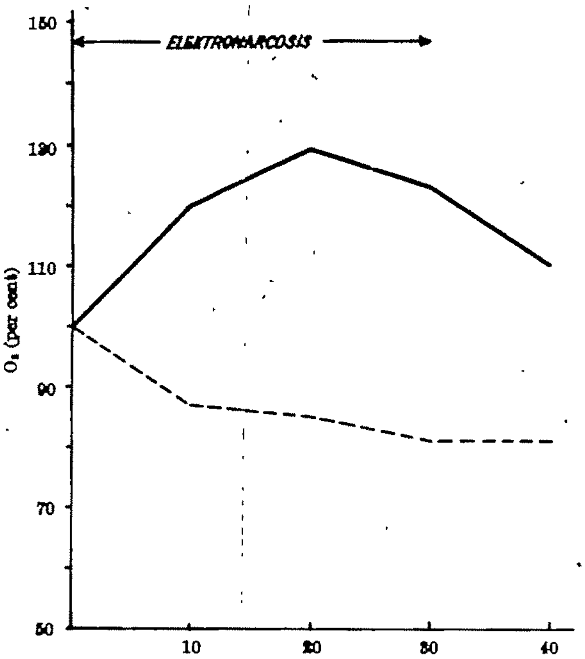


Fig. 1. Oxygen consumption during electronarcosis. ——, During electronarcosis; ...., control

In 10 rabbits the resting values of oxygen consumption and carbon dioxide output were measured. The average value from a 15-min. measurement was taken as 100 per cent. Having carried out these measurements we induced electronarcosis by combining the Leduc and direct current (tension 50 V., frequency 100 c./sec. admixture of the direct current 15 per cent, relation of impulse length to break 1 : 9, intensity 0·6 m.amp.). The current is applied through external bitemporal electrodes with felt covering soaked in sodium chloride solution. The values were followed for 15 min. before electronarcosis, for 30 min. of the electronarcosis duration and for 15 min. afterwards. The same animals served as controls for the same length of time but without electronarcosis.

(1) *Oxygen consumption.* A clear rise of oxygen consumption during electronarcosis was observed in all cases. The maximum is attained 20 min. after the beginning of electronarcosis and reaches about 150 per cent of the original value. In the following course of electronarcosis oxygen consumption decreases slightly, but after 30 min. it is still more than 120 per cent. When the electronarcosis is interrupted the oxygen consumption falls abruptly. Average values in time are shown in Fig. 1.

(2) *Carbon dioxide output.* The output increases during electronarcosis by a rise which is even sharper than that of oxygen consumption. A second rise of the output occurs after interrupting the electronarcosis. The time course is given in Fig. 2.

(3) The values of the respiration quotient can be elaborated from the preceding measurements. The curve in time follows roughly that of the preceding curve, but the rise after interrupting the narcosis is more marked.

The rise of oxygen consumption is striking, considering its fall in all types of drug narcosis. The explanation for this might be found in an increased muscle tone which can be proved especially at the

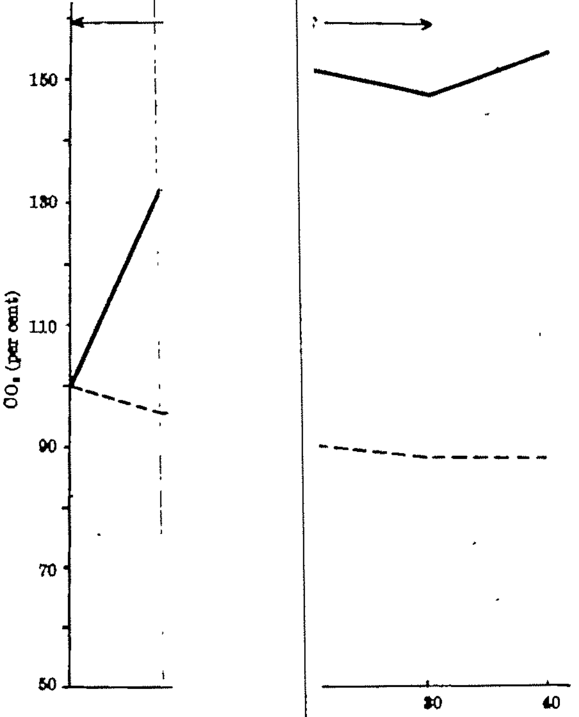


Fig. 2. Carbon di

g electronarcosis. ——, Dur-
. . . ., control

beginning of
that a gradual
20-min. durat
animals awaker
fall of oxygen c
out electronarc
metabolism of
have been impc

In accordance with
es can be observed after
onarcosis. When the
ition falls rapidly. The
the control group with-
tributed to a decreased
imal whose movements

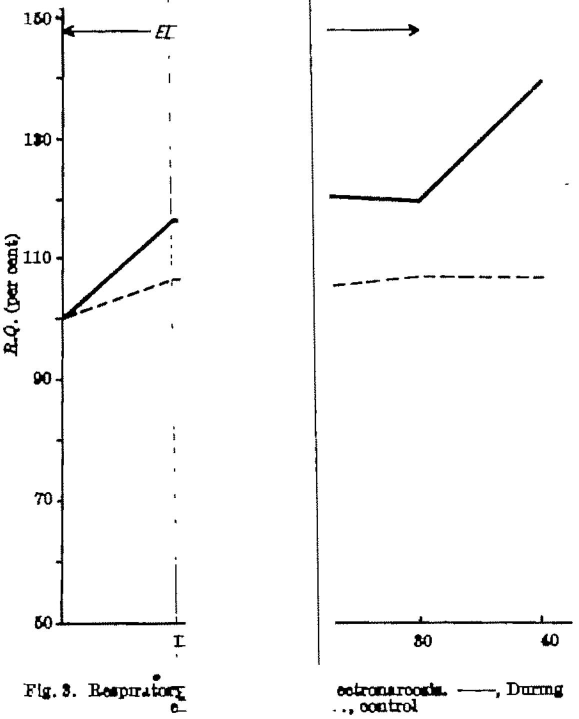


Fig. 3. Respiratory

ectronarcosis. ——, During
. . ., control

The rise in carbon dioxide output is the result of an increased tissue metabolism evident already from the changes in oxygen consumption.

The course of values measured after interrupting the electronarcosis implies that no oxygen debt ensues during the electronarcosis. The changes of the respiration quotient leave room for an assumption that the tissue metabolism changes during electronarcosis are not only quantitative but qualitative as well.

JAROSLAV STRMISKA
ANTONÍN VACEK

Traumatological Research Institute,
Brno,
and
Biophysical Institute of the Czechoslovak
Academy of Science,
Prague.

Role of Mucoid Substances of the Aorta in the Deposition of Lipids

THE mechanism of deposition of lipids in the vessel-wall seen from the point of view of the pathogenesis of atherosclerosis represents the central problem of the latter. In agreement with numerous data[1-4], our previous investigations[5] proved that in the morphogenesis of both human and experimental atherosclerosis the deposition of lipid substances in the aorta is preceded by an increase of metachromatically stainable mucoid substance.

By means of immuno-electrophoresis it could be proved that one part of the lipids in the aortic intima is identical with plasma-β-lipoprotein[6].

Bernfeld's[7] investigations have proved the formation of specific complexes between polyanions of high molecular weight and β-lipoprotein. Based on this, we have supposed a kind of complex-formation between the substances of similar chemical character, accumulated in the aortic wall (mucoids) and the plasma-β-lipoprotein. Thus the formation of this specific complex might be considered as the beginning of the process of lipid deposition. Our supposition finds support in the histological findings that the deposition of lipids mainly occurs in those areas of the aorta which are rich in metachromatically stainable substances.

Based on these facts we have investigated whether the mucopolysaccharides of sclerotic human aortic intima dispose of the ability of binding β-lipoprotein specifically.

Employing the method of Dyrbye and Kirk[8] we have isolated the mucopolysaccharides of sclerotic human aortic intima. The isolated mucopolysaccharides may be separated by paper-electrophoresis into two fractions: one of them having a higher mobility, being periodic acid–Schiff-negative and containing a considerable amount of sulphate, and the other with a lower mobility, periodic acid–Schiff-positive, with mere traces of sulphate.

The mixture of mucopolysaccharides obtained in this way was electrophorized after having been mixed with pure human β-lipoprotein. We have stated that the β-lipoprotein moves together with the aortic mucopolysaccharide fraction of lower mobility (Fig. 1).

After having mixed the aortic mucopolysaccharides with native (normal) human plasma and electro-

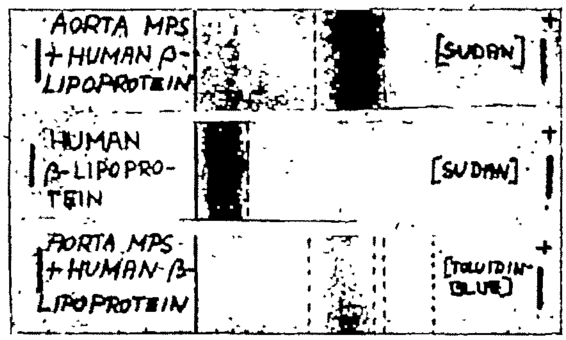

AORTA MPS + HUMAN β-LIPOPROTEIN
[SUDAN]
+
HUMAN β-LIPOPROTEIN
[SUDAN]
+
AORTA MPS + HUMAN-β-LIPOPROTEIN
[TOLUIDIN-BLUE]
+

Fig. 1. Interaction of pure human β-lipoprotein with aortic mucopolysaccharides. Veronal buffer, pH 8 6, 16 hr., 200 V., 10 m.amp.

phorized the mixture we have found that the β-lipoprotein fraction of the plasma also in this case moved together with the mucopolysaccharide fraction of lower mobility. In this case, however, the interaction causes a retention because of the higher mobility of the native β-lipoprotein (Fig. 2). The mobility of plasma-α-lipoproteins does not show any change. This circumstance proves that mucopolysaccharides of the aortic intima did not bind the plasma-α-lipoproteins. It is in conformity with the fact that plasma-α-lipoprotein cannot be shown to be present in the sclerotic aortic intima with the method of immuno-electrophoresis.

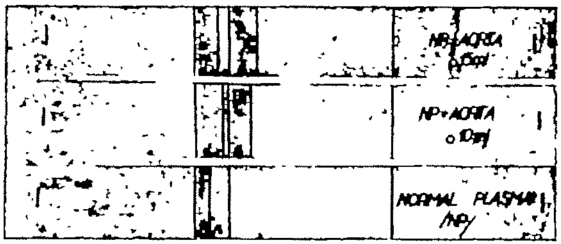


Fig. 2. Interaction of normal human plasma-lipoproteins with aortic mucopolysaccharides. Stained with sudan black. 400 V., 30 m.amp., 2 hr. Borate buffer, pH 8 6

The present investigations support our supposition that the basis of deposition of plasma-β-lipoproteins in the sclerotic aortic intima may be found in the ability of binding plasma-β-lipoprotein of some specific mucopolysaccharides of the aortic intima.

Details and discussions of these problems will be published elsewhere.

S. Gerő
J. Gergely
T. Dévényi
L. Jakab
J. Székely
S. Virág

Third Medical Clinic,
University of Budapest.

---

[1] Schultz, A., *Virchow's Arch. Pathol. Anat.*, 239, 415 (1922).

[2] Faber, M., *Arch. Pathol.*, 48, 342 (1949).

[3] Rinehart, J. F., in "Connective Tissue in Health and Disease", edit. by Munksgaard, Ejnar, 239 (1954).

[4] Buck, R. C., *Arch. Pathol.*, 58, 576 (1954).

[5] Gerő, S., Farkas, K., Gergely, J., Jakab, L., Székely, J., and Virág, S., Orv. Hetil, Budapest (in the press).

[6] Ott, H., Lohss, F., and Gergely, J., *Klin. Wschr.*, 36, 383 (1958).

[7] Bernfeld, P., Donahue, V. M., and Berkowitz, M. E., *J. Biol. Chem.*, 226, 51 (1957).

[8] Dyrbye, M., and Kirk, J. E., *J. Gerontol.*, 12, 20 (1957).

Effect of Lysergic Acid Diethylamide on Larval Growth

Lysergic acid diethylamide is known to be hallucinogenic in man[1] and to produce behavioural aberrations in experimental animals. When administered to spiders[2], lysergic acid diethylamide improved the regularity and angles in the pattern of the web. In the liver fluke (*Fasciola hepatica*) lysergic acid diethylamide intensified the motility[3]. However, in most cases the effects of lysergic acid diethylamide decrease shortly after withdrawal of the drug. In humans the effects may persist as long as 24 hr. in many cases[4]. Increased resistance to lysergic acid diethylamide on repeated administration has been reported[5]. Our present investigation shows that incorporation of lysergic acid diethylamide with the food caused marked reduction in growth of larvæ of *Tenebrio molitor*, which was not reversed by returning the larvæ to normal diet.

Adult larvæ of the same age and weight were carefully selected from a stock and divided into two groups of thirteen each. Group I received the basal diet consisting of 77 per cent corn meal, 15·4 per cent bran, 7·6 per cent wheat germ supplemented with 1 per cent of yeast extract. Group II received the same diet except that 2·5 mgm. of lysergic acid diethylamide were added per 10 gm. of diet. The larvæ were returned to fresh diet every week. The growth-rates of these two groups are presented in Table 1, which shows the inhibitory effect of lysergic acid diethylamide on the growth of the larvæ.

Experiments have been carried out to test the duration of the effect of lysergic acid diethylamide. Small larvæ were selected and placed on the lysergic acid diethylamide diet for the first four weeks and then returned to the control diet. The results are presented in Table 2. The toxic effect of lysergic acid diethylamide on the growth of the larvæ persists long after the withdrawal of the drug. This long-standing effect of lysergic acid diethylamide is different from that of a vitamin deficiency where fast growth-rate

Table 1. Effect of Lysergic Acid Diethylamide on Larval Growth

No. of week	Average weight per larva	
	Group I (control)	Group II (fed with the drug)
Start 0	20 6	19·3
1	29·8	22 4
2	40·8	23·1
3	51·3	23·5
4	61·5	26·2
5	71 0	27 9

Table 2. Irreversibility of the Effect of Lysergic Acid Diethylamide

No. of week	Average weight per larva		
	Group 1 Control	Group II Drug diet, first four weeks only	Group III Drug plus reserpine, first four weeks only
Start 0	2·6	3·0	2·5
1	3·7	3·6	2·9
2	4·8	4 2	3·0
3	6·6	4·3	3·5
4	8·9	4·9	4·2
5	12·4	5·8	4·7
6	16·7	7·0	5·3
7	20·6	8·8	5·9
8	27·8	11·3	6·3
9	36·1	14·1	7·2
10	45·0	17·7	8·4

occurs on th
this may in
diethylamide
Further, addi
of lysergic a
larvae (Table
diet, on the
plus reserpin
25 per cent in

Child
Creedmoor
Queens Vill

[1] Rothlin, E., an
and Stratton
[2] Witt, P. N., Ex
[3] Mansour, T. E.,
[4] Becker, A. N.,
[5] Freedman, D. X
197, 1178 (1

Urinary Ex
# of C

The prosta
testicular hor
prerequisite fo
of the gland.
reflected in wh
secretion. T
prostatic acid
intimately de
the testes.

Prostatic se
it has been po
paper electro
these fraction
In some cases
characteristic

As it is evi
secretion is de
hormone, and
tion differs fro
prostato-vesic
studying the
suffering from

The materia
23–43 years.
prostato-vesic
gland for pape
protein compo
out for reduc
mixture of ves

Hormone ti
specimen of
substances : (1
Brown's meth

Furthermore
were carried o

Six of the
values for œst
limits given b
however, prese
(Table 1).

The urinary
noticeably hig

on of the vitamin. Also
e effect of lysergic acid
er than usually presumed.
e did not reduce the effect
de on the growth of the
larvae died on the control
iethylamide and the drug
ortality-rate was usually
veeks and none thereafter.

D. V. Siva Sankar
Arthur Kopelman
Peter Schilder
Eleanor Gold

l,
k.

armacology of LSD-25" (Grune
).
951).
., 12, 406 (1957).
2, 402 (1949).
K., and Ornitz, E. M., *Science*,

Œstrogens in Cases
ato-vesiculitis

ensitive target organ for
oduction of which is a
evelopment and function
tionship is consequently
e composition of prostatic
ntitative occurrence of
[1-3] and citric acid[4] is
e endocrine function of

ntains proteins, of which
ify different fractions by
mutual relationship of
tively fixed correlation.
stato-vesiculitis a rather
n was obtained[6].
composition of prostatic
he activity of testicular
composition of the secre-
in many cases of chronic
considered worth while
estrogens in individuals

7 men in the age-group
ded as cases of chronic
n was taken from the
tic examination of the
ditional test was carried
to reveal any possible
h[5].
performed on a 48-hr.
gard to the following
2) œstrone ; (3) œstriol.
ification was used[7,8].
ations of gonadotrophins
ght in mice).
examined showed titre
es lying well within the
normal men[8]. Eleven,
tres of these substances

f gonadotrophins was
atter group (Table 1).

Table 1

No.	Urinary excretion of Œstrogens γ/24 hr.				Gonadotrophins (M.U./24 hr.)
	Œstradiol	Œstrone	Œstriol	Total œstrogens	
1	1·5	4·5	2·4	8·4	> 6·5 <13
2	1·5	5·4	4·2	11·1	< 6·5
3	0·0	3·8	5·4	8·7	> 6·5 <13
4	1·8	0·0	6·0	7·8	< 6·5
5	2·1	5·4	2·4	9·9	< 6·5
6	2·1	7·5	1·8	11·4	> 6·5 <13
7	5·1	8·1	5·4	18·6	>13 <96
8	5·1	12·6	10·8	28·5	< 6·5
9	6·3	9·0	5·4	20·7	>96 <960
10	3·6	11·1	4·2	18·9	> 6·5 <13
11	12·0	7·5	4·8	24·3	>13 <96
12	5·4	7·8	4·8	18·0	>13 <96
13	2·6	7·5	22·2	32·8	> 6·5 <13
14	3·8	8·4	9·6	21·8	< 6·5
15	5·4	6·3	3·6	15·3	> 6·5 <13
16	6·3	9·0	4·2	19·5	> 6·5 <13
17	10·5	9·3	8·4	28·2	>13 <96
	Range and mean values according to Brown (ref. 8)				Normal value
	0·0–6·3 *M* 1·5	3·0–8·2 *M* 5·4	0·8–11·0 *M* 3·5	6·0–17·8 *M* 10·3	<13

A comparison now between the electrophoretic diagrams of all the cases with normal urinary titres (Fig. 1) with those with more or less increased œstrogen excretion (Fig. 2) brings out a difference. The two protein fractions nearest to the starting point are in the former cases comparatively less prominent, while in the latter they have a dominant character found in many cases of chronic prostato-vesiculitis[6].

By way of introduction, the point was made that the prostate gland in its capacity as a secondary sex organ in relation to both its development and secretory activity is ultimately dependent on testicular hormone.

Evidently, in many cases of chronic prostato-vesiculitis there occur high œstrogen urinary excretions. Since in certain of these cases the gonadotrophin titres are similarly increased, this might express an inhibition of testosterone production.

This circumstance might be interpreted as primary, making the gland susceptible to infection. Or, on the other hand, it might be a consequence of a primary prostatic infection. Finally, as a new point of view, a reduced testosterone activity might influence the target gland to develop an inflammatory reaction, clinically interpreted as a state of infection.

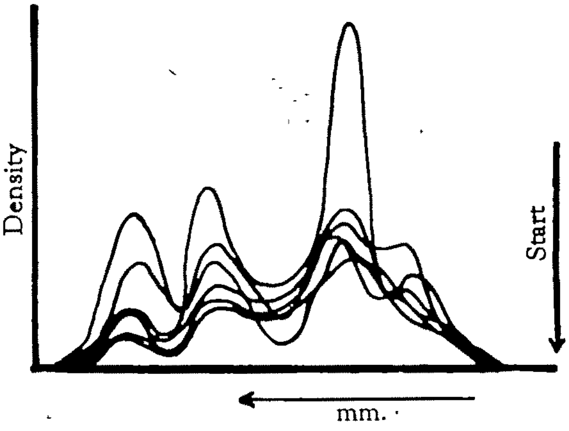


Fig. 1

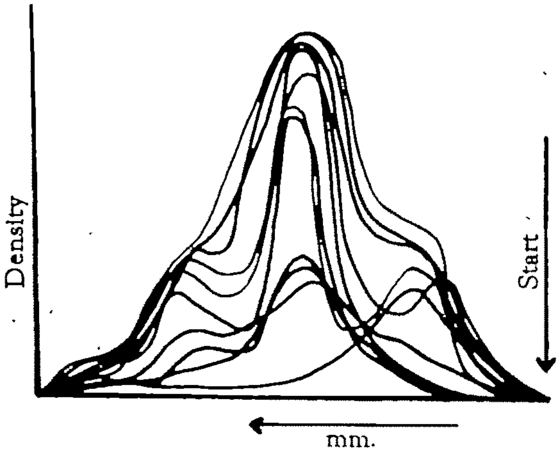


Fig. 2

My thanks are due to Dr. B. H. Persson for valuable ielp in performing the hormone determinations.

GUNNAR NYLANDER

Surgical Department,
University Hospital,
Uppsala.

Gutman, A. B., and Gutman, E. B., *Proc. Soc. Exp. Med. and Biol.*, 41, 277 (1939).
Scott, W. W., and Huggins, C., *Endocrinol.*, 30, 107 (1942).
Engberg, H., Andersson, E., Sury, B., and Raft, J., *Endocrinol.*, 5, 42 (1947).
Humphrey, G. F., and Mann, T., *Nature*, 161, 352 (1948).
Nylander, G., *Acta chir. Scand.*, 109, 473 (1955).
Mann, T., *Biochem. J.*, 40, 481 (1946).
Brown, J. B., *Biochem. J.*, 60, 185 (1955).
Brown, J. B., *Mem. Soc. Endocrinol.*, 3, 1 (1955).
Brown, J. B., Bulbrook, R. D., and Greenwood, F. C., *J. Endocrinol.*, 16, 49 (1957).

Eosinophil Leucocyte-attracting Effect of Histamine in Skin

WHEN histamine is injected into skin, one of the ffects that follows is an attraction of eosinophil eucocytes. A number of reports of this have been ublished[1-4]; but none of these papers discussed the ffects of widely differing rates of dosage, nor the arying degrees of eosinophilic infiltration around the njection site. The purpose of this communication is o report upon the extent of the eosinophil infiltration vhich follows various doses of histamine as the acid hosphate into the skin of horses.

The skin of the necks of cross-bred ponies was ised. The sites for injection and subsequent biopsy vere so placed that the centres of the sites were at east 10 cm. apart. The intradermal injections onsisted of the required amounts of histamine acid hosphate (B.D.H.) dissolved in 0·2 ml. sterile hysiological saline. The development of oedema vas measured and recorded, and the skin biopsies vere made 4 hr. after injection. The method has een described in detail elsewhere[5].

Six ponies were prepared each with 11 test sites for iopsy on both sides of the neck, a total of 132 sites. njections of histamine were given so that doses of ·01 μgm. to 20 mgm. were dispersed at random among he available sites on each pony, while two control sites n each pony received the saline vehicle only. From he skin biopsies, sections were prepared, and counts of the eosinophils occurring in 25 consecutive high-power fields were made. The results are expressed as an average number of eosinophils in each field (Fig. 1). Each observation is plotted with the standard deviation.

In the conditions of this experiment, a maximal eosinophilic infiltration occurred with doses approximating to 100 μgm. A second high response occurred with doses of 5 mgm. Some infiltration with eosinophils occurred with a dose as low as 0·05 μgm., while the control sites which did not receive any histamine had an average eosinophil count less than 0·1 cell per high-power field.

In another experiment a circle of 20 cm. diameter was prepared and shaved on the lateral aspect of the neck of a cross-bred pony. An intradermal injection of 5 mgm. of histamine acid phosphate was made in the centre of the circle and the precise injection site marked. After 4 hr., the oedema was carefully recorded on a scale drawing and skin biopsies were taken along 4 radii of the circle at 1-cm. intervals. The eosinophilic infiltration of each was assayed and the results are shown in Fig. 2. It was found that two areas of oedema could be recognized: a primary zone around the site of injection and a secondary zone ventral to this, presumably due to the spread of the histamine by gravity to areas below the primary site.

Replicates of this experiment using 15 mgm. of histamine acid phosphate gave an essentially similar result except that both the oedema and the eosinophilia extended over a slightly larger area. A dose of 100 μgm. gave a similar picture so far as the inner 5-cm. radius of the circle was concerned, but there was no secondary oedema.

In the skin of horses, intradermal injections of histamine produce a degree of eosinophilic infiltration which is related to the dose of histamine. From about 0·5 μgm. to 50 μgm. the increase is linear. It is of interest that doses greater than 200 μgm. produce less eosinophilic infiltration than do smaller doses, but presumably no local concentration of histamine approaching these levels could occur in life. The secondary oedema which follows intradermal injection

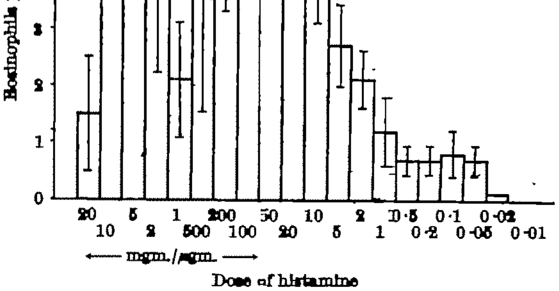


Fig. 1. The eosinophilic infiltration of horse skin after intradermal injections of various doses of histamine acid phosphate. Each normogram is the mean of six replicates on different animals, plotted with the standard deviation

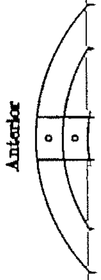
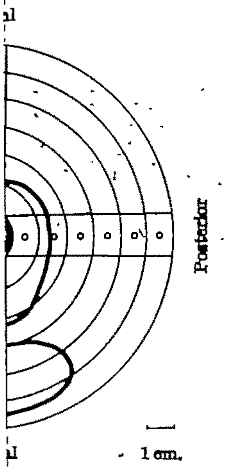


Fig. 2. The co
injection of hist
1 cm. apart on
site of injection
formed are indif
the concent



ophils around an intradermal
f a pony. Biopsies were made
e the centre of which was the
e two areas of oedema which
y line. The figures indicate
s in each biopsy specimen

of large dose
increase in e
approximately
The *p*H of t
not critical, a
*p*H with sod
reduction of
phosphate (th
produce eosin
cerned.

Equine Res
Animal H
New

[1] Archer, R. K.,
[2] Archer, R. K., *J*
[3] Kline, B. S., Col
(1932).
[4] Knott, F. Q., and
[5] Rick, R. F., *Au*

is accompanied by an
tent of the tissue over
.

tamine acid phosphate is
f the solution to neutral
te produced only minor
Injections of an acid
histamine base) did not
tion of the tissue con-

R. K. ARCHER

'87 (1956).
5 (1959).
idolph, S. A., *J. Allergy*, 3, 531
Guy's Hosp. Rep., 84, 230 (1934).
ee., 5, 109 (1954).

LOGY

Effect of 6-
ine on the Net *In vitro* Gas
of Sensitive and Resistant
Leukaemia Cells

It was recen
to develop an
ic cells to va
upon the hypo
which would
cells might n
In an attempt
ments with se
*L*1210 mouse
A prelimina
cells were incu
apparatus sho
but that the r
A straight-lin
(carbon dioxi
and time cont
considered a

that it might be possible
he sensitivity of leukaem-
ierapeutic agents based
concentrations of drugs
gen-uptake of sensitive
which were resistant[1].
hypothesis some experi-
mercaptopurine-resistant
were carried out.
in which sensitive strain
at 37° C. in a Warburg
en-uptake was irregular,
production was constant.
between net gas output
less oxygen utilization)
re than 7 hr., and was
ieter for a study of the

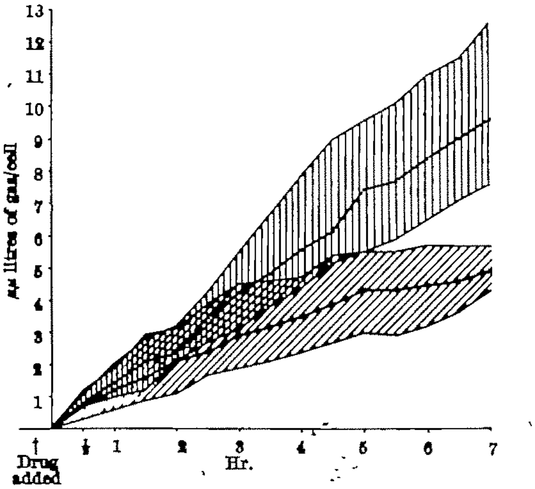


Fig. 1. The effect of 6-mercaptopurine on the net gas production of sensitive *L*1210 cells.
●, and vertical shading, sensitive cells: no drug control; ×, and oblique shading, sensitive cells: 6-mercaptopurine

in vitro action of drugs. The effect of 6-mercaptopurine on sensitive cells was studied in three experiments. Two vessels containing cells alone and two containing cells and 6-mercaptopurine (10 *M* twice and 6 *M* once) were set up each time. Between 7 and 15 million cells in 5 ml. of a mixture of medium 199 (80 per cent) and normal human serum (20 per cent) were used and the drug added between 30 and 45 min. before the first readings. Fig. 1 summarizes the results. The thick lines represent the averages of the six readings and the shaded area the ranges. 6-Mercaptopurine caused a decrease in the net gas production; this effect noticeable at 3 hr. is clearly significant by 5 hr.

When a 6-mercaptopurine-resistant strain of *L*1210 cells became available through the courtesy of Dr. L. W. Law, of the U.S. National Cancer Institute, the experiments were repeated. Under the same experimental conditions the *in vitro* gas production of

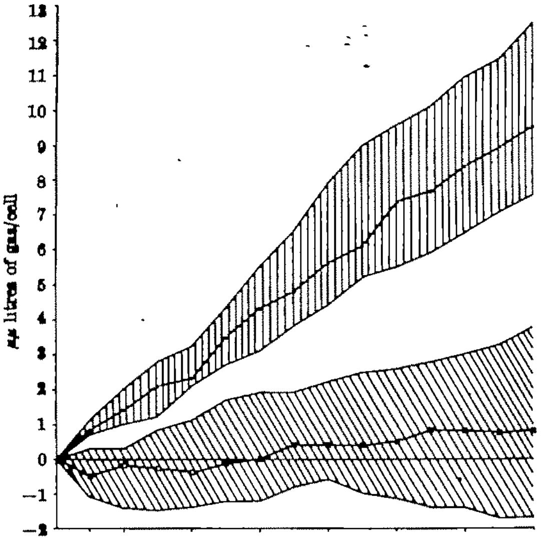


Fig. 2. A comparison of the net gas production of sensitive and 6-mercaptopurine-resistant *L*1210 cells
● and vertical shading, sensitive cells: no drug control; □ and oblique shading, sensitive cells: 6-mercaptopurine

the resistant cells was found to differ considerably from that of the sensitive cells.

This difference is illustrated in Fig. 2. The net gas production of the resistant cells was recorded on three separate occasions utilizing 2, 2 and 4 vessels, respectively. The average finding of the eight recordings is given in the thick line and the range by the shaded areas. On one occasion sensitive cells tested at the same time gave results which fell into the range illustrated in Fig. 1.

The effect of 6-mercaptopurine on resistant cells was also studied. The net gas production in these circumstances fell within the range for the controls. It is not, however, possible to draw any firm conclusions from this since the readings have a rather wide range around unity and so any effect of the drug would be difficult to detect.

While no support has been gained for the hypothesis that stimulated this investigation, two points of interest have emerged. First, a simple reproducible system for the investigation of the effect of 6-mercaptopurine upon sensitive *L*1210 cells has been found, and secondly, a profound difference in the respiratory behaviour of sensitive and 6-mercaptopurine-resistant *L*1210 cells has been observed.

This work was carried out during the tenure of a Leukæmia Society Fellowship. I am grateful to Mr. D. E. S. Truman for his help with manometry, and to Miss M. Barrett of the Wellcome Research Laboratories for sending me mice inoculated with *L*1210 cells. Messrs. Burroughs Wellcome kindly supplied the 6-mercaptopurine.

H. J. Woodliff

Department of Medicine,
University of Cambridge.

---

[1] Woodliff, H. J., and Davis, J. M. G., *Nature*, 185, 477 (1960).

Electrophoretic Separation of Certain *In vitro* and *In vivo* Reactions of Rabbit Anti-Mouse Erythrocyte Serum

Rabbit anti-mouse-erythrocyte serum provided an excellent model for the study of *in vitro* and *in vivo* immunological reactions. In addition to its strongly hæmolytic and agglutinating properties for, and its combining ability with, mouse erythrocytes, this antiserum readily produces anæmia in mice, a species especially suitable for this purpose.

These reactions were studied as quantitatively as possible under comparable conditions: hæmolysin was measured in 50 per cent hæmolytic ($H/2$) units in a total volume of 2 ml. Approximately 5×10^7 erythrocytes were lysed by one $H/2$ unit of hæmolysin. Saline agglutinin was titrated by a 1·26-fold dilution system and recorded in scores (++++ = 10, +++ = 8, ++ = 5, + = 3, + *w* = 1). In this way, the end-points were spaced more closely and the strength of the serum was represented more precisely. The combining ability was detected by using unlabelled and fluorescein *iso*cyanate-labelled sheep anti-rabbit globulin serums. With the former, an indirect anti-globulin test was done and the agglutinating titres were recorded. The formalinized mouse erythrocytes were sensitized with the anti-mouse erythrocyte serum or its fractions. It was then coated with the fluorescent serum, washed, and examined microscopically with ultra-violet light. The brightness of the green fluorescence was recorded as − (negative), +, ++, +++, ++++ (positive).

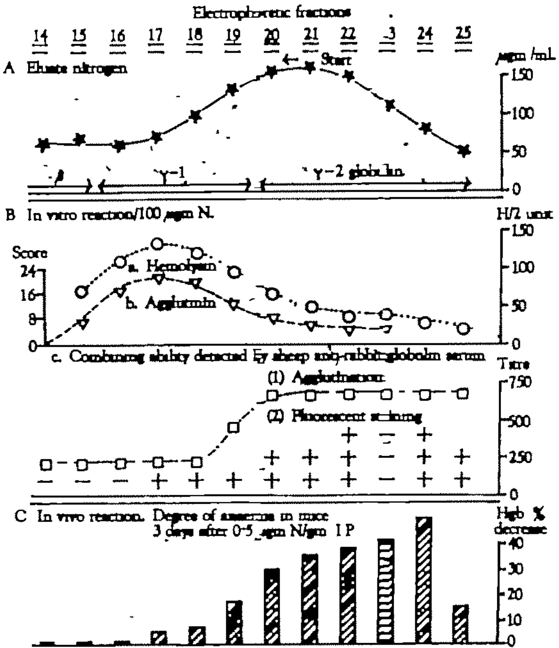


Fig. 1. Association of immunological reactions with electrophoretic fractions of rabbit anti-mouse erythrocyte serum

Groups of mice were injected intraperitoneally with 0·01 ml. of different dilutions of rabbit anti-mouse erythrocyte serum per gram of mouse. The potency of the serum was measured by the degree of anæmia at its maximum, which was usually 3 days after the injection. The degree of anæmia was expressed in terms of percentage hæmoglobin decrease, as compared with the pre-injection value. Hæmoglobin was determined with the cyan-methæmoglobin method using a red-cell-counting pipette to minimize the amount of blood required.

Rabbit anti-mouse erythrocyte serum was prepared by injecting rabbits intraperitoneally with 1 ml./kgm. of a 10 per cent suspension of thoroughly washed erythrocytes. Injections were repeated four times weekly in the first and third week. Antiserum was collected 7 days after the last injection. Fractionation of serum was accomplished by starch-zone electrophoresis[1]. At the end of each run the 50-cm. long starch block was divided evenly into 25 fractions. Buffered saline eluates from each fraction were adjusted to contain equal numbers of μgm. of protein nitrogen before their activity was tested. Similar results were observed with fractions of 5 antisera. An example is shown in Fig. 1 in which only the β- and γ-globulins (fractions 14 to 25) are listed. Samples from other fractions were also tested concurrently but found to be negative. The association of the various immunological reactions with the globulin fractions can be summarized as follows.

In *in vitro* studies, the hæmolysin and saline agglutinin were similarly distributed. Most of them were associated with the γ-1 globulin fractions. The combining ability as demonstrated by unlabelled and fluorescein-labelled sheep anti-rabbit globulin serums was associated mainly with γ-2 globulin fractions. These findings are essentially the same as those reported by the isotope-tracing technique in the rabbit anti-sheep erythrocyte system[2].

In *in vivo* experiments, the degree of anæmia in mice increased progressively from fractions 19 to 24

which contain
anæmia-produc
with the combi
or hæmolysin.
Successful se
for the anæmia
sin in the rabb
demonstrated b
This work wa
the National
Public Health
fellowship.

Depa
Chi
Mount Sinai M
Hosp

[1] Kunkel, H. G., an
80, 42 (1952).

[2] Stelos, P., and Ta

Sediment
γ-Chain

FROM the X-
Perutz and his
ination of the
of human hæ
human hæmog
half-molecules,
amino-acids.
showed that nc
of four polypep
these types—af
inal valyl–leucy
by Rhinesmith,
terminal valyl–
of chain, later n
fœtal hæmoglol
It carried a t
hæmoglobin F
terminal valyl
be identical wit
Differences b
have in general
in one amino-a
A new type of
by Jones, Schr
they found tha
β-chains.
In 1958 the
described[12], and
sidered to be a
pigment was fc
hæmoglobin H
was not known
to form the 'Ba
therefore, exam
ture containing
weight approxi
hæmoglobin 'B
blood of a patie
of the Governm
Pure hæmoglob
phoretically fro
also examined.

It is obvious that the
more closely associated
ın with saline agglutinin

) component responsible
agglutinin and hæmoly-
erythrocyte serum was
rch-zone electrophoresis.
ı part by Grant A–77 of
Health, United States
he Carl Howard Litvin

CHANG-LING LEE
TAMON TAKAHASHI
ISRAEL DAVIDSOHN
:hology,
School,
h Foundation and
Illinois.

roc. Soc. Exp. Biol. and Med.,

nf. Dis., 100, 126 (1957).

cteristics of the
ı (Hæmoglobin
ı')

f horse hæmoglobin by
,[2] and Ingram's exam-
ed by tryptic digestion
can be concluded that
posed of two identical
ing approximately 280
chroeder and Pauling[4]
moglobin (A) consisted
only two types. One of
d α-chain—had a term-
β-chains were identified
d Martin[5] as carrying a
residue. A third type
was observed in human
hroeder and Matsuda[6].
l residue. The other
ly known to carry a
s shown by Hunt[9] to
of hæmoglobin A.
hæmoglobin variants
be due to an alteration
he α- or the β-chain[10].
variant was described
and Vinograd[11] when
H consisted solely of

variant 'Bart's' was
ts properties, was con-
etal hæmoglobin. This
e fœtal counterpart of
d solely of γ-chains. It
these chains combined
in molecule. We have,
entation-rate of a mix-
moglobin A (molecular
) and 11 per cent of
vas prepared from the
to us by Dr. B. Ramot
Tel-Hashomer, Israel.
vas separated electro-
e on starch block and

Solutions of the carboxy proteins equilibrated by dialysis against phosphate–sodium chloride buffer pH 8·0, ionic strength 0·35 (potassium dihydrogen phosphate 0·0044 M, disodium hydrogen phosphate 0·0652 M, sodium chloride 0·15 M), were studied in the Svedberg oil-turbine ultracentrifuge at 54,000 rev./min., the diagonal schlieren system being used for optical observation.

The mixture of hæmoglobin A and hæmoglobin 'Bart's' sedimented as a single symmetrical peak when examined at concentrations of 1·5 and 1·0 gm. protein/100 ml. At the latter concentration the sedimentation coefficient was $S_{20,w} = 4 \cdot 13\ S$. A solution of hæmoglobin 'Bart's' examined at 0·36 gm./100 ml. also sedimented as a single component, with $S_{20,w} = 4 \cdot 49\ S$. These values for the sedimentation coefficients are in excellent agreement with those obtained at corresponding concentrations of carboxyhæmoglobin A by Kegeles and Gutter[14]. From these observations it may be concluded that the molecular weight of hæmoglobin 'Bart's' is very close to that of hæmoglobin A, approximately 68,000.

By analogy with Jones *et al.*[11], who have named hæmoglobin H β_4, we suggest that hæmoglobin 'Bart's' should be referred to as γ_4.

Fœtal hæmoglobin ($\alpha_2\gamma_2$) is distinguished by a 'tryptophan notch' in the ultra-violet spectrum and by being more resistant to denaturation by alkali than adult hæmoglobin ($\alpha_2\beta_2$). Hæmoglobin γ_4 shares these properties to a different degree. Choremis, Zannos-Mariolea, Ager and Lehmann[15] produced a figure in which the absorption spectra of solutions of equal strength of $\alpha_2\gamma_2$ and γ_4 are compared, and it can be seen that for γ_4 the 'tryptophan notch' is about twice that of $\alpha_2\gamma_2$. The alkali resistance of γ_4 is, however, only about one half that of $\alpha_2\gamma_2$. A possible explanation is that the distinctive ultra-violet spectrum is due to chemical properties of the γ-chain, but that the alkali resistance is associated with the structural arrangement of the four chains in the hæmoglobin molecule. The combination of α- and γ-chains would then produce a less-accessible target for the denaturing agent than that of γ-chains by themselves.

R. A. KEKWICK

Lister Institute of Preventive Medicine,
London, S.W.1.

H. LEHMANN

St. Bartholomew's Hospital,
London, E.C.1.

[1] Perutz, M. F., Liquori, A. M., and Eirich, F., *Nature*, 167, 929 (1951).

[2] Cullis, A. F., Dintzis, H. M., and Perutz, M. F., "Conference on Hemoglobin", Publication 557, Nat. Acad. Sci., 50 (Nat. Res. Council, Washington, D.C., 1958).

[3] Ingram, V. M., *Nature*, 178, 792 (1956).

[4] Rhinesmith, H. S., Schroeder, W. A., and Pauling, L., *J. Amer. Chem. Soc.*, 79, 4682 (1957).

[5] Rhinesmith, H. S., Schroeder, W. A., and Martin, N., *J. Amer. Chem. Soc.*, 80, 3358 (1958).

[6] Schroeder, W. A., and Matsuda, G., *J. Amer. Chem. Soc.*, 80, 1521 (1958).

[7] Porter, R. R., and Sanger, F., *Biochem. J.*, 42, 287 (1948).

[8] Masri, M. S., and Singer, K., *Arch. Biochem. Biophys.*, 58, 414 (1955).

[9] Hunt, J. A., *Nature*, 183, 1373 (1959).

[10] Ingram, V. M., *Brit. Med. Bull.*, 15, 27 (1959).

[11] Jones, R. T., Schroeder, W. A., Balog, J. E., and Vinograd, J. R., *J. Amer. Chem. Soc.*, 81, 3161 (1959).

[12] Ager, J. A. M., and Lehmann, H., *Brit. Med. J.*, i, 929 (1958).

[13] Hunt, A. J., and Lehmann, H., *Nature*, 184, 872 (1959).

[14] Kegeles, G., and Gutter, F. J., *J. Amer. Chem. Soc.*, 73, 3770 (1951).

[15] Choremis, C., Zannos-Mariolea, L., Ager, J. A. M., and Lehmann, H., *Brit. Med. J.*, ii, 348 (1959).

RADIOBIOLOGY

Potentiation of Hair-Growth by Ultra-Violet Light

SINCE Findlay performed his pioneer experiments in 1928[1], much research has been carried out to investigate the carcinogenic action of ultra-violet light on skin.

Little work has been done, however, to establish the exact wave-length of light concerned in the production of tumours, and it was in the course of experiments designed to elucidate this problem that a growth-promoting effect of ultra-violet light on hair was observed.

The apparatus used in this work was the monochromator described by Magnus *et al.*[2], which employs a large quartz, water-filled prism for dispersion and a 2-kW. high-pressure xenon arc lamp (Osram *XBO* 2001) as light-source. Male mice of strain *A*, aged 2–3 months, were used in the experiments.

The hair was removed from the flanks of a mouse with Clukes small animal clippers, and the animal was placed in a jacket of 'Cellophane' secured with Spencer Wells forceps. The jacket had an opening cut in the side to correspond with the exit slit of the monochromator, and was held in a clamp with this opening opposite the exit slit.

A series of six mice was exposed to ultra-violet light of wave-length 2600 Å. for a period of four weeks, irradiated five days per week, daily dose: $2 \cdot 5 \times 10^7$ ergs. cm.$^{-2}$.

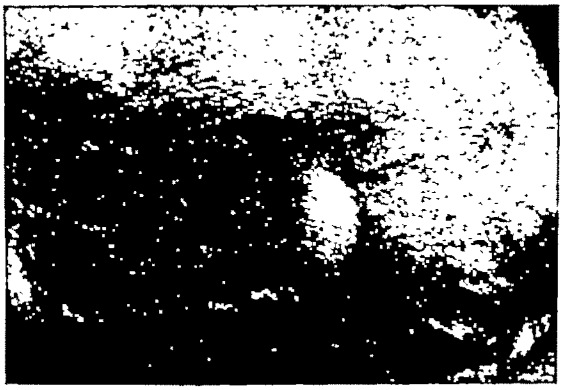


Fig. 1. Flank of mouse showing tuft of hair in irradiated patch

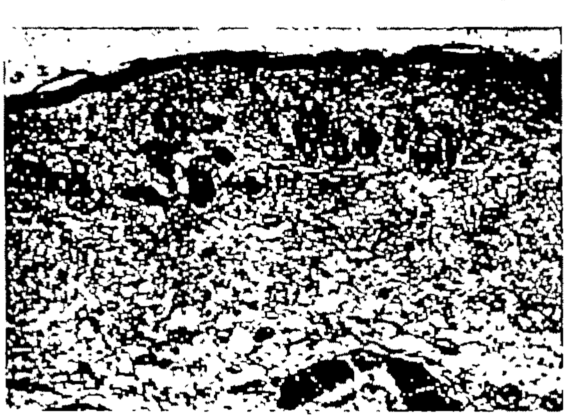


Fig. 2. Serial section from edge of the patch. Compare with the control

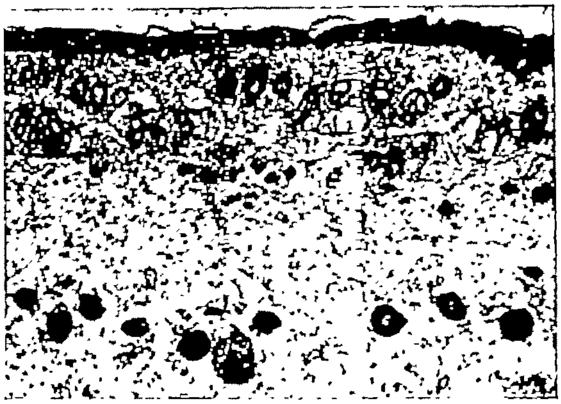


Fig. 3. Serial section from just inside the edge of the patch. The resting phase hair follicles are undisturbed, but activity can be observed in the dermis. The epidermis is characteristically thickened

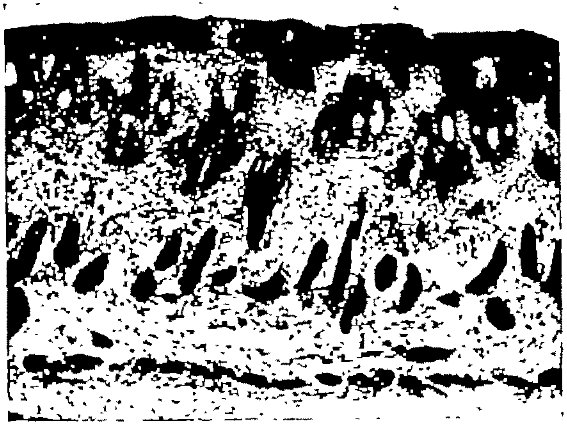


Fig. 4. Serial section from the centre of the patch. The active hair follicles are very evident, and the resting phase follicles are considerably disordered. The epidermis is extremely thickened in this region

In each specimen, a considerable potentiation of hair-growth was observed in the irradiated patch of skin.

As the hair growth-cycle was not at an identical stage in each specimen, the appearance of hair through the epidermis did not occur at the same time in each animal. There were, however, similar changes in the skin of each animal, and by the end of three weeks

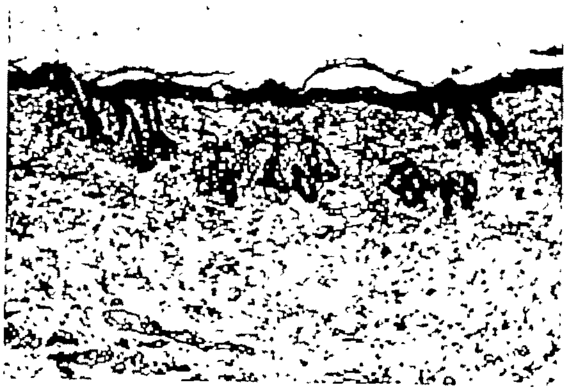


Fig. 5. Section from opposite flank as control. The hair growth-cycle is in its resting phase, the hair club and capsule lying in a position close to the epidermis, just below the level of the sebaceous gland duct

irradiation a
apparent, whil
from the origir
After two da
patch appeare
reaction. This
lengths of tim
appearance of
patch. Hair
these ridges wh
appearing quite
growing on it.
The tuft of h
in each case, t
and the other
examination of
across the pat
were stamed w
A gradient of f
outer edges of
centre (Figs. 2
and stained (Fi
Work is now
of irradiation a
of other wave-
This work ha
British Empire

of hair was invariably
ling skin was still bare
g. 1).
e skin in the irradiated
ing a typical erythema
maintained for varying
ways followed by the
ges at the edges of the
rved growing between
subsided, the skin then
an oblong tuft of hair

down to the skin again
eing further irradiated,
illed for a histological
Serial sections were cut
erior to posterior, and
ematoxylin and eosin.
was observed from the
aching a peak at the
sections were also cut

study the further effects
to determine the effects
he growth of hair.
ed by a grant from the
ign.

B. E. JOHNSON

Institute of I
Lisle S
London,

[1] Findlay, G. M., Lc
[2] Magnus, I. A., Por
Wright, W. D.,

).
, K. J., Moreland, J. D., and
, 261 (1959).

Polyvalent ical Tolerance in
Homolc ion Chimæras

THE 'seconde
chimæras may
hæmatopoietic
irradiated mice
from adult don-
evidence that :
(1) The imm
animals is of d
lymphoid cells
(2) The cor
immunologically
which became
host's antigens
tolerance of the
If this hypot
to extend the i

homologous radiation
by using embryonic
therapy of lethally
responding cells derived
ct seems to be indirect

acity of the surviving
y originating from the
embryonic graft.
tween the host and
ells of the homograft
lose contact with the
to the immunological
ts host.
tempts might be made
tolerance of the embryonic graft to more antigens than those specific for its lethally irradiated host only, with the eventual aim of converting the homologous radiation chimæras into universal recipients of homologous tissues from any randomly selected individual of an antigenically heterogeneous population. The same principle could be used here as in the experiments of Hašek and Hašková[4] on polyvalent immunological tolerance in ducklings: to expose immunologically immature cells to the complete antigenic spectrum representing the given population. In the treatment of lethally irradiated mice, these conditions could be accomplished by means of pooled embryonic hæmatopoietic cells derived from a sufficiently great number of donors.

A preliminary experiment was made to estimate the suitable number of donors[5]. It was assumed that this number must exceed the minimal number of embryonic donors the pooled cells of which need to be administered to normal recipients to render them capable of developing a second-set reaction against a skin homograft from any donor selected at random. It was demonstrated that 40 embryonic donors are necessary to induce a 'universal' transplantation immunity by means of their pooled cells. With 50 embryonic donors, therefore, the experiments were started to induce a 'universal' immunological tolerance in homologous radiation chimæras.

Adult female mice of a random-bred strain *H* were used. All 65 control skin homografts carried out between randomly selected individuals of this population were rejected during 23 days with a mean survival-time of 10·7 days. Irradiated animals (900 r. X-rays ; 220 kV., 22 m.amp., half-value layer 1·2 mm. copper, 27 r./min. at 70 cm.) have been given intravenously 0·5 ml. of embryonic liver cell suspension containing 10^7 cells per mouse. The survivors were skin grafted approximately 2 months later with the results shown in Table 1.

From the results presented here, it seems to be evident that :

(1) Even if the skin grafts originate from the same individual or from the same inbred strain as the therapeutic dose of embryonic hæmatopoietic cells, a low proportion of them fails to survive, probably because of the recovering immunological capacity of the host.

(2) No grafts survive from donors other than those of the therapeutic dose of hæmatopoietic cells with the exception of cases when pooled embryonic cells from 50 donors were administered.

(3) The mean survival-time of the rejected grafts seems to be slightly prolonged in homologous radiation chimæras in comparison with that in non-irradiated recipients of the same population.

Table 1. EFFECT

PROCEDURE IN LETHALLY IRRADIATED RANDOM-BRED *H*-MICE ON THE RESULTS OF SKIN GRAFTING

Group	Donor c	iver cells	Donor of the skin graft	Successful grafts (intact after 2 months)	Mean survival-time of the rejected grafts (days)	
					In radiation chimæras	In control non-irradiated *H*-mice
1	Inbred	9-day old	*CBA*	17/20	17·0	9·7
			C 57 BL	0/5	12·0	9·2
2	Random old	8–19-day	*H*-donor of the embryonic liver cells (embryonic skin frozen with glycerol)	8/10	17·0	11·0
	Not poo donor	ryonic	Randomly selected adult *H*	0/8	15·3	10·7
3	Random old, po	.8–19-day r donors	Randomly selected adult *H*	5/9	17·0	10·7

(4) Immunological tolerance may be induced in he pooled embryonic inoculum leading to the ompatibility not only between graft and host but lso among the individual components of the graft tself. Immunological competition among pooled noculum of adult bone marrow cells seems to account or the failure in the attempt of Murray *et al.*[6] to nhance the transplantability in lethally irradiated abbits. This would be also in agreement with the inding of Billingham *et al.*[7] and Gorer[8].

(5) It might be useful to increase the number of mbryonic donors to more than 50. As the number f the donors is raised, the antigenic contribution rom each of them decreases on one hand, but on he other the probability increases of a given antigen occurring several times in the pool.

(6) With regard to antigenic heterogeneity, both he mouse population as described here and the duck opulation of Hašek and Hašková seem to resemble he wild population much more closely than the andom-bred rats used in experiments of Billingham nd Silvers[9]; the induction of a state of 'polyvalent' mmunological tolerance by means of a pool of mmunologically immature cells comprising the omplete antigenic spectrum of a wild population eed not, therefore, be beyond practical possibilities.

This work is part of a research contract with the International Atomic Energy Agency.

ALENA LENGEROVÁ

Institute of Biology,
Czechoslovak Academy of Sciences,
Na cvičišti 2,
Prague 6.

---

[1] Lengerová, A., Conf. on Biological Basis of Tissue Transplantation (Prague, 1957); *Trans. Bull.*, 5, 69 (1958).

[2] Barnes, D. W. H., Ilbery, P. L. T., and Loutit, J. F., *Nature*, 181, 488 (1958).

[3] Uphoff, D. E., *J. Nat. Cancer Inst.*, [illegible], 625 (1958).

[4] Hašek, M., and Hašková, V., Conf. on Biological Basis of Tissue Transplantation (Prague, 1957); *Trans. Bull.*, 5, 69 (1958).

[5] Lengerová, A., and Chutná, J., *Folia Biol.* (Prague), 6, 50 (1960).

[6] Murray, J. E., Wilson, R. E., Dealy, J. B., Sadowsky, N. L., and Corson, J. M., "Biological Problems of Grafting", 354 (Liège, 1959).

[7] Billingham, R. E., and Brent, L., *Phil. Trans. Roy. Soc.*, B, 242, 439 (1959).

[8] Gorer, P. A., "Biological Problems of Grafting", 366 (Liège, 1959).

[9] Billingham, R. E., and Silvers, W. K., *J. Immunol.*, [illegible], 667 (1959).

BIOLOGY

Mutations affecting the Density of Bacteriophage λ

IT has been shown by Weigle, Meselson and Paigen[1] that λ-phage particles able to transduce galactose markers have buoyant densities in caesium chloride which differ from that of the phage from which they were derived. The altered densities are transmitted to the offspring.

Weigle *et al.*[1] showed that spontaneous clear (*c*) mutants derived from λ reference[2] are not altered in density. They did find, however, that the phages liberated, after induction, by a certain strain of bacteria lysogenic for λ were denser than λ reference.

While studying the densities of the λ mutants used by Jacob and Wollman[3] and by Kaiser[2] we found phages of two other densities. The buoyant densities in caesium chloride of plaque-forming λ are given in Table 1.

Table 1

Phage	Buoyant density symbol	Buoyant density in CsCl (gm./cm.^{3})	Origin of the phages
λref	*B*0	1·508	Kaiser (ref. 2)
λdense	*B*1	1·512	Weigle *et al.* (ref. 1)
λco	*B*2	1·491	Jacob and Wollman (ref. 3)
λc *mi*	*B*2	1·491	and Kaiser (ref. 2)
λc *m*6	*B*2	1·491	
λ*h*	*B*3	1·504	Appleyard *et al.* (ref. 4)
λ*m*5	*B*3	1·504	Jacob and Wollman (ref. 3)

The densities were measured using the density of λ reference as density reference (see Weigle *et al.*[1]) in a Spinco analytical ultracentrifuge by the method of density gradient of Meselson, Stahl and Vinograd[5].

Phages of the density *B*2 were chosen for a detailed genetic study. These phages carrying the markers *c mi* or *c m*6 were crossed to λ reference (and later to λ*m*5) of density *B*0. The progeny phages of these crosses were analysed by density gradient centrifugation. The phages, suspended in caesium chloride solution in water, are placed in 'Lusteroid' tubes in the *SW* 39 swinging bucket rotor of a Spinco ultracentrifuge and spun for 16 hr. at 22,000 r.p.m. Then as described by Weigle *et al.*[1] the bottoms of the tubes are pierced and successive emerging drops are collected separately. The contents of each drop are later analysed for the number of phages and for the genetic markers these carry.

The results show that virtually all the progeny phages have the densities *B*0 and *B*2 of either of the parents (about 0·1 per cent of the progeny phage which seem to have an intermediate density are at present under study). All the phages of density *B*0 or *B*2 respectively transmit this density to their progeny regardless of the genetic markers they carry. Recombinant phages of density *B*2 when crossed with one another give progeny only of the density *B*2 (and this is true of recombinants of density *B*0 also). Density *B*2 thus behaves as a single genetic character. We shall call *b*2 this character and $b2^{+}$ its allele in λ reference. By comparing the relative frequencies of different genetic markers at the densities *B*0 and *B*2 respectively it is possible to locate *b*2 on the genetic map of λ. It is very near *m*5. In fact in a cross between λ*m*5 $b2^{-}$ and λ$m5^{-}$ *b*2 only about 0·01 per cent recombinants λ$m5^{+}b2^{+}$ and λ*m*5*b*2 are observed.

In a cross between *b*2 and $b2^{+}$ the phenotype *B*2 or $B2^{+}$ (or *B*0) respectively always corresponds to the genotype *b*2 or $b2^{+}$, that is, there is no phenotypic mixing.

The phages $b2^{+}$ are able to mutate to *b*2, but reverse mutations have not been looked for.

The phages *b*2 are different from $b2^{+}$ not only in density but also in their ability to form stable lysogens. In all the cases studied the decrease in density was always accompanied by loss in the ability to form stable lysogens. The marker *b*2 is perhaps identical to the marker *l* of Jacob and Wollman[3] which they located near *m*5 and which also prevents stable lysogenization.

The density *B*1 seems also to be determined by a locus *b*1, located in the *c* region of the genetic map of λ. The presence of *b*1 increases the density of λ without affecting its lysogenizing frequency.

We have been unable to study quantitatively the properties of the phages of density *B*3, for the phages

of this phe
become part
and in lytic c
in favour of
appear as a
can be osmo
(according t
(private com
in crosses c
lysogenizatio
ence.

The cause
present unkn
involved in t
Weigle *et al.*[1]
of its deoxyri
only 83 per c
of λ*b*2+.

Laborato
Univer

Divisi
California Ins

[1] Weigle, J., Mese
[2] Kaiser, A. D.,
[3] Jacob, F., and
[4] Appleyard, R
565 (1956).
[5] Meselson, M., St
43, 581 (1957

Combined
and Dark-

'THOROTRA
identified quit
ordinary light
in sufficient q
trast' is seen
clumps.

Small quant
when ingested
intermingled
see.

A method c
any standard
annuli and cir
found which
'Thorotrast' ir
quantities, to

The microsc
usual way, an
oil-immersion
stop. The ×
objective in
stituted for th
×95 stop as

The result,
tion, shows t
particles in a
tion of the p
made out, wh
ventional da

instable. Stocks of λ*B*3
sed in the course of time
h there is a strong selection
phenotype *B*3+ which may
f mutations. Phages λ*B*3
l by choline hydrochloride
devised by S. Brenner
Phenotypic mixing occurs
*B*3+. The frequency of
equal to that of λ refer-

nges in densities are at
an idea of the magnitudes
, it may be calculated (see
s due only to an alteration
content λ*b*2 would possess
xyribonucleic acid content

G. KELLENBERGER
M. L. ZICHICHI

que,
).

J. WEIGLE

nology,

n, K., *J. Mol. Biol.*, 1, 379 (1959).
55).
. *Inst. Pasteur*, 87, 653 (1954).
., and Baird, K. M., *Virology*, 2,
ad, J., *Proc. U.S. Nat. Acad. Sci.*,

ion, Phase-contrast,
wing of 'Thorotrast'
Sections

thorium dioxide) can be
ue sections when using an
rovided that it is present
r such conditions 'Thoro-
istic refringent brownish

trast', however, especially
es or other cells, or lying
cells, are often difficult to

se-contrast microscope of
viding it is fitted with
the phase-plate) has been
exact distribution of
s, in either large or small
l.

the light centred in the
stem adjusted for phase-
ng the ×95 phase-plate
), or other low-powered
×40 range is now sub-
objective, but using the

ial dark-ground illumina-
' as brightly illuminated
ound field; but the posi-
n the tissues can still be
case when using a con-
denser.

If the sub-stage condenser is now moved up and down, a whole range of contrasting illuminations is obtained from near dark-ground, through a spectral series of contrasting colours in both specimen and background, to white illumination when a stained preparation appears as seen under an ordinary light microscope. For photographic purposes the differential effect may be increased by the use of appropriate colour-filters.

The effects just described are not seen when a fresh sample of 'Thorotrast' is examined, but only after it has been incorporated into body tissues. These effects may also be observed, though in a lesser degree, when using a continuously variable phase-contrast microscope. Such instruments, however, are less common than standard phase-contrast equipment.

The method may also be used with advantage for the examination of living cells, stained, and unstained sections; especially it has been found useful for rapid preliminary inspection of such objects as tissue explants, cultures of protozoa and similar living objects. Finally, the method allows rapid change over to oil-immersion, with or without phase-contrast, since the ×95 stop remains centred throughout.

E. W. BAXTER

Biology Department,
Guy's Hospital Medical School,
London, S.E.1.

Ageing of Mitochondria

THE ability of ethylenediamine tetraacetic acid to stabilize mitochondria is well known[1–4]. The present work was concerned with the effect of ethylenediamine tetraacetic acid on mitochondria in 0·25 *M* sucrose during and after rigorous treatment either by pre-incubation with carbon tetrachloride or by standing at 22° C. and then at 0° C. for prolonged periods.

Christie and Judah[7] found that washed mitochondria isolated from liver homogenates which had been pre-incubated at 0° C. for 3–4 hr. with carbon tetrachloride oxidized certain substrates at very low rates. The oxidations affected were those catalysed by enzyme systems which require pyridine nucleotides for electron transport. Normal activities could be restored by the addition of co-factors containing the appropriate pyridine nucleotide.

In the present work 10 per cent w/v homogenates of rat liver were prepared at 0–1° C. in 0·25 *M* sucrose, and in 0·25 *M* sucrose + 0·001 *M* ethylenediamine tetraacetic acid. Carbon tetrachloride was added to a concentration of 0·03 *M*, and mixed with the homogenate by shaking. Mitochondria were isolated immediately from portions of the homogenates by differential centrifuging[8]. They were then re-suspended in 0·25 *M* sucrose to wash off residual carbon tetrachloride, re-centrifuged and re-suspended in 0·25 *M* sucrose. The remaining portions of the homogenates were shaken gently at 0–1° C. for 90 min. in contact with carbon tetrachloride; mitochondria were then isolated, washed and re-suspended in 0·25 *M* sucrose.

Mitochondria from homogenates treated with carbon tetrachloride for 90 min. were found to have lost much of their ability to oxidize citrate (Table 1). Normal rates of citrate oxidation were restored by adding 0·0005 *M* diphosphopyridine nucleotide, 0·00067 *M* glutathione and 0·04 nicotinamide to the

Table 1. EFFECT ON AGEING OF MITOCHONDRIA OF ETHYLENEDIAMINE TETRAACETIC ACID (EDTA) IN HOMOGENATE
Procedure: described in text. Results shown are the ranges and means of three experiments, each in duplicate

Homogenate medium	Oxygen uptake (µl./30 min./0·6 mgm. enzyme nitrogen)					
	Time 0		Time 0 + 90 min.		Time 0 + 210 min.	
	Range	Mean	Range	Mean	Range	Mean
Sucrose 0·25 M + CCl_4 0·03 M	71–96	84	25–43	36	—	—
Sucrose 0·25 M + CCl_4 0·03 M + EDTA 0·001 M	89–119	108	79–117	87	—	—
Sucrose 0·25 M	94–112	101	—	—	29–41	34
Sucrose 0·25 M + EDTA 0·001 M	87–114	104	—	—	70–95	81

System: adenosine-5-monophosphate 0·001 M; magnesium sulphate 0·0067 M; potassium chloride 0·025 M; inorganic orthophosphate buffer, pH 7·4, 0·013 M; cytochrome *c* 0·00001 M; sodium citrate 0·01 M; 0·5 ml. 20 per cent (w/v fresh liver) mitochondria in 0·25 M sucrose; water to 3 ml. final volume; 0·1 ml. 20 per cent potassium hydroxide in centre well to absorb carbon dioxide; gas phase air; temperature 38° C.

reaction mixture. However, Table 1 shows that the presence of 0·001 M ethylenediamine tetraacetic acid in homogenates reduced considerably the fall in citrate oxidation.

Similarly, ethylenediamine tetraacetic acid was found to protect mitochondria in liver homogenates subjected to severe ageing at 22° C. and 0° C. In order to accelerate ageing, 10 per cent liver homogenates were stood for 30 min. at 22° C. during which time the homogenate temperature rose to 16·5° C., and then for a further 180 min. at 0–1° C. Table 1 shows that although such treatment in 0·25 M sucrose homogenates greatly impaired the ability of mitochondria to oxidize citrate, mitochondria from 0·25 M sucrose + 0·001 M ethylenediamine tetraacetic acid homogenates gave normal rates of oxidation. The protective effect of ethylenediamine tetraacetic acid was demonstrable whether or not additional ethylenediamine tetraacetic acid was added to the respiratory reaction mixture.

Surprisingly, the capacity of mitochondria, aged by either of the above ageing procedures, to oxidize citrate was maintained or restored by the addition of 0·001 M ethylenediamine tetraacetic acid only to the system used to measure citrate oxidation (Table 2).

Mitochondria aged by standing or by carbon tetrachloride lose the sensitivity of adenosine triphosphatase to activation by calcium ions and 2 : 4-dinitrophenol, and they become fully sensitive to activation by magnesium ions[9–13]. It has been implied that the change in adenosine triphosphatase response might be related in some way to the loss of mitochondrial pyridine nucleotides and the inactivation of dependent enzyme systems[11–13]. However, in the present work, the omission of magnesium from the respiratory medium and the addition of 0·01 M sodium fluoride, which removes further magnesium ions with or without the addition of 0·001 M adenosine triphosphate, did not prevent the fall in citrate oxidation rates subsequent to either ageing treatment. Siekevitz *et al.*[10] have shown that adenosine triphosphatase of aged mitochondria is activated largely by bound magnesium ions or by bound magnesium ions plus magnesium–ethylenediamine tetraacetic acid, and that the addition of 0·005 M ethylenediamine tetraacetic acid did not greatly inhibit the adenosine triphosphatase activity of fresh or aged mitochondria. Consequently the stabilizing effect of ethylenediamine tetraacetic acid against the loss of activity of pyridine nucleotide-dependent enzyme systems of aged mitochondria would appear to be by some mechanism other than inhibition of adenosine triphosphatase.

Table 2. EFFECT OF ETHYLENEDIAMINE TETRAACETIC ACID ON MITOCHONDRIA ISOLATED FROM AGED HOMOGENATES
Procedure: described in text. Results shown are the means of four experiments all of which gave good agreement for equivalent readings

Homogenate medium	Additions	Oxygen uptake (µl./30 min./0·6 mgm. enzyme nitrogen)		
		Time 0	Time 0 + 90 min.	Time 0 + 210 min.
Sucrose 0·25 M	None	88	60	33
Sucrose 0·25 M	EDTA 0·001 M	89	82	71
Sucrose 0·25 M + CCl_4 0·03 M	None	87	—	40
Sucrose 0·25 M + CCl_4 0·03 M	EDTA 0·001 M	93	—	79

System: as in Table 1.

It appears that prolonged standing in 0·25 M sucrose or pre-incubation with carbon tetrachloride does not lead to direct passive diffusion of pyridine nucleotides from mitochondria. Such treatment must, however, alter the mitochondria in such a way as to permit the operation of a secondary change occurring after the commencement of incubation at 38° C. in the respiratory medium and leading to the loss of pyridine nucleotides and inactivation of dependent enzyme systems. Ethylenediamine tetraacetic acid prevents this secondary change. It may also prevent the primary damage by these ageing procedures as it is unnecessary to add ethylenediamine tetraacetic acid to the respiratory medium in order to maintain normal rates of citrate oxidation by mitochondria aged in 0·25 M sucrose + 0·001 M ethylenediamine tetraacetic acid. However, it is possible that sufficient ethylenediamine tetraacetic acid is taken up by mitochondria during ageing to prevent an ethylenediamine tetraacetic acid-sensitive reaction from occurring when the isolated mitochondria are incubated.

Accumulation of calcium ions from the homogenate during ageing might lead to further damage when mitochondria are incubated at 38° C. and to the loss of pyridine nucleotides[14]. However measurement of the calcium content of trichloracetic acid extracts of mitochondria by the ethylenediamine tetraacetic acid–calcon method[15] showed that the concentration fell from 30–35 µgm. to 16–18 µgm./gm. wet liver during 5 hr. standing in a 0·25 M sucrose homogenate at 0–1° C. Therefore it is unlikely that the effect of ethylenediamine tetraacetic acid is associated with chelation of calcium ions.

Hunter *et al.*[16] have discussed the influence of various factors on the re-incorporation of dinitropyridine nucleotide into mitochondrial enzyme systems, and suggest that the effect of ethylenediamine tetraacetic acid is likely to be due to complexing with the mitochondrial membrane rather than to chelating metal ions. The results of the present work favour such an interpretation. Ethylenediamine tetraacetic acid would appear to prevent the loss of pyridine nucleotides from incubated, respiring, aged mitochondria either by acting at the mitochondrial membrane to maintain its semi-permeable character or by inhibiting the release of bound pyridine nucleotides from mitochondrial enzyme systems. It is possible that ethylenediamine tetraacetic acid exerts its influence by complexing with structural cations and altering the charge on the mitochondrial membrane or at the site of binding of pyridine nucleotides.

I wish to
R. A. Simmo

Divisio
McM
Commonwea
Rese
Glebe

[1] Cleland, K. W.
[2] Slater, E. C., a
[3] Raaflaub, J.,
[4] Hunter, F. E.,
[5] Von Korff, R.
[6] Lester, R. L.,
(1958).
[7] Christie, G. S.,
[8] Schneider, W.
[9] Potter, V. R.,
205, 893 (19
[10] Siekevitz, P.,
Biophys. Ac
[11] Recknagel, R.
[12] Recknagel, R.
(1959).
[13] Siekevitz, P.,
[14] Potter, V. R.,
W. W., et al.
[15] Golby, R. L., E
Med., 50, 42
[16] Hunter, F. E.
Atchison, A.

Marked H

THE deter
has been by i
ear plugs. B
whales in Au
3 and 7 years
being 4 or 5
from humpba
found that th
5 years.

Until recen
these results
Dawbin[3] obta
back whales
at least 1 ye
19 months re
immature wh
minimum age
plugs and ba
these whales,
tation of the
results consis
individual.

Further in
humpback w
October 6, 19
migrating sou
It was then
30 ft. in len
August 26, 19
25° 21′ S. 112°

As ear plugs
obtained from
compare the a
known minim
pretation of b
of this whale w
ear plugs con
postulate of tw
whale was bet
was at least at

heda Flint-Gallé and Mr.
al assistance.

C. H. GALLAGHER

ealth,
ory,
d Industrial
ion,
Vales.

(1952).
., Nature, 170, 118 (1952).
88, 27 (1955).
iol. Chem., 216, 357 (1955).
108 (1957).
Biochim. Biophys. Acta, 29, 103

Proc. Roy. Soc., B, 142, 241 (1954).
176, 259 (1948).
Simonson, H. C., J. Biol. Chem.,

L., and Lindberg, O., Biochim.

D. D., Fed. Proc., 16, 105 (1957).
D. D., J. Biol. Chem., 234, 1052

Fed. Proc., 12, 267 (1953).
ques", third ed., edit. by Umbreit,
blishing Co., Minneapolis, 1957).
and Reilley, C. N., J. Lab. Clin.

dgers, W. F., Schutz, B., and
84, 693 (1959).

hale of Known Age

ge in humpback whales
s using baleen plates and
s, I found that humpback
reach puberty between
ajority of puberal whales
aki[2], using the ear plugs
n in North Pacific waters,
at sexual maturity was

been possible to check
nce from marked whales.
idence from two hump-
w Zealand waters when
ecaptured after 12 and
ince both were sexually
wbin showed that the
rity was 3–4 years. Ear
re collected from one of
nt methods of interpre-
age determination gave
probable age of this

now available from a
(Mark No. 11689) on
153¼° E., when it was
east coast of Australia.
yearling approximately
ark was recovered on
ale humpback shot at
vest coast of Australia.
, and testis weights were
, it has been possible to
om these organs with the
ring the method of inter-
scribed by me[1], the age
as at least 5 years. The
nations, and, using the
per year, the age of this
years. Since the whale
of its second year when

marked, it was probably 6 years of age when shot. So the indirect methods using baleen plate traces and ear plug laminations give estimates of age in good agreement with the known age.

The testes each weighed 1·0 kgm., which indicates[5] that this whale was sexually immature, and that puberty would probably have been attained at 7 years of age. This is above the age at which most male humpbacks have been estimated to reach puberty; but it is not an isolated example since, of 118 males (from the west coast of Australia) the ear plugs of which contained 12 laminations, 6 per cent were still sexually immature.

The body-length of this whale was recorded as 36 ft. 9 in., which is relatively short for a male of 6 years but within the range of lengths recorded for males of that age. In 164 males from Australian whaling stations estimated on the evidence from ear plugs to be 6 years old, the body-lengths ranged from 34 ft. 7 in. to 43 ft. 3 in. with a mean length of 39·11 ft., standard deviation 1·62 ft., and a standard error of mean 0·13 ft. It is therefore probable that this was a slow-growing individual relatively late in maturing.

The recovery of this mark is also of interest because it is the first recovery on the west coast of a mark fired into a whale on the east coast of Australia. This change of migration path followed the mingling during the summer of 1958–59 of some of the group V (130° E.–170° W.) with the group IV (70° E.–130° E.) population of humpback whales which I[4] have shown in the region of the Antarctic from 110° E. to 130° E.

R. G. CHITTLEBOROUGH

Division of Fisheries and Oceanography,
Commonwealth Scientific and Industrial
Research Organization,
Sydney, Australia.
Jan. 14.

---

[1] Chittleborough, R. G., *Aust. J. Mar. Fresh. Res.*, 10, 125 (1959).
[2] Nishiwaki, M., *Sci. Rep. Whales Res. Inst. Tokyo*, 14, 49 (1959).
[3] Dawbin, W. H., *Nature*, 183, 1749 (1959).
[4] Chittleborough, R. G., *Norsk Hvalfangsttid.*, 48, 510 (1959).
[5] Chittleborough, R. G., *Aust. J. Mar. Freshw. Res.*, 6, 1 (1955).

Morphogenetics of *Micrasterias americana* in Clone Culture

Waris, Grönblad and I have studied the plasmatic basis of the morphological units in *Micrasterias* species and their dependence on the nuclear influence[1]. The names of the morphological units and the schematically drawn plasmatic axes are shown in Fig. 1. The form, as well as the number, of the morphological units may be altered by a change in environmental conditions and by a change in the relative nuclear influence.

The concept 'nuclear effect per cytoplasmic unit' is of importance when variation in the morphology of the cell is considered. The variation can be induced artificially in different cell types (anucleate, hypohaploid, haploid, hyperhaploid, subdiploid and diploid cell types; binucleate cells of different types, mononucleate double cells; uniradiate, triradiate and quadriradiate types). The degree of organization of the side lobes usually increases in parallel with an increase in nuclear quantity; but the polar lobe usually undergoes only slight modification.

Also the number of morphological units may increase with the nuclear quantity, whereupon

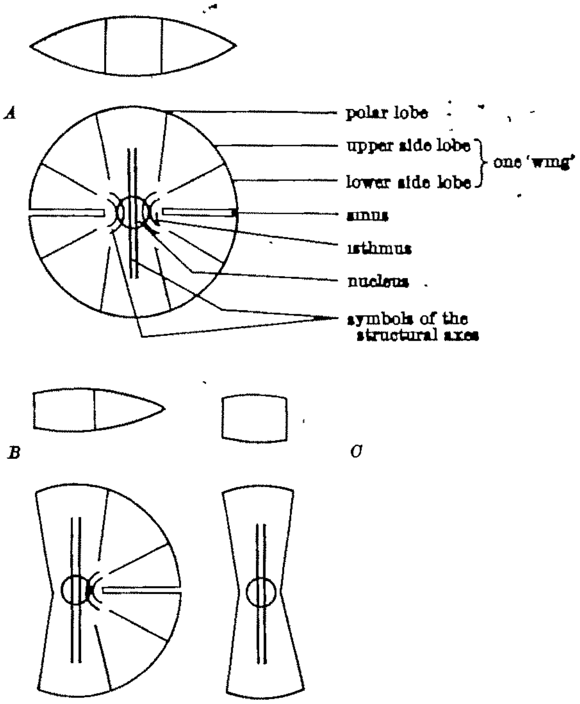


Fig. 1. Schematic drawings of different types of *Micrasterias*. *A*, Normal biradiate cell from the end and from the front; *B*, uniradiate cell; *C*, radiate cell

triradiate and quadriradiate forms are produced from the normal biradiate form. Such forms are found in Nature[3] and can be produced artificially from some *Micrasterias* species (*M. thomasiana*, *M. rotata*, *M. torreyi*, *M. angulosa*). The triradiate and quadriradiate forms of *Micrasterias* species are always diploid forms.

Since 1939 we have had under cultivation a clone of *Micrasterias thomasiana* var. *notata* which was produced spontaneously and in which one of the wings is absent from the cells. These cells are uniradiate forms. Since then, uniradiate forms of the species *M. torreyi*, *M. rotata* var. *evoluta*, *M. thomasiana* and *M. americana* have been discovered. An analogous form was also produced from *M. fimbriata*; but the clone died before it could be investigated in detail.

The significance of the nuclear effect per cytoplasmic unit is clearly seen in this haploid uniradiate cell. Morphological analysis has revealed that the existing morphological units in the uniradiate cell resemble the units in diploid cells in both size and form as a result of nearly equal ratio between nuclear quantity and cytoplasmic units in these two types of cells.

Because the number of cytoplasmic units was seen to increase with the nuclear quantity, the hypothesis was suggested that conversely a decrease in the nuclear influence (per cytoplasmic unit) may lead to the elimination of a cytoplasmic unit. This was later demonstrated in the case of *M. torreyi* double cells, which are cells that, owing to abnormal cytokinesis, contain the plasma of more than one haploid cell and a varying number of nuclei (one haploid, one diploid nucleus, or two haploid nuclei in different sites in the cell). These experiments revealed an effect of subnormal nuclear influence in accordance with the hypothesis, and clarified in principle the process by which uniradiate cells are produced.

A uniradiate cell may 'remutate' into a normal biradiate form. This is the same process that occurs when a biradiate cell becomes transformed into a triradiate cell by an increase in the number of side lobe units. The question then arose whether a cell with new side lobe units could be produced, and whether such a cell consisting of only polar lobe units is capable of existence. The method employed to produce the cell with no-side lobe unit was in principle the same as that used to produce uniradiate cells: some of the plasmatic units in double and other complex cells may lose their ability of reproduction, but the cell may still be capable of continuing its existence.

The organisms studied in the present investigation were uniradiate cells of *M. thomasiana* and *M. americana*. The desired result was obtained with the latter species. Numerous double cells of different types were produced in old cultures exposed to continued illumination. From one of such culture tubes with different types of abnormal cells, cells which lacked both side lobe units were produced spontaneously.

The new cell type, here called the aradiate type, is depicted in Fig. 2. This cell type scarcely resembles the genus *Micrasterias*. Perhaps the genus *Ichtyodontum* recently described by Scott and Prescott exhibits similar main features.

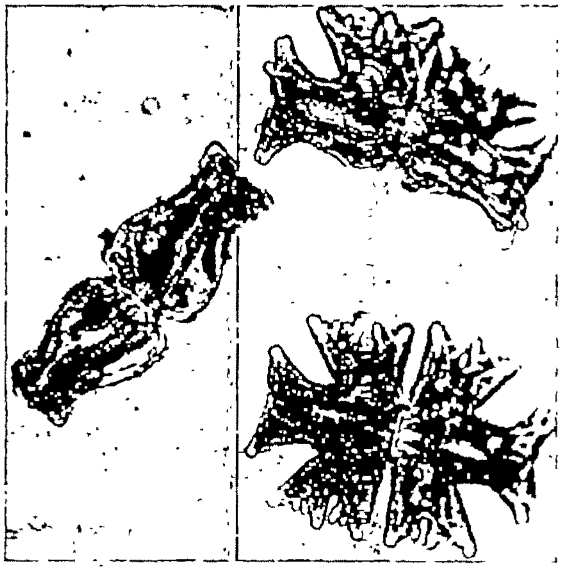


Fig. 2. *Micrasterias americana*. Biradiate, uniradiate and aradiate cell grown in the same culture tube

The aradiate *Micrasterias americana* cell thus has only one of the three morphological components of the normal biradiate *Micrasterias* cell. The following differences were noted when the aradiate cells were compared with normal *M. americana* cells growing in the same culture tube and hence under identical conditions. The aradiate cell is longer than the biradiate haploid cell. The apex of the former cell differs in form from that of the polar lobes of the latter in that the processes are always less well developed. When seen in end-view the cross-section of the aradiate cell is round except the apex which is usually irregular and sometimes forms an equilateral triangle.

The aradiate form has not been observed to undergo remutation to a uniradiate or biradiate form,

although the
occurred to d
same conditi
uniradiate con
for every thou
On the bas
study of the a
ism of the m
sterias cell ma
There are in
tic axes or ske
the cell to th
units are sev
isthmus of the
semi-axes beg
halves of the
daughter semi-
the plane pas
The present n
determines the
phological uni
existence. Al
after the nucl
undifferentiate
when the pare
the parent sem
parent semi-ce
Normal rege
only if the axe
the interphase
dependent on
nuclear effect i
the metabolic
may happen th
axes is able to
cell. Hence if
is not capable
semi-cell will b
lobe unit. In
axes are lack
pointed out tha
lead to the re
binucleate cells
component of
development of
If the nuclear
that one of th
semi-axes are
This leads to a
in 'remutation'
or the mutation
cell after ploidi
The plasmati
differ in natur
generate only a
semi-axes only t
aradiate cell ty
expected to rem
new side lobes.
The lobes ma
of the adjoining
uniradiate cells
metrical when v
of the aradiate
higher degree of
normal cell. T
triradiate diplo
lateral triangles
ology of the pol
existence of side

of divisions that has
thousand. Under the
tation' frequency in a
has been about twenty

er conclusions and the
ricana cells, the mechan-
velopment of a *Micra-*
roughly as follows.
sterias cell three plasma-
extend from one end of
very cell division these
ane of division at the
septum has formed, the
d generate the lacking
parent and full-grown
netrically located about
he isthmus of the cell.
e per cytoplasmic units
omplexity) of the mor-
their existence or non-
ucleate cells are formed
during mitosis, three
n in the new semi-cell,
iradiate, only two when
liate and four when the

e semi-axes is possible
d full maturity during
s metabolic process is
of the nucleus. If the
rious units compete for
f nuclear origin and it
the two side lobe semi-
ter the division of the
atic side lobe semi-axes
o reproduction, the new
lack the corresponding
ell type both side lobe
connexion it may be
abolic competition may
e of the two nuclei in
nt supply of metabolic
igin required in the

enough, it may happen
ranches and two new
t instead of only one.
he number of wings as
cell into a normal cell
te cell into a triradiate

le lobe units obviously
semi-axes are able to
xes and the polar lobe
ng to the fact that the
le lobes, it cannot be
ed forms by producing

fluence on morphology
pex of the polar lobe of
species) is often asym-
front. The polar lobe
as no side lobes has a
n the polar lobe of the
of the polar lobes of
torreyi often are equi-
end view. The morph-
s the existence or non-

This work was supported by a grant from Suomen Kulttuurirahasto.

PAAVO KALLIO

Department of Botany,
University of Turku,
Finland.

---

[1] Kallio, P., *Arch. Soc. Zool.-Bot. Fenn. Vanamo*, 2, 42 (1949). Waris, H., *Physiologia Plantarum*, 3, 236 (1950); 4, 387 (1951). Kallio, P., *Ann. Botanici Soc. Zool.-Bot. Fenn. Vanamo*, 24, 2, 1 (1951); *Bull. Torr. Bot. Club*, 80, 4, 247 (1953); *Arch. Soc. Zool.-Bot. Fenn. Vanamo*, 8, 1, 57 (1953); 9, 118 (1954); 11, 2, 193 (1957). Grönblad, R., and Kallio, P., *Botaniska notiser*, 2, 167 (1954). Waris, H., *Ann. Acad. Sci. Fenn.*, A, IV, 40, 1 (1958). Waris, H., and Kallio, P., *Ann. Acad. Sci. Fenn.*, A, IV, 37, 1 (1957). Kallio, P., *Ann. Acad. Sci. Fenn.*, A, IV, 44, 1 (1959).

[2] Heimans, J., *Blumea*, Supp. II, 52 (1942).

Nonanal as a Growth Factor for Wood-rotting Fungi

SOME years ago Suolahti[1] found that volatile substances evaporating from wood of various trees strongly promoted the growth of several wood-destroying Hymenomycetes. In particular, the development of aerial mycelium was favoured. The effect seemed to be correlated with the presence of oleic acid and other unsaturated fatty acids in the wood. The active substance or substances could not be identified.

Since nonanoic acid (pelargonic acid) and nonanal (pelargonic aldehyde) are known to be formed during autoxidation of oleic acid[2], it appeared desirable to test these two nine-carbon compounds for growth-promoting activity.

The compounds were administered to the fungi either through the liquid phase or through the gas phase. In both cases two media were tested: a synthetic mineral–salt–glucose medium (modified medium 3, ref. 3) and a water solution of 5 per cent malt extract. The following species of wood-destroying fungi were studied: *Stereum sanguinolentum* Fr., *Daedalea unicolor* Bull. ex Fr., *Polyporus cervinus* Pers. and *P. applanatus* Pers. ex Wallr.

In the first type of experiment, where water solutions of the substances to be tested were pipetted into the liquid nutrient medium, nonanal was found to produce a strong promotion of growth in *Stereum sanguinolentum* (Table 1), whereas the other species showed a weak or no response. Nonanoic acid had no effect in all cases. The response of *Stereum* was stronger in the synthetic medium than in the malt extract medium, and could already be observed after one day. In the latter medium the increase in weight seemed to be due mainly to the more abundant production of aerial hyphae in the flasks with nonanal.

Because of its volatility, nonanal rapidly disappears from the medium. Therefore, in prolonged experiments further addition of nonanal solution was made

Table 1. GROWTH OF *Stereum sanguinolentum* IN LIQUID CULTURE WITH AND WITHOUT NONANAL

Nutrient solution	Dry weight of mycelium (mgm. per flask)		
	After 19 days	After 25 days	After 30 days
Synthetic medium (control) D : o + nonanal	0·9 ± 0 5·9 ± 0·8	1·3 ± 0·1 9·3 ± 1·5	1·9 ± 0·2 12·7 ± 0·8
Malt extract (control) D : o + nonanal	32·0 ± 1·3 42·8 ± 1·2	38·7 ± 0·9 53·1 ± 2·1	42·7 ± 3·1 58·2 ± 1·6

Each culture flask originally contained 20 ml. nutrient solution. Every two days each control flask was supplemented with 1 ml. distilled water and each one of the other flasks with 1 ml. distilled water saturated with nonanal. Average values, ± standard errors, taken from four parallel cultures. Temperature, 25° C.

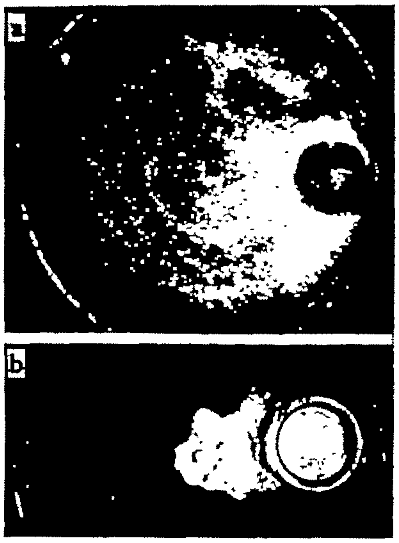


Fig. 1. Two cultures of fungi growing on the synthetic nutrient agar medium. To the right in the Petri dish the cup with a drop of 'Tween 40' containing 5 per cent nonanal (× ½). *a*, *Daedalea unicolor*, 8 days old culture; *b*, *Polyporus applanatus*, 9-day old culture

every two or three days. For these reasons the concentration of nonanal was never constant during the experiment. However, an original concentration of about 10 μmoles per litre, which means about 30 μgm. per flask, was sufficient to produce strong promotion of growth in *Stereum sanguinolentum*.

In the second type of experiment, where the substances to be tested were supplied through the gas phase, the fungi were grown in Petri dishes and the media were solidified with 1·5 per cent agar. The inoculum was placed in the centre of the agar plate. At the periphery, close to the glass wall, a small aluminium cup was introduced, containing the test substance dissolved in 'Tween 40' (polyoxyethylene sorbitan monopalmitate), a solvent which did not in itself affect the growth of the fungi under the conditions of the experiment. Solutions with 5 and 1 per cent (w/w) nonanal were used.

In these experiments the effect of nonanal was obvious in all species and in both tested concentrations, manifesting itself as an increase in the development of aerial mycelium and sometimes also as a faster growth of the substrate hyphae (Fig. 1*a*). The response of *Polyporus applanatus* was particularly drastic, a high and thick wall of interwoven air hyphae being formed around the cup containing the nonanal solution (Fig. 1*b*).

With *Stereum sanguinolentum* as test organism, the effect of a few other compounds chemically related to nonanal was studied in liquid culture experiments. Octanal and decanal produced a slight increase in the rate of growth, whereas nonanol and nonanoic acid proved to be completely inactive.

Preliminary experiments have shown that a number of other wood- or soil-inhabiting *Hymenomycetes* also respond positively to nonanal, for example, *Polyporus fomentarius* L. ex Fr., *Mycena metata* Fr., *M. adonis* Fr., *Coprinus narcoticus* Fr. and *Boletus variegatus* Sw. ex Fr.

The question whether Suolahti's wood factor is identical with nonanal, or not, must probably remain unanswered until the wood factor is isolated and analysed. At present it is also impossible to say anything with certainty about the biochemical mechanism behind the growth-promoting activity of nonanal. Earlier investigators have only observed inhibitory effects of this substance[4], except for one case of stimulation of spore germination[5]. Reports on the role of long-chain aldehydes in bacterial bioluminescence[6] and catalase activity[7] may indicate the possibility that nonanal functions in some way as an enzyme activator.

A more detailed report of the methods and results will be published elsewhere.

I am indebted to Prof. A. Fredga for the sample of nonanal.

NILS FRIES

Institute of Physiological Botany,
University of Uppsala.

[1] Suolahti, O., "Über eine das Wachstum von Fäulnispilzen beschleunigende chemische Fernwirkung von Holz", thesis (1951).

[2] Ellis, G. W., *Biochem. J.*, 30, 753 (1936). Ralston, A. W., "Fatty Acids and Their Derivatives" (John Wiley and Sons, Inc., New York, 1948). Iselin, E., *Mitt. Gebiete Lebensm. Hygiene*, 40, 105 (1949).

[3] Fries, N., *Physiologia Plantarum*, 1, 330 (1948).

[4] Penfold, A. R., and Grant, R., *Proc. Roy. Soc. N.S.W.*, 60, 167 (1926). Okazaki, K., and Homma, A., *J. Pharm. Soc. Japan*, 74, 1131 (1954).

[5] French, R. C., and Weintraub, R. L., *Arch. Biochem. and Biophys.*, 72, 235 (1957).

[6] Cormier, M. J., and Strehler B. L., *J. Amer. Chem. Soc.*, 75, 4864 (1953).

[7] Kaplan, J. G., *J. Gen. Physiol.*, 38, 197 (1954–55).

BACTERIOLOGY

A New Species of Green Sulphur Bacteria

IN 1959 two strains of green bacteria were isolated in pure culture from mud of the Kujalnik estuary (near Odessa) and of Lake Sakaky (Crimea).

These strains are identical as to their characters, and in some features they differ from all other green sulphur bacteria studied in pure culture[1]. The micro-organisms isolated are motile, short, rod-shaped cells measuring about 1·0–1·5 × 0·8–0·9μ (Fig. 1). The suspension of cells has absorption maxima at 750 and 457 mμ. The purified green pigment of the bacterium has absorption maxima in ethyl ether at 660, 432 and 412 mμ. These maxima are typical of the chlorophyll of green bacteria[2,3].

Like other green bacteria, the isolated organisms require for their growth anaerobic conditions and light. Good growth is observed on a modified Larsen's medium[4] containing: 0·1 per cent ammonium chloride, 0·1 per cent potassium dihydrogen phosphate, 0·5 per cent magnesium chloride, 2 per cent sodium chloride, 0·1 per cent calcium chloride, 0·3–0·5 per cent sodium bicarbonate, 50 μgm./100 gm. iron (as ferric chloride), 0·1 per cent hydrated sodium sulphide ($Na_2S.9H_2O$) and a complex of trace ele-

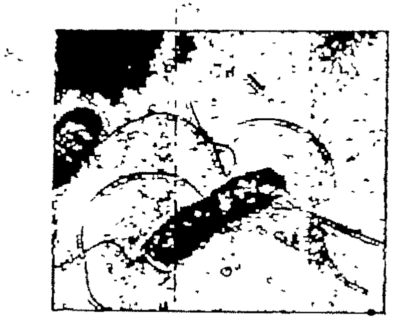


Fig. 1. Electron micrographs of *Chloropseudomonas ethylicum* cells grown on a medium containing ethanol. × 7,000

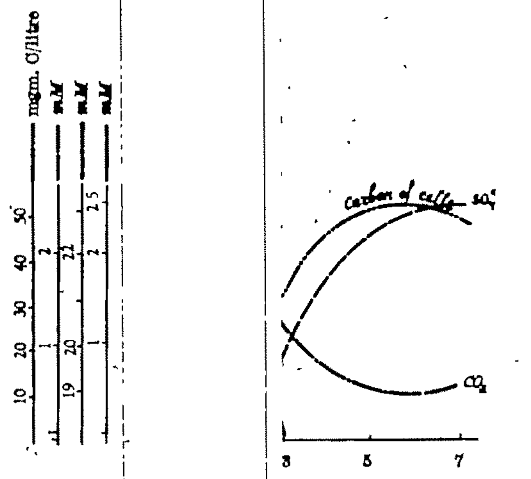


Fig. 2. Photo
medium

pseudomonas ethylicum on a
cent sodium sulphide

ments. The i
ture, 28–30° C
During the
they oxidize th
and then to sul
on a medium
In contrast
green bacteria
utilize for thei
which are add
per cent togeth
for anaerobio
taining the gr
pyruvate, glu
some amino-a
Especially g
containing 0·1
of ethanol by
intensive cons
production of
acid appears
ethanol.
During the
medium conta
in the cells pr
the carbon dio

7·2; optimal tempera-

eria on such a medium,
phide at first to sulphur
. No growth is observed
sulphate.
own free-living sulphur
is described are able to
rent organic compounds
um in quantities of 0·1
dium sulphate, necessary
anic compounds main-
cteria include: acetate,
sugars. Peptone and
lized by the bacteria.
as observed on medium
hanol. The utilization
ms is followed by the
bon dioxide and by the
ig. 3). Thus the acetic
oduct of oxidation of

of the bacteria on a
the quantity of carbon
the carbon content in
This indicates that the

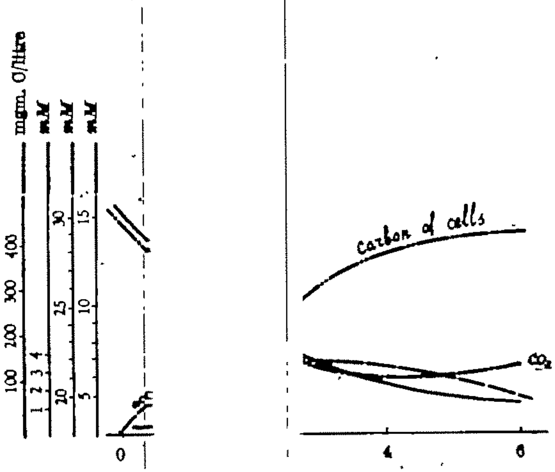


Fig. 3. Photo
med

pseudomonas ethylicum on a
per cent ethanol

bacteria utilize in their constructive processes both the carbon from added sodium bicarbonate and ethanol.

Examination of the organisms isolated leads us to include them in the family Chlorobacteriaceae. In their motility these bacteria are similar to *Chloropseudomonas* Czurda and Maresch[4].

In Bergey's "Manual"[5], *Chloropseudomonas* is included in the genus *Chlorobium*. But no known members of *Chlorobium* show any motility. For this reason it may be more logical to name the green bacteria described *Chloropseudomonas*. As the best development of these bacteria takes place on the medium containing ethanol, we propose as a specific designation *Chloropseudomonas ethylicum*.

V. V. SHAPOSHNIKOV
E. N. KONDRATIEVA
V. D. FEDOROV

Biological Department,
Moscow State University,
Moscow.

[1] Shaposhnikov, V. V., Kondratieva, E. N., and Ramenskaya, A. A., *Doklady Akademii Nauk S.S.S.R.*, **20**, 6 (1959).
[2] Larsen, H., *Kon. Norske vidensk. Selskabs, Skrifter*, **3** (1953).
[3] Goodwin, T. W., *Biochim. Biophys. Acta*, **18**, 2, 309 (1955).
[4] Czurda, V., and Maresch, B., *Arch. Mikrobiol.*, **8**, 2, 99 (1937).
[5] "Bergey's Manual of Determinative Bacteriology" (1948 and 1957).

Appearance of New Deficient Characters in Streptomycin-resistant Mutants of *Bacillus subtilis*

We have previously reported[1] that a new deficient character, uracil-dependence, appeared through a genetic interaction between two mutant cells of *Bacillus subtilis K*. It has lately been found, however, that the uracil-dependent progeny could be recovered among the colonies which appeared on a streptomycin-containing medium on which cells of a methionine- and histidine-dependent, and streptomycin-sensitive strain (*met,his,str-s*) had been plated[2]. Besides the uracil-dependence, some new characters, for example, histidine-dependence and thiamine- or niacin-dependence, appeared in other streptomycin-resistant mutants of *B. subtilis K*. These facts might have some connexion with the discovery of similar phenomenon in *Salmonella*[3] as well as with the mechanism of drug-resistance.

The first experiment was carried out with the *met, his,str-s* strain. About 5×10^8 cells harvested from a culture in nutrient broth were plated on nutrient agar and a synthetic medium (Gray and Tatum's medium plus methionine and histidine). Each medium contained streptomycin in the amounts shown in Fig. 1. It was found that smaller numbers of resistant colonies appeared on the nutrient agar than on the synthetic medium, and, moreover, the size of the colonies on media with low concentrations of streptomycin were generally smaller than those on media with higher concentrations. To test growth response, all the colonies which appeared on the nutrient agar were printed to the synthetic medium by the replica plating method. At a concentration of 5γ of streptomycin per ml., 8 out of about 10^3 colonies tested could not grow on the synthetic medium. At 10γ/ml., 5 out of 5, at 25γ/ml., 6 out of 9, and at 50γ/ml., 3 out of 3 could not. It was shown by the auxanographic technique that these irregular colonies required uracil for growth in addition to methionine

Table 1. VARIOUS STREPTOMYCIN-RESISTANT MUTANTS OF *B. subtilis K*

Mutant strains	Genotype	Frequencies	Types of Sm.-resistant	New type/Normal	Revertant
*A*1	***ade,str-s***	10^{-8}	Sm.-dependent, normal	2/0, 0/10	—
*A*11	***ade,met,str-s***	c. 10^{-8}	histidine-dependent	1/0	—
*A*15	***ade,his,str-s***	10^{-8}	Sm.-dependent, *X*-dependent*, normal	2/4/4	Sm.-resistant
*A*16	***ade,glu,str-s***	10^{-8}	normal	0/10	—
*A*2	***ade,,str-s***	c. 10^{-7}	Sm.-dependent, thiamine-dependent	3/2/0	Sm.-resistant
*A*17	***ade,ura,str-s***	c. 10^{-7}	normal	0/150	—
*T*1	***try,str-s***	c. 10^{-8}	normal	0/7	—
*T*12	***try,thi,str-s***	c. 10^{-8}	normal	0/4	—
***M*12**	***met,his,str-s***	10^{-8}–10^{-7}	uracil-dependent, normal	1,000/0–0/70	Sm.-resistant
*L*1	***leu,str-s***	c. 10^{-7}	normal	0/60	—
Wild	***str-s***	10^{-8}	Sm.-dependent, normal	2/5	Sm.-sensitive

* An unknown factor. Sm., Streptomycin.

and histidine. Because the frequencies of new type appearance per total cells plated were almost equal regardless of the concentration of streptomycin, it is supposed that the *met,his,ura,str-r* mutant cells which had pre-existed in the mother culture of the tester strain were selected by this procedure.

Next, experiments were extended to the nine other biochemical mutants as well as the wild strain of *B. subtilis K* (Table 1). The third column in Table 1 shows the frequencies of recovery of resistant colonies at a concentration of 70–80 γ/ml. of streptomycin. The fourth indicates the type of new characters which appeared, and the fifth the ratio of new types among the resistant colonies obtained. In short, strain *A*11 gave one histidine-dependent, strain *A*1 two streptomycin-dependent colonies, strain *A*2 three streptomycin-dependent and two thiamine-or niacin-dependent. The wild strain gave only two colonies positive for streptomycin-dependence.

Finally, the relationships between the new dependent characters and streptomycin-resistance were examined. The spontaneous reversions of the new genetic characters gave no changes in streptomycin-resistance, and moreover the cross[4] between *T*17 (*try,thi,str-s* and phage-resistant) and the resulting methionine-, histidine-, uracil-dependent and streptomycin-resistant mutant produced the progeny, tryptophan-dependent and streptomycin-resistant and phage-sensitive, but not streptomycin-resistant and uracil-dependent. The results indicated that no close linkage relationship was observed between new deficient characters and streptomycin-resistance, and that each locus behaved independently in reverse mutation and genetic interactions.

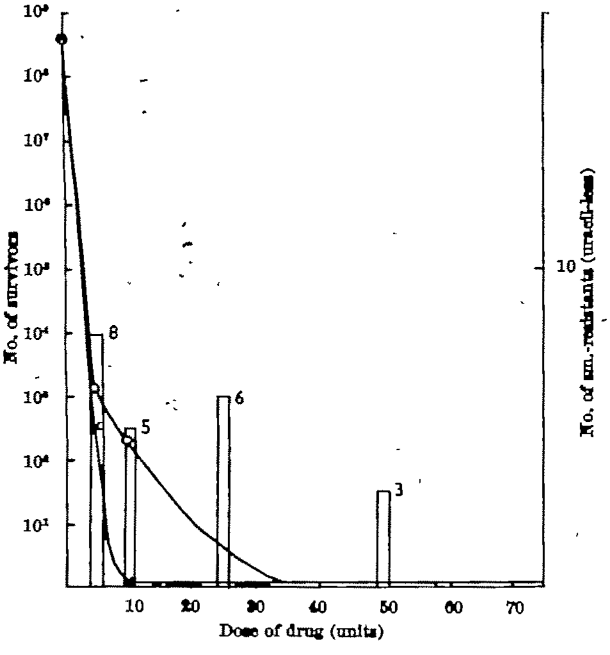


Fig. 1. Broth culture of ***M*12** (***met,his,str-s***) was inoculated on to the media containing various concentrations of streptomycin. Synthetic medium, Gray and Tatum's medium; complete medium, nutrient agar. Histograms indicate the total number of uracil-requiring, streptomycin-resistant colonies. ○, on synthetic medium; ×; on complete medium

MASAMICHI KOHIYAMA
YONOSUKE IKEDA

Institute of Applied Microbiology,
University of Tokyo.

---

[1] Kohiyama, M., and Ikeda, Y., *Nature*, **184**, 208 (1959).
[2] Kohiyama, M., *C.R. Acad. Sci., Paris* (in the press).
[3] Watanabe, T., and Watanabe, M., *J. Gen. Microbiol.*, **21**, 30 (1959).
[4] Kohiyama, M., *Z. Vererbungslehre*, **90**, 347 (1959).

GENETICS

Secondary Selection in Pure Lines of Rice

It is generally accepted in self-pollinated plants that once a pure line has been isolated no further improvement can be achieved by further selection within that line.

Ghose and Daiya[1] found the increase in yield of secondary selections from pure lines of rice (*Oryza sativa* L.) to be small. Experience in Malaya, however, indicates that a re-selection after a number of years from among populations in a pure line could give significant increases. The selection 'Siam 29' was distributed to farmers round about 1930. This selection eventually practically replaced all the unselected 'Siam' in all areas where this variety was planted. After the Second World War, it was observed that minor differences exist in the 'Siam 29' material collected from various places where this material was distributed. A re-selection was therefore carried out in 1949. Sub-strains isolated from this re-selection were found to be identical in morphological characters to that of 'Siam 29'. Some of these sub-strains have given significant yield increases over 'Siam 29', the control, in variety trials conducted over a three-year period. Results of one of the variety trials is given in Table 1 to show the increases of these sub-strains over 'Siam 29'.

Re-selection in two other varieties, the 'Nachin' and the 'Seraup Kechils', has given similar results. Re-selection in the 'Mayang Sabatils', however, gave very small and insignificant increases.

Since *O. sativa* L. is principally autogamous, and outcrossing is only of the order of 0·41 per cent[2], increases obtained by re-selection in pure lines, such

Table 1. (Ref.

5 Balanced Lattice Squares; 180 Acres

Variety	…acre)	Variety mean	Percentage (of Siam 29)
	1957		
Siam *E.R* 25	3,285	3,591	121 9
" " 16	3,314	3,547	120·4
" " 56	3,234	3,422	116·1
" " 26	3,218	3,419	116·0
" " 69	3,222	3,376	114·6
" " 59	3,127	3,359	114 0
" " 6	3,294	3,351	113·8
" " 11	3,119	3,343	113·4
" " 54	2,845	3,332	113·1
" " 24	3,286	3,291	111·7
" " 71	2,918	3,269	110·9
" " 48	3,064	3,197	108 5
" " 20	2,802	3,187	108·1
" " 46	2,754	3,165	107·4
" " 10	2,800	3,165	107 4
" " 18	3,004	3,142	106·6
" " 13	2,837	3,135	106·0
" " 72	2,929	3,130	106 0
" " 29	2,968	3,057	103 7
" " 42	2,948	3,030	102 8
" " 38	2,893	3,011	102 2
" " 32	3,008	2,978	101·1
Siam 29 (Control)	2,687	2,947	100 0
Siam *E.R.* 73	2,706	2,931	99·5
" " 70	2,952	2,907	98·6
Season mean *S.E.* lb./ac.	3,012 ±131	3,210 ± 109	

S.E. seasons ±

nteraction ± 115 lb./acre

as in the ab
improved stra
or that there i
affected yield.
I acknowled
the Public S
Malaya, to pu

Division
Department
Kuala
Federati

[1] Ghose, R. L. M.,
Paper *IRC/BP*
[2] Brown, F. B., *M*
[3] Brown, F. B., Se

dicate that established
not totally homozygous
tion of mutations which

s the kind permission of
nission, Federation of
unication.

T. K. Van

e,

International Rice Commission

0, 4 (1957).
of Agric. (1959).

Selfing
npatible Cocoa

The Upper
importance to
so that it is di
homozygous o
anism operate
female gamete
followed by th
normal fusion
Attempts ha
clone ('Nanay
from a tree co
of the pollen
provide the o
marker-gene de
Out of some
which gave
character and
thought to be
The theory
proportion of
combined we
remain on the
alleles, or allel

oa varieties, of great
re all self-incompatible
n valuable alleles in the
incompatibility mech-
re of fusion of male and
same dominant allele,
hole ovary even though
n other ovules.
o self a self-incompatible
ng a quantity of pollen
it together with a little
self. The tree used to
m is homozygous for a
e seedlings ('axil spot').
, one pod was obtained
owing the 'axil spot'
These four seedlings are
of the clone.
tempt was that if the
h dominant alleles were
low the flower may
ovules in which different
thers present, had come

together could develop into seed. 'Nanay 32' has the alleles 2 and 4 on Knight and Rogers's terminology[2], allele 2 being dominant to allele 4. These four seedlings will thus be 2·4 or 4·4, any ovules which were 2·2 having failed.

Posnette[3], who demonstrated that pods could be set on a self-incompatible tree when both its own pollen and pollen from a self-compatible tree were applied to the same flower, suggested a similar method for determining if any of the seeds resulted from self-fertilization. He suggested pollinating a self-incompatible white-beaned tree with both its own pollen and pollen from a compatible tree homozygous for purple-bean, when any white beans obtained would result from self-pollination as the purple-bean characteristic is dominant. Van der Knaap[4] applied pollen from a compatible white-seeded tree to a self-incompatible tree heterozygous for purple and white beans together with its own pollen, and obtained an indication that some selfing was taking place from the lower proportions of white beans in the progenies than when the tree was only crossed. The present work is believed to be the first actually carried out in which it is possible to pick out the selfed seedlings.

D. R. Glendinning

West African Cocoa Research Institute,
P.O. Box No. 8,
Tafo,
Ghana.

[1] Cope, F., *Nature*, 181, 279 (1958).
[2] Knight, Ronald, and Rogers, H. H., *Heredity*, 9, 1, 69 (1955).
[3] Posnette, A. F., *Trop. Agric.*, 17, 67 (1940).
[4] Van der Knaap, W. P., Rep. Fourteenth Intern. Hort. Cong., 1, 1287 (1955).

Occurrence of a Brown Mutation in the Syrian Hamster

Cinnamon or 'brown' mutations in species of rodents are well-known modifications of the pigmentary physiology of the wild agouti colour. A comparable mutation is now recorded for the Syrian hamster, *Mesocricetus auratus*, one of the comparatively recent additions to the range of laboratory rodents. The mutant allele is inherited as a recessive to the normal gene and the genetic symbol *b* is proposed for its designation.

In the cinnamon hamster all the eumelanic pigmentation, which is normally black in the wild type, is now changed to brown. The overall effect is a cinnamon-orange of a particularly rich colour. This is due to the fact that the wild agouti Syrian hamster is considerably more auburn than the drab agouti of, say, the mouse or rabbit. The agouti brown mouse or rabbit is much brighter than the black agouti, and this brightening effect is greatly enhanced in the hamster, as a consequence of the initial auric pigmentation. The auburn colour is due to abundant phaeomelanin, which is possibly only indirectly affected by the brown mutation. The simplest assumption at present is that the brightening is due to an optical effect; although it is also possible that the modification of black eumelanin to brown could so shift the pigmentary processes that additional phaeomelanin is formed out of the chromogenic substrate.

The colour of the cinnamon hamster is a rich cinnamon-orange. The black flashes of the wild type are replaced by brown, as are also the black tips of the coat hairs and the shafts of the vibrissae. The dark blue undercolour of the coat is changed to a lighter hue. The pale cream colour of the undersurfaces (jaw, throat and stomach) of the animal are unchanged. The ear auricula are peach-grey instead of black. A most conspicuous alteration has occurred in the eye colour, where, by reflected light, the pupil glows a rich sanguine red. This feature is more pronounced than that found in cinnamon mutants of the mouse or rabbit. It would suggest a relatively severe reduction in the quantity of eumelanin present in the various eye tissues.

The eye colour of the cinnamon is a brighter red than that found in the genetically distinct ruby-eye dilute (*ruru*) hamster[1]. In this mutant type the eye colour, viewed by a reflected light, is a dull ruby red. The two mutants cannot be confused, for the ruby-eye animal has a diluted bluish-fawn coat. It is of interest that the gene combination *bbruru* exhibits the action of both mutant genes. The coat colour is a soft cinnamon-beige while the eye colour is a translucent red, lighter and distinctive from that of either the cinnamon or ruby-eye. It has also been observed that the *b* allele is hypostatic to the cream (*ee*) mutation[1], except for eye colour. The genotype *BBee* has cream-yellow fur colour, while the genotype *bbee* also has cream fur plus the red-eye colour associated with *b*.

The mutant allele was discovered in the United States during the early part of 1958 by a hamster fancier, and animals carrying the gene were imported into Britain in the early months of 1959. An imported male bred to normal females produced an F_1 of 100, all of which were wild type. The F_2 generation consisted of 148 ♂♂ *B*, 160 ♀♀ *B*, 44 ♂♂ *b* and 63 ♀♀ *b*. The observed segregation of cinnamon offspring is a good fit to a 3 : 1 ratio ($\chi_1^2 = 0{\cdot}14$; $P \simeq 0{\cdot}70$), and the sex ratio is a good approximation of equality ($\chi_1^2 = 2{\cdot}17$; $P > 0{\cdot}10$). A test for possible partial sex linkage in the segregation above was completely negative ($\chi_1^2 = 1{\cdot}63$; $P \simeq 0{\cdot}20$).

The evidence presented in the above paragraphs indicates that the cinnamon-orange phenotype of the Syrian hamster is inherited as a monogenic, autosomal, recessive character. It is suggested that the mutant allele is a probable homologue of the brown mutation known in several other species of rodents.

I wish to acknowledge the kind co-operation of Mrs. Margaret Beher in obtaining specimens of cinnamon hamsters.

ROY ROBINSON

St. Stephens Road Nursery,
Ealing, London, W.13.

---

[1] Robinson, R., *Nature*, 176, 353 (1955); *J. Genet.*, 56, 85 (1958).

PSYCHOLOGY

Experimental Evidence for Extra-Sensory Perception

SINCE making my reply (*Nature*, 185, 949) to Mr. C. E. M. Hansel's communication in *Nature* of November 7, 1959, I have examined the question in greater detail. The periodic segmental effect noted by Mr. Hansel is, I find, entirely restricted to the experiments done at the 'rapid rate' of calling; in the much larger group of 6,039 (+1) trials aimed at normal speed, the effect does not appear. As the reader may easily verify by means of Table XXXII of Appendix D (p. 139) of the original Shackleton report (*Soc. Psych. Research Proc.*, Part 167), there is no significant decline in the segments of the run and the corresponding graph shows an absence of any marked pattern. This provides a strong argument against the hypothesis that the guesser arranged his 'hits' so as to fall on certain pre-assigned positions in the scoring sheet.

Mr. Hansel suggested that an inspection of the positions of the (+2) hits on the scoring sheets concerned might throw light on the question. I therefore tabulated the hits in positions 1–23 for every column of the 'rapid rate' experiments. At first sight I was struck by the number of hits in a column which were spaced at a common interval. For example, column 7(*b*) on March 28 contained 11 hits in the positions 3, 4, 6, 7, 10, 11, 14, 18, 20, 21, 22. Of these, five are spaced at four trials apart, that is (6, 10, 14, 18, 22). But I discovered that such regularities can be obtained quite as frequently from a table of random numbers. I opened Tippett's table at page II, in which the random digits are arranged in columns of two-figure numbers.

Starting at the top of the first column and working down the succeeding columns in order, I constructed random positions in the column for a total of 10 hits as follows. Passing over the two-figure numbers 92–99 for obvious reasons, but retaining 00, each number was divided by 23 and the remainders noted. This was continued until 10 remainders were obtained which represented a random distribution of 10 (+2) hits in the first 23 places of the column, the remainder 0 standing for place No. 23. This process was continued until the first 47 sets of 10 hits were obtained. No gaps were left except those corresponding to the numbers 92–99, and of course the same remainder was not used more than once in a set of 10.

In the first 47 sets of 10 (+2) hits formed in this way, there were 17 with ⩾5 hits spaced at equal intervals.

For example, the first of these begins at II (1) 14, which means at the fourteenth entry down the first column of page II of Tippett's random numbers, and the seventeenth begins at II (14) 12.

There were also 16 sets of 10 each of which contained 4 hits spaced at equal intervals The first of these begins at II (2) 21 and the last at II (13) 48.

In the actual experiment there are 11 columns with scores ranging from 9 to 12 and so comparable with the control series, and these comprise 4 columns each with 5 hits equally spaced. These occur on March 21, 1941 Col. (6*b*), March 28, 1941 Col. (7*b*), March 28, 1941 Col. (8*b*) and April 18, 1941 Col. (7*a*).

A simple contingency table:

17	30	47
4	7	11
21	37	58

gives $\chi^2 = 0{\cdot}02$ with $0{\cdot}8 > P > 0{\cdot}7$, which is not abnormal, and this shows that regularly spaced hits occur quite as frequently in a random distribution as they do in the actual experiment.

The 11 columns of the actual experiment comprise 5 columns each with 4 hits equally spaced. These occur on March 21, 1941, Col. (6*a*), April 18, 1941, Col. (5*a*), May 22, 1942, Cols. (2*b*) and (3*b*), and June 5, 1942, Col. (1*b*).

The appro
correction)
significance.
Mr. Hans
are due to
probable, o
have observe

"Caer Ga
Bettws-y-
N. Wale

As I said
would "poss
causing a pe
the fact th
results obta
indicate tha
experiments.
rate' experi
sittings whe
experiments
sittings. Th
thorough ran
and as I sa
effect would
ments (that i
16, 21, etc.)
In addition,
line number
to mask any
the 'rapid ra
the pooled r
different tec
targets, and
different age
positions in t
the score sh
thus surprisi
a marked ext
experiments.
Dr. Soal's
unbroken run
score sheets t
Both Dr. Soa
obtained from
theoretical v
result, howe
formulated by
unusually lar
hits are spac
If a trick
expect runs
above the ch
were to atte
spaced positi
suitable rand
he wrote dow
the agent cou
the event of f
at these five
Soal's analysi
on every fifth
used employ
tend to produ
when the exp
basis of hits r
Dr. Soal sel
for his analy
average score

cy table (without Yates's
7, which again has no

segmental salience effects
ental design seems im-
any experimenters who

S. G. SOAL

ly, if a trick was used it
cessarily reveal itself by
ise in the scores". Thus
y is not present in the
'normal rate' does not
not employed in those
results for the 'rapid-
e the scores from six
ts for the 'normal-rate'
cores from some thirty
greater opportunity for a
he code in the latter case,
al letter the periodicity
he five possible arrange-
, 10, 15, 20 or lines 6, 11,
equal numbers of times.
—such as every fourth
en used part of the time
ect. In the case of both
ormal rate' experiments,
cores obtained when two
used to determine the
ipient worked with two
scores at the different
of twenty-five spaces on
ned in the tables. It is
odicity is present to such
results of the rapid-rate

frequencies with which
at equal spacings on the
light on the experiments.
imates and the values he
ts agree closely with the
ay be calculated. This
credits the hypothesis,
the score sheets have an
cases where four or five
n interval.
ve should not necessarily
spacings to appear at
us even if the percipient
five hits at five equally
o do so would depend on
earing. If, for example,
ols at these five positions,
im to obtain five hits in
dom numbers appearing
0·0384). But also, Dr.
uch runs whether spaced
intervals. If a trick was
line number, this would
f hits at smaller spacings
es are calculated on the
sed over the column.
t eleven scoring columns
ould be noted that the
ven hits per column of

twenty-five guesses (twenty-three of which could be scored). The percipient would have had to obtain about three hits by means of a trick in each column of the score sheet, in order to achieve scores similar to those obtained in the experiment.

Dr. Soal does not say how many experiments have been produced in which the results show a segmental salience effect, and I suspect that 'many' is certainly less than ten. Even if a high proportion of the experiments on extra-sensory perception have shown a segmental salience effect, I would not regard the suggestion that such effects are due to faulty experimental design as improbable.

Dr. Soal has himself revealed many weaknesses in the experimental work of other investigators in this sphere, and as I have pointed out elsewhere[1], I have been unable to find satisfactory evidence for extra-sensory perception in spite of many attempts to obtain it. If precognitive telepathy does not take place owing to processes not existing in Nature which permit its occurrence—as I consider to be the case—something must be responsible for the highly significant results obtained in some of the experiments and not in others. Whatever it is can be included in the general term 'experimental error'. While it is of interest to know what causes experimental error to arise, we must await a foolproof experimental design and a result which can be confirmed by other independent investigators before having to consider seriously the hypothesis of extra-sensory perception as an alternative explanation. The presence of a segmental salience effect must be taken in conjunction with the fact that there is a weakness in the experimental design which permits the result to arise by means of processes which are well understood, and that exploitation of this weakness without sufficient care would inevitably produce the salience effect.

C. E. M. HANSEL

Department of Psychology,
University of Manchester.

---

[1] Hansel, C. E. M., *New Scientist*, **5**, No. 119 (1959).

Preliminary Psychomotor Stress Studies with Subnormal Psychopathic Subjects

IN a series of research studies concerned with stress reactivity in adult male patients of subnormal intelligence quotient (*I.Q.*) and of known delinquent or psychopathic history, it has been established that stability, and possibly prognosis, are related to behavioural and physiological measures of stress reactivity[1,2]. Stress reactivity has been regarded as a continuous single variable, and it seems that instability corresponds with very high or very low reactivity, and stability with moderate reactivity, findings which are similar to those of Lykken[3], for primary and neurotic sociopaths, and the views of Eysenck[4,5] and Franks[6,7], concerning introversion–extraversion and conditionability. In general, physiological measures, such as the conditioning-rate of the galvanic skin response, correlate more highly with various social criteria than do behavioural measures. This is for three reasons: (*a*) the physiological techniques reduce extraneous stimulus and response factors to a minimum; (*b*) the techniques are applicable to subjects of quite low *I.Q.*, for example, down to 60; (*c*) the responses usually indicate a required range of scores from unreactivity to high reactivity.

There is clearly much in common with this stress reactivity variable, Eysenck's continuum of varying excitatory/inhibitory balance and Davis's[8] continuum of inertia-overactivity, which was originally determined from flying personnel research. Techniques aimed to assess Davis's psychomotor variate carry fewer disadvantages than most behavioural measures of stress reactivity in that the intellectual requirements need not necessarily be high, and the response can be assessed along a continuum from unreactivity to high reactivity. Venables[9,10] designed such a technique to demonstrate psychomotor differences between dysthymics and hysterics, and also found a close relationship between the psychomotor response and autonomic reactions. Using the same technique, Anthony[11] found highly significant differences between the psychomotor responses of delinquents and non-delinquents among Air Force personnel, with indications that the variate carries a high predictive validity.

In view of this similarity in conclusion from the different research sources, and also in view of the possibility that the Davis–Venables–Anthony technique might be of practical use in a battery of stress reactivity tests designed to predict behaviour for subnormal psychopaths, a series of experiments was instigated. These were designed to determine: (*a*) the relationship this variate has to galvanic skin response conditioning score (stress reactivity); (*b*) the main constituent of the psychomotor stressor, that is, whether it is speed stress or load stress[12] or both; (*c*) the modifications necessary to make the technique more practicable for low *I.Q.* subjects.

The original test required the subject to move a lever to the left or to the right, and back to the original position, in response to signal lights which flashed on a display panel at regular intervals. The lever operated a pen writing on moving paper, which recorded the amplitude of the subject's response (R), and the time taken (W), giving a third index R/W or speed. The test was in three consecutive parts, namely, series A, simple stimulus conditions at a moderate rate of presentation; series B, complex stimulus conditions at a higher rate of presentation, and C, identical to series A. Both Venables and Anthony found that the indices most highly associated with psychiatric or social criteria were: (*a*) the general score-level for speed, R/W, under all stimulus conditions; (*b*) the difference in speed under conditions B and C; (*c*) the direction of change, that is, increase or decrease in speed.

For practical purposes, and in order to overcome the time-consuming measurement of 150 individual responses for each patient, modified apparatus was designed and constructed with the aid of money made available by the Mental Health Research Fund. As in the previous experiments by Venables and Anthony, the subject is required to move a lever from a centre position to the right or to the left in response to visual signals on a display panel. With the new technique the lever is arranged to activate a 10 counts/sec. electronic pulse clock on being moved off centre. An electromagnetic counter driven by the clock indicates the integrated time variate (W). To the lever is also attached a series of gear wheels and ratchets allowing its total integrated movement (the amplitude of the response, R), to be read directly from a revolving scale. Stimulus presentation has been automatized by using a pulsed uniselector so that the whole test, involving 150 stimulus-response pairings and calibration, occupies 7–10 min.

Five experimental trials have been carried out with different groups of 20 patients of *I.Q.* range 60–90, and one trial with normal male adults. Trial 1 followed the Venables–Anthony stimulus presentation procedure in respect of both speed stress (time interval between stimuli) and load stress (the complexity of the stimuli), and was found to be beyond the capabilities of too many patients. Trial 2 used the load stress but left the presentation-rate constant at a moderate level for series A, B and C. No significant correlation coefficients were found between any psychomotor variate and conditioning score. Trial 3 investigated the practice effect by presenting series A conditions three times in succession and comparing the resultant scores with those for trial 2. No significant differences were found, and it was concluded that the load stress, on its own, is unimportant in producing significant behaviour for these patients, with this test. In view of this, the subsequent experiments investigated the rate of presentation factor in relation to galvanic skin response conditioning with load conditions uniform for series A, B and C. No significant correlation coefficients were found for trial 4, when the rate of presentation was increased from 30 signals a minute in Series A and C to 50 signals a minute in series B. In trial 5, the rate of presentation was further increased to 60 signals a minute in series B, and this was found to produce a psychomotor stress reaction which correlated slightly with the conditioning score for the galvanic skin response. The measure used was the variate R/W, or speed, for series B, and the difference in R/W between series B and C. Assessed against galvanic skin response conditioning score, $\chi^2 = 3 \cdot 6$ and $3 \cdot 4$ respectively, $P = 0 \cdot 05$. The normal subjects were tried at a presentation-rate of 50 signals a minute, but R/W scores did not differ significantly from those of the patients under the same conditions.

No firm conclusions are possible at this stage; but the indications are that Anthony's finding concerning psychomotor stress in relation to relatively mild delinquent instability, can be associated with the general concepts of stress reactivity applied in the laboratory assessment of more severe psychopathic instability. The automatized technique has considerable practical appeal, but it seems necessary to concentrate more upon the rate of stimulus presentation stressor than the stimulus load stressor, and judicious experimentation with the former may provide valuable information.

J. E. Tong
I. C. Murphy*
F. R. Adams†

Psychology Department,
Rampton Hospital,
Retford, Notts.

* Medical Research Council Scholar.

† Present address: Ruskin College, Oxford.

[1] Tong, J. E., *J. Ment. Sci.*, 105, 935 (1959).
[2] Tong, J. E., and Murphy, I. C., *J. Clin. Psychol.* (in the press).
[3] Lykken, D. T., *J. Abnorm. Soc. Psychol.* 55, 6 (1957).
[4] Eysenck, H. J., *J. Ment. Sci.*, 101, 28 (1955).
[5] Eysenck, H. J., *J. Ment. Sci.*, 105, 61 (1959).
[6] Franks, C. M., *J. Abnorm. Soc. Psychol.*, 52, 143 (1956).
[7] Franks, C. M., *Brit. J. Delinq.*, 6, 192 (1956).
[8] Davis, D. R., "Pilot Error: Some Laboratory Experiments" (H.M. Stationery Office, 1948).
[9] Venables, P. H., *Brit. J. Psychol.*, 46, 2, 101 (1955).
[10] Venables, P. H., *J. Gen. Psychol.*, 55, 199 (1956).
[11] Anthony, H. S., *Nature*, 183, 343 (1959)
[12] Conrad, R., *Brit. J. Indust. Med.*, 8, 1 (1951).

Artificial

ONE of the
which has not
ness of the cr
of the parietal
this can occas
skull, such a
normal skull.
suggested as a
me that fraud
tion. Since th
he could, why
bones ? But
thicken ? A h
Some potassiu
4¼ oz. were dis
this solution w
fourths of a hu
The bone wa
individual who
been degreased
oxide. It was
After remainin
solution the b
become as sof
removed with
put on a plat
gentle spray re
small particles
tables, which r
thick and a littl
was placed in th
5–6 hr., accom
inner and oute
harden or othe
now somewhat
removed from t
delaminated st
bone, at the oc
mm. Where the
bone is at the m
by a blow with
four pieces), 6·
is at the corres
I am confident
could do a grea

As in the Pilt
thickened bone
pansion, while
remained relati

It is not su
potassium hydr
bones. It is sug
similar means.

The results o
as to whether
skull bones may
action of variou
have lain.

My thanks ar
Princeton Univ
potassium hydr

Princeton, Ne

THE results
described by Dr

OLOGY

of Bone and the Skull

out the Piltdown bones
the unexplained thick-
he maximum thickness
mple, is 12 mm. While
hed in a contemporary
ldom encountered in a
mic anæmia has been
nation. It occurred to
ast as good an explana-
axer) faked everything
thickness of the skull
cause skull bones to
ld seem a likely agent.
being readily available
z. of tap-water, and in
e right posterior three-
bone of an adult male.
-room specimen of an
irty years ago, and had
nary manner with per-
3.50 p.m. on April 15.
d, for 6 days in this
derably thickened and
The bone was gently
p.m. on April 21, and
t to wash it under a
emoval of innumerable
the inner and outer
a sediment about ¼ in.
inch square. The bone
ry, which it did within
h flaking away of the
attempt was made to
e bone. The bone is
an when it was first
t in its dried somewhat
er than the untreated
argins, by some 2–2·5
rtion of the same skull
as artificially produced
ch broke the skull into
ness, the treated bone
8·7 mm. in thickness.
ttle more patience one
han that.

too, in this artificially
s undergone most ex-
d outer tables have

that the hoaxer used
n the Piltdown skull
uite possibly he used a

ent raise the question
of palæolithic human
in part, be due to the
the soils in which they

epartment of Geology,
pplying me with the
this experiment.

ASHLEY MONTAGU

ment carried out and
agu are certainly most interesting; but they cannot be considered as providing a possible explanation of the unusual thickness of the Piltdown cranial bones, for two reasons: (1) Chemical analyses have confirmed that the Piltdown cranial bones are slightly mineralized (for example, they contain 0·1 per cent adsorbed fluorine); indeed the conclusion that they are sub-fossil has recently been confirmed by radiocarbon dating[1]. Sub-fossil bones which have lost a considerable proportion of their collagen matrix obviously will not be expanded appreciably by any chemical treatment—or at least not to an extent anywhere nearly comparable with that occurring in the case of a dissecting-room specimen with full collagen content. (2) The striking uniformity and small size of the diploic spaces in the Piltdown cranial bones are incompatible with any artificial expansion.

In the British Museum collections here there are other crania with walls not only as thick as those of the Piltdown cranium, but also showing the same combination of naturally thickened diploe and extremely thin inner and outer tables. The two most striking examples are the cranium of an Ona Indian from Tierra del Fuego, which has already been figured in comparison with Piltdown[2], and a Bronze Age skull from Sutton Courtenay in Berkshire (Oxf. *E*.118. 227).

KENNETH P. OAKLEY

Sub-Department of Anthropology,
British Museum (Natural History),
London, S.W.7.

---

[1] *Nature*, **184**, 224 (1959).

[2] *Bull. Brit. Mus.* (*Nat. Hist.*), *Geol.*, **2**, No. 6, 259 (1955).

MISCELLANY

The Serengeti National Park

THE interesting article on this subject by Dr. A. S. Thomas in *Nature* of May 21, p. 605, seems to call for the following comments:

(1) The new northern extension of the Park ('fly-bush' country without human inhabitants) was not added for the sake of antelopes, but because it was reported to be rich in elephant and rhinoceros.

(2) The southern boundary of the Park was, in the west, pushed outwards practically to the edge of present cultivation; the overspill of the ungulate migration to the south-east falls largely in the Conservation Unit under Government administration or in areas to some extent controlled with regard to 'game'.

(3) It is known, at least in respect of some types of ground, what may be expected to happen when pastoral activity is eliminated; large parts of the Park were already free from this. Moreover, in what is now the Conservation Unit (Ngorongoro) wild animals and domestic herds will continue to co-exist.

(4) The withdrawal of the Park boundaries from an area where human utilization could not be eliminated, that is, the Conservation Unit, was recommended mainly because experience has shown that dual control by Trustees and Government is unsatisfactory; and only where there is no human occupation can Government allow park trustees a clear field. In the Conservation Unit the Government has an opportunity of demonstrating what can be done in the way of reconciling conservational and pastoral interests—an experiment of great interest, on lines such as Dr. Thomas suggests.

LANDSBOROUGH THOMSON

Zoological Society of London.

FORTHCOMING EVENTS

Wednesday, July 13

Royal Institute of Chemistry, London Section (at Shell-Mex House, Strand, London, W.C.2), at 6.30 p.m.—Special General Meeting.

Friday, July 15—Friday, July 22

Sixth Commonwealth Mycological Conference (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1).

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Georgina McRobert Research Fellow (with histological training and preferably some experience in immunological methods), to collaborate in the immunopathological research programme being carried out in the Departments of Pathology, Bacteriology and Biological Chemistry—The Secretary, The University, Aberdeen (July 14).

Head (graduate, with good industrial and teaching experience) of the Engineering Department (Civil, Electrical and Mechanical Engineering)—The Principal, Dudley and Staffordshire Technical College, Dudley (July 15).

Research Fellow in Pure Science—The Secretary, Durham Colleges in the University of Durham, 38 North Bailey, Durham (July 15).

Lecturer in Chemistry, and a Lecturer in Chemical Engineering at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (July 15).

Assistant, Grade B (graduate in mathematics, science or engineering or with equivalent qualifications, and capable of teaching the subject up to H.N.C. and G.C.E. Ordinary standard) in Mathematics—The Principal, Derby and District College of Technology, Kedleston Road, Derby (July 16).

Assistant Lecturer (with a special interest in the general field of invertebrate palaeontology) in Palaeontology—The Secretary, University College, Gower Street, London, W.C.1 (July 16).

Chemist (Assistant Experimental Officer grade) in the Pedology Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (July 16).

Lecturer in Physical Metallurgy at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (July 16).

Research Students (with a good degree in physics or mathematics) for experimental and/or theoretical work on a variety of problems including: properties of ionized gases, plasma physics, geophysical hydrodynamics, rock magnetism, study of the Earth's interior, and geomagnetism—The Administrative Assistant, Department of Physics, King's College (University of Durham), Newcastle upon Tyne 1 (July 16).

Assistant Lecturer (with a special interest in field ecology, pollen analysis or experimental taxonomy) in Botany—The Registrar, The University, Sheffield (July 18).

Research Fellow (graduate or person experienced in biochemistry) in the Department of Pharmacology, to work as part of a research team investigating various aspects of rheumatism and other diseases—The Secretary, The Welsh National School of Medicine, 34 Newport Road, Cardiff (July 18).

University Research Students in the Departments of Botany, Geography and Physics—The Registrar, The University, Hull (July 18).

Research Assistant (with an honours degree in geology, a good background in chemistry, and an interest or postgraduate experience in sedimentary studies) in the Department of Geology, to work on recent sediments—The Secretary, University College, Gower Street, London, W.C.1 (July 20).

Research Associate (graduate, with special qualifications in physical chemistry, physics or mineralogy and petrology) in the Department of Geology, for work upon hydrated alumino-silicate glasses and metals and for the development of apparatus for such work—Prof. F. W. Shotton, University of Birmingham, Edgbaston, Birmingham 15 (July 21).

Lecturer in the Department of Organic Chemistry, University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 22).

Jeyes' Research Fellow (suitably qualified graduate) in the Biology Department, for research on biological or physico/chemical aspects of chemical soil sterilization—The Registrar, University College of North Staffordshire, Keele, Staffs (July 23).

Assistant Director of Graduate Studies in the Department of Physical Chemistry—The Registrar, The University, Leeds 2 (July 25).

Analytical Chemist (with a degree in chemistry or A.R.I.C.) at Ruakura Animal Research Station, New Zealand, to assist the officer in charge of the Biochemical Servicing Section of the Research Station, and to undertake non-routine analysis and to develop new methods—The High Commissioner for New Zealand, 415 Strand, London, W.C.2, quoting Ref. No. B.11/2/31 (July 30).

Assistant Lecturer in the Department of Metallurgy—The Registrar, The University, Manchester 13 (July 30).

Assistant Lecturer or Lecturer in Inorganic Chemistry—The Secretary, The Royal College of Science and Technology, Glasgow (July 30).

Chemist, Grade 3 (preferably M.Sc. in analytical and organic chemistry or biochemistry) in the National Biological Standards Laboratory, Canberra, for the development of methods for the analysis of drugs, etc.; checking of methods submitted by manufacturers; and the supervision of testing of drugs sold in Australia—The Director-General of Health, Department of Health, Canberra, Australia (July 30).

Head (with scientific training to graduate level, not necessarily in textile technology, but possibly in engineering or physics) of the Department of Textile Industries—The Principal, College of Technology, Belfast (July 30).

Lecturers in Mathematics, Physics, and Biology at the Royal University of Malta—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 30).

Physicist/Mathematician (graduate with a higher degree in physics or mathematics) at the New Zealand Oceanographic Institute, Department of Scientific and Industrial Research, Wellington, to carry out research in various branches of physical oceanography, for example, the dynamics of ocean systems; mixing processes; behaviour of water masses in boundary areas; or other aspects of the transfer of energy between atmosphere and ocean—The High Commissioner for New Zealand, 415 Strand, London, W.C.2, quoting Ref. No. B.11/21/29 (July 30).

Librarian (male graduate with a library qualification, and preferably a scientific background)—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1 (July 31).

Senior Lecturer in Physical Chemistry at the University of Natal, Pietermaritzburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, July 31).

Senior Lecturer in Physics at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (August 15).

Chair of Education in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, August 31).

Lecturer in Archaeology—The Secretary of University Court, The University, Glasgow (August 31).

Lecturer/Senior Lecturer in Zoology; and Chair in Theoretical Physics at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 31).

Lecturer (with an honours degree in psychology together with acceptable qualifications and practical experience in clinical psychology) in Psychology at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, August 31).

Departmental Demonstrator in Biochemistry—The Administrator, Department of Biochemistry, The University, South Parks Road, Oxford (September 15).

Assistant, Grade B (preferably with teaching experience) in the Department of Chemistry, Colour Chemistry and Dyeing, to teach general and inorganic chemistry to H.N.C. standard—The Principal, Huddersfield College of Technology, Huddersfield.

Assistant Lecturer (preferably with a Ph.D. in microbiology and research experience in this field) in the Department of Industrial Microbiology—Prof. E. Küster, Department of Industrial Microbiology, University College, Ardmore House, Stillorgan Road, Dublin.

Biochemical Assistant to assist with diabetic research—The Director, Medical Unit, Kings College Hospital Medical School, Denmark Hill, London, S.E.5.

Biochemist, Basic grade (graduate in chemistry or Associate or Graduate Member of the Royal Institute of Chemistry), in the Department of Pathology—The Group Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2.

Hospital Physicist (with one or two years previous experience) in the Department of Pathology, for radioisotope work covering a wide field—The Group Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2.

Laboratory Technician (male or female, A.I.M.L.T., and preferably with experience in blood transfusion work) in the Uganda Government Medical Department—The Crown Agents, 4 Millbank, London, S.W.1, quoting Ref. M.3C/52442/NF.

Lecturer or Assistant Lecturer (Grade E) in the Department of Applied Physics—The Principal, Welsh College of Advanced Technology, Cathays Park, Cardiff.

Lecturer or Assistant Lecturer in Physics at the University College of the West Indies—The Secretary, Inter-university Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Mathematical Physicists (capable of leading teams in theoretical research, and proved ability to do effective work in novel fields)—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 2696/34.

Postdoctoral Fellow in Organic Chemistry, to work in collaboration with Dr. E. J. Forbes on the photochemistry of tropolones and related topics—The Deputy Registrar, The University, Edgbaston, Birmingham 15.

Postdoctorate Fellow in the Chemistry Department, for work on infra-red emission from gaseous chemical reactions—Prof. J. C. Polanyi, Department of Chemistry, University of Toronto, Toronto, Ontario, Canada.

Professor or Associate Professor of Mathematical Physics; and Assistant Professors (2) in Applied Mathematics or Mathematical Physics at the Royal Military College of Canada—Dept. 2009, National Employment Service of Canada, 61 Green Street, London, W.1.

Research Assistant (recently qualified organic chemist or biochemist) to undertake work on a chemical problem connected with cancer research—Professor Green, Department of Experimental Pathology and Cancer Research, The University, Leeds 2.

Research Assistant (suitably qualified graduate) in Botany and Zoology, to work on problems in cyto-chemistry, entomology, animal ecology or freshwater biology—Dr. J. K. Sparing, Head of the Department of Botany and Zoology, Sir John Cass College, Jewry Street, London, E.C.3.

SCIENTIFIC OF (with a science degree, and pre-
ferably a special r blood transfusion techniques)
IN THE LABORAT H LONDON TRANSFUSION CENTRE,
for duties consist ical laboratory work and research
and also to take istration of the department—The
Director, South I n Centre, Stanley Road, Sutton,
Surrey.

SENIOR LECTURE ATHEMATICS, and a LECTURER IN
MATHEMATICS at I , The University College of Sierra
Leone—The Secre ity Council for Higher Education
Overseas, 29 Wob m, W.C.1.

TECHNICAL OFF), with a degree in mathematics,
or an honours deg with a mathematical background)
IN THE SURVEY vernment of Kenya, for survey
computations and / plans—The Director of Recruit-
ment, Colonial O l, quoting BCD.103/7/09/NF.

REPORTS r PUBLICATIONS

(not in ly Books Supplement)

and Ireland

Planning, Vol. ril, 1960): Consumer Protection
and Enlightenmen London: Political and Economic
Planning, 1960.) [254

Ministry of Hou vernment. Third Progress Report
of the Standing Te on Synthetic Detergents. Pp. 18.
(London: H.M. S 60.) 1s. 6d. net. [254

The Imperial Fo niversity of Oxford. Thirty-fifth
Annual Report, . (Oxford: Imperial Forestry
Institute, The Un [254

National Coal B r Coal. Pp. 24. (London: The
National Coal Boa [254

The Institute o f the Council and Statement of
Accounts for the 6. (London: Institute of Fuel,
1960.) [254

Petroleum Infor .K. Petroleum Industry Statistics
Relating to Consu ery Production 1958 and 1959
Pp. 10. (London mation Bureau, 1960.) [254

Department of ustrial Research. Problems of
Progress in Indust Made Easier: a Review of Four
Recent Studies. E ns of Progress in Industry No. 7:
The Older Worker Hilary M. Clay. Pp. 20. 1s. 8d.
(London: H.M. S 960.) [254

National Institu hy. Collected Reprints, Vol. 7.
Reprints Nos. 248- odalming: National Institute of
Oceanography, 19 [254

Government of Ministry of Agriculture. Leaflet
No. 24: Liver F 4. Leaflet No. 40: Grassland
Husbandry. Pp. 43: The Cattle Crush. Pp. 4.
(Belfast: Ministr 960.) [254

Department of S strial Research. Forest Products
Research. Bulletin ation of Hardwoods: a Lens Key.
Second edition. E tes. (London: H.M. Stationery
Office, 1960.) 7s. [254

ntries

Organization for ic Co-operation. Co-operation in
the Field of Scien l Research. Report by Mr. D.
Wilgress. Pp. 2 ization for European Economic
Co-operation, 1960 [224

Trinidad and To Annual Report for 1958. Pp. 11.
(Trinidad: Gover ice, 1959.) [224

Publications de l pour l'Etude Agronomique du
Congo Belge. Flo et du Ruanda-Urundi. Vol. 9.
Spermatophytes. Comité exécutif de la Flore du
Congo Belge et le l'Etat. Pp. vi+597 (56 planches).
(Bruxelles: Instit l'Etude Agronomique du Congo
Belge, 1960.) [224

National Acade ational Research Council. Sub-
committee on Rad -NS-3002: The Radiochemistry
of Cadmium. By Pp. vi+57. 75 cents. NAS-NS-
3002: The Radio nic. By Harold C. Beard. Pp.
vi+27. 50 cents. he Radiochemistry of Francium.
By Earl K. Hyde. ts. (Washington, D.C.: Office of
Technical Service Commerce, 1960.) [224

American Institu ences. Origins of Angiospermous
Plants. By A. L. slated from the Russian by Mrs.
Olga Hess Gankin lyard Stebbins. Pp. i+68. 3.50
dollars. Essays on Morphology of Plants. By A. L.
Takhtajian. Trans ssian by Mrs. Olga Hess Gankin.
Edited by G. Ledy. +130. 5.50 dollars. (Washington,
D.C.: American I al Sciences, 1958 and 1959.) [224

East Africa Hig t African Meteorological Depart-
ment Annual Repo . ii+34. (Nairobi: Government
Printer, 1960.) Sh [224

Canada: Depar Affairs and National Resources.
National Museum. letin No. 164: The Terrestrial
Cryptogams of N land. By Rudolph M. Schuster,
William C. Steere. mason. Pp. iii+132 (4 plates).
2 dollars. Bullet ibutions to Zoology, 1958. Pp.
iii+59. 1 dollar. Printer, 1959.) [224

World Health nternational Work in Leprosy,
1948–1959. Pp. *WHO Chronicle*, 1960, 14, 2–39.)
(Geneva: World on; London: H.M. Stationery
Office, 1960.) 1 S ; 0.30 dollars. [224

Official Records alth Organization No. 98: The
Work of WHO, 1 rt of the Director-General to the
World Health As e United Nations. Pp. x+233.
(Geneva: World on; London: H.M. Stationery
Office, 1960.) 6 S ; 2 dollars. [224

A Dover Sampler: a Collection of Brief Non-Technical Passages from 44 Dover Books Explaining Science, for the Enjoyment of the Science-Minded Browser. Selected and Edited by George Barkin. Pp. 63. (New York: Dover Publications, Inc.; London: Constable and Co., Ltd., 1959.) [224

The Erosion of Victoria Beach: Its Cause and Cure. By Prof. J. E. Webb. (A lecture given before the Philosophical Society, University College, Ibadan, 11 December, 1959.) Pp. 42 (20 figures). (Ibadan: Ibadan University Press, 1960.) 3s. 6d. [224

Seventy-sixth Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution, 1958–1959. Pp. ii+41+4 plates. (Washington, D.C.: Government Printing Office, 1960.) [224

Chicago Natural History Museum. Fieldiana: Zoology. Vol. 39, No. 34 (March 16, 1960): Review of *Pionus maximiliani* (Kuhl). By Ellen Thorne Smith. Pp. 379–385. (Chicago: Chicago Natural History Museum, 1960.) [224

Museum of Comparative Zoology at Harvard College. Breviora. No. 116 (January 6, 1960): Insectivores of the Middle Miocene Split Rock Local Fauna, Wyoming. By Katherine M. Reed. Pp. 11+2 plates. No. 117 (January 20, 1960). Notes on Hispaniolan Herpetology. 1: *Anolis christophei*, New Species, from the Citadel of King Christophe, Haiti. By Ernest E. Williams. Pp. 7. No. 118 (February 24, 1960): A Survey of the Leptodactylid Frogs, Genus *Eupsophus*, in Chile. By José M. Cei. Pp. 12. No. 119 (March 8, 1960): Arctic Archibenthal and Abyssal Mollusks from Drifting Station Alpha. By Arthur H. Clarke, Jr. Pp. 17+1 plate. No. 120 (March 9, 1960): Two Species of Tortoises in Northern South America. By Ernest E. Williams. Pp. 13+3 plates. No. 121 (March 10, 1960): Three New Species of Micrathena (Araneae, Argiopidae) from South America. By Arthur M. Chickering. Pp. 11. No. 122 (March 11, 1960): Notes on Certain Species of Micrathena (Araneae, Argiopidae) from South America. By Arthur M. Chickering. Pp. 7. No. 123 (March 14, 1960): *Alepisaurus brevirostris*, a New Species of Lancetfish from the Western North Atlantic. By Robert H. Gibbs, Jr. Pp. 14. No. 124 (March 15, 1960): Anisian Ammonoids from Malaya. By Bernhard Kummel. Pp. 8+1 plate. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1960.) [224

United States Department of Health, Education, and Welfare: Public Health Service. Publication No. 759: Highlights of Research Progress in General Medical Sciences, 1959—Items of Interest on Research Studies supported by the Division of General Medical Sciences, National Institute of Health, Bethesda 14, Md. Pp. v+23. (Washington, D.C.: Government Printing Office, 1960.) 15 cents. [224

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 122, No. 2: A Preliminary Review of the Family Gonostomatidae, with a Key to the Genera and the Description of a New Species from the Tropical Pacific. By Marion Grey. Pp. 57–125. Vol. 122, No. 3: Trichecodon Huxleyi (Mammalia: Odobenidae) in the Pleistocene of South-eastern United States. By Clayton E. Ray. Pp. 127–142+2 plates. Vol. 122, No. 4: Contributions Toward a Reclassification of the Formicidae. 3: Tribe Amblyoponini (Hymenoptera). By William L. Brown, Jr. Pp. 143–230. Vol. 122, No. 5: Land Shells of Navassa Island, West Indies. By Ruth D. Turner. Pp. 231–244+7 plates. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1960.) [224

Fondation Universitaire, Bruxelles. Trente-neuvième Rapport Annuel, 1958–1959. Pp. 144. (Bruxelles: Fondation Universitaire, 1960.) [224

Commonwealth of Australia: Department of External Affairs. Australian National Antarctic Research Expeditions. ANARE Reports, Series B, Vol. 1: Zoology. The Birds of Heard Island. By M. C. Downes, E. H. M. Ealey, A. M. Gwynn, and P. S. Young. Pp. 135. (Melbourne: Antarctic Division, Department of External Affairs, 1959.) [224

United States Department of the Interior: Fish and Wildlife Service. Fishery Bulletin 167: Estimates of Larval Tuna Abundance in the Central Pacific. By Donald W. Strasburg. Pp. iv+231–255. (Washington, D.C.: Government Printing Office, 1960.) 25 cents. [224

Smithsonian Institution: United States National Museum. Bulletin 217: Birds of Anaktuvuk Pass, Kobuk, and Old Crow: a Study in Arctic Adaptation. By Laurence Irving. Pp. viii+409+13 plates. (Washington, D.C.: Government Printing Office, 1960.) 2 dollars. [224

Republic de Colombia: Departamento de Cordoba. Secretaria de Agricultura y Ganaderia. Estudios de Suelos Preliminares del Departamento de Cordoba. Por Irusta y Fortoul. Pp. 60+4 maps. (Bogota: Instituto de Fomento Algodonero, 1959.) [224

Companhia de Diamantes de Angola (DIAMANG). Servicos Culturais. Dundo–Lunda–Angola. Museu do Dundo. Subsidios de História (Ultramarina e Continental). Publicacoes Culturais No. 47: List of Editions of the *Libro del Infante don Pedro de Portugal*. By Francis M. Rogers. Pp. 118. (Lisboa: Companhia de Diamantes de Angola, 1960.) [224

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2.
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

BRITISH DEFENCE RESEARCH AND DEVELOPMENT

THE pattern of British defence policy can seldom have been so quickly transformed as that set forth in the Report on Defence* issued on February 17. Claiming that during the third year of the Five-year Plan for Defence the Government's broad defence policy had undergone no major change, the recent White Paper on Defence admitted that it might be decided not to rely exclusively on fixed-site missiles as the successor to the medium bomber armed with the stand-off powered bomb. Accordingly, the possibilities of mobile launches, whether aircraft or submarines, for long-range delivery of nuclear warheads are being investigated.

In opening a debate on this White Paper on February 29, the Minister of Defence, Mr. Harold Watkinson, paid a tribute to the work of his Chief Scientific Adviser and his team of experts, and referred to the immense technological changes taking place in defence by new methods of computation and production, which are enabling problems to be solved which could not have been even formulated with precision a few years ago. But, apart from suggesting that we might be led to give greater emphasis to mobility and flexibility, he said nothing further to foreshadow his announcement on April 13 that the Government has decided to discontinue the development of *Blue Streak* as a military weapon. Indeed, on February 29, he had endorsed what Mr. Sandys, his predecessor as Minister of Defence, had said in the Defence debate in February 1959, that *Blue Streak* was going ahead, but that we would watch the progress of other developments in the United States and elsewhere, and that with the rapid advances of science, which are constantly upsetting earlier assessments, strategic plans and weapon programmes can never be regarded as permanent or inevitable. Specifically, he said that what we have learned from the development of *Blue Streak* has been of some help to the Americans, and that we have already learned much both in the technique of propulsion and in the design of the very complicated guidance and computation systems that are the necessary concomitant of any ballistic missile. Final decisions on the balance Britain should hold between fixed-site missiles and mobile launchers, Mr. Watkinson said then, had not been taken, and he would like much more information about *Skybolt*, a ballistic missile of considerable range which could be launched from an aircraft, and also about the future development of *Polaris*, a solid-fuel rocket generally designed for a mobile role, and he was also having examined more closely the defence aspects of space research, at which he thought we need to look very carefully. Lord Hailsham, too, in the House of Lords debate on March 9, had been equally emphatic that British policies must be constantly open to revision, and equally he stressed the fact that the nuclear weapon, though in his view indispensable, is no more than one of the factors that make up defence policy. Of the £1,600 million covered by the Defence Estimates, no more than about 20 per cent could be attributed to the nuclear deterrent and its defence, and 10 per cent to the deterrent itself. About 14 per cent was spent on research and development, and in this connexion Lord Hailsham affirmed that we must be ruthless in our determination to scrap anything which cannot be justified, and resolute to support whatever is necessary by way of research and development.

Little was, in fact, said about defence research and development, though, in the House of Commons, Mr. J. Grimond suggested that, taking research into account, the whole of the nuclear weapon programme of research and development would represent 15–20 per cent, and Sir Alexander Spearman asserted that on research alone the United States is spending more than double our defence budget. Mr. Watkinson asserted, however, that it is much nearer 15 per cent, but on April 13 he admitted that the cost of completing the *Blue Streak* project would be between £500 and £600 million. None of the £95 million already spent would be wasted if it was decided to go ahead with *Blue Streak* as a launcher for a space satellite; but the admitted costs for *Seaslug*, *Thunderbird* and *Firestreak* bring the estimated missile bill to some £205 million, leaving out of account the stand-off weapon of the Royal Air Force designed to be launched outside the range of the enemy's defences, for which no figures are available in the Auditor-General's recent analysis. Incidentally, Sir Frederick Brundrett, former chief scientist to the Ministry of Defence, who still considers that *Blue Streak* could provide at least until 1970 an effective independent British contribution to the Western deterrent, has also supported the submarine-launched missile in preference to an air-launched missile.

There are two points made in these Defence debates that are of particular interest to the scientist and technologist. First, the inordinate time taken to plan, develop and produce the more complicated and technical weapons of itself increases the expense, and Lieut.-Commander S. L. C. Maydon suggested that it might be worth while to set up a small committee of experts consisting of an experienced industrialist, a senior Service officer of up-to-date ideas and a man experienced in time-and-motion study to look into the possibility of reducing the time taken to design and build a ship, aircraft, tank or other equipment. Commander Maydon did not suggest that this would lead to more than comparatively minor savings or short cuts, but in view of the magnitude of the expenditure involved they could be well worth while.

---

* Report on Defence 1960. Pp. 18. (Cmnd. 952.) (London: H.M. Stationery Office, 1960.) 1*s*. net.

The second
Vice-Admiral
year, namely
Service offic
senior Ministe
tions, becau
which is the e
Viscount Bri
a Service jou
Cowley: "It
times that t
great that n
hope to keep
results of thi
of the advic
officers. The
or a year of
This, as A
dangerous p
the vital in
tactics and s
of this year's
the Navy Est
evidence eno
many membe
unbiased info
in the debate
members of
of informatio
the United St
on the Estin
said that th
scant inform
scientific an
policy. Stre
Services for t
ledge and sk
Government's
ments, which
of the highe
strength of t
the defence
have now be
the Ministry
which they a
to ensure th
and the unit
progressively
served under
appearance
of Aviation
supply of gui
of much rad
of nuclear w
However,
formed disc
The first is
implications
Institute fo
was freely m
is Prof. P. M
delivered bef
published in

nes a comment made by
lett in a defence debate last
outside a small circle of
nt officials and possibly
to answer the vital ques-
possess the information
any opinion worth while.
an editorial comment in
ure by General Sir John
tragedies of our modern
hnological advance is so
has left the Services can
w inventions. One of the
the Services the benefit
of their senior retired
touch within six months

t put it, is a novel and
ew people indeed possess
out which the study of
ste of time, and a perusal
nce, on the Air Estimates,
Army Estimates provides
despite all the efforts of
nt to obtain factual and
E. L. Mallalieu's comment
the Navy Estimates that
e nothing like the sources
members of Congress in
g suggestions or criticisms
e noted. Nor can it be
itself adds much to the
e for discussion on the
pects of British defence
he increasing need in the
ntific and technical know-
cellent equipment of the
development establish-
y scientists and engineers
The maintenance of the
nents is a vital feature of
scientific establishments
to the War Office from
ng with the functions to
every care is being taken
and technical resources,
al staffs, which have been
er recent years, are pre-
ngements. With the dis-
of Supply, the Ministry
en responsibility for the
ncluding ballistic missiles,
lectronic equipment, and

nt contributions to in-
cently become available.
chan's examination of the
dence published by the
idies, to which reference
ence debates. The second
Tizard Memorial Lecture
tute on February 11 and
ch 5, p. 647. The third is
the Report on Basic Research in the Navy by the United States Naval Research Advisory Committee*. Reference was made to the latter report in *Nature* of February 27, but was confined to only one interesting aspect of the inquiry—the possibility of measuring the effectiveness of research and development—and by no means indicates the extent of the contribution which the two volumes of this report could make to the public understanding of the interrelations of defence and civil research. Besides this model for the discovery and application of knowledge, which is the major appendix constituting Vol. 2, together with some man-power studies bearing on research and development, there is a chronological list of naval technical developments to illustrate the impact of science and technology on the evolution of the United States Navy and a brief bibliography. The first volume comprises the conclusions and recommendations of the Naval Research Advisory Committee and the report to that Committee on basic research in the U.S. Navy, prepared by A. D. Little, Inc., setting forth the nature of basic research and its relation to military ends.

It is these conclusions and recommendations that deserve to be noted at the present moment when misgivings are being expressed about the soundness of the scientific and technical advice being tendered on defence matters in Britain, and the adequacy of existing arrangements to ensure that such advice is timely and effective. The report points out that in the past basic research has transformed naval strategy and tactics by its findings in such fields as radar, inertial guidance, missile propulsion and nuclear propulsion, and suggests that the United States Navy should support enough research in each area of interest to provide effective coupling and judgment for its own needs. That may well be too much a counsel of perfection for Britain, with her more limited resources; but it is assuredly true for her also that each Service Department should be competent and alert to appreciate the scientific findings of its own or other workers, and the significance of such findings to its own responsibilities and functions.

The Naval Research Advisory Committee considers that the basic research effort in the United States Navy should be about doubled to restore the former relation of basic research to the total research and development effort, and this would bring that effort nearer to the 16 per cent now current in progressive scientific and engineering industries. The report does not attempt to detail the programme proper, but it suggests that the Office of Naval Research should prepare detailed programmes in some seventeen fields of scientific work related to the missions of the Navy. Some of these are obvious prime or major responsibilities; others require effective co-ordination with what is being done elsewhere. The fields specifically listed are: physics; astronautics and aeronautical engineering; material sciences; electronics; mechanics; medical sciences; biology and biological sciences; oceanography; chemistry; geography; psychology; operational research; meteorology; astronomy and astrophysics; mathematics; combustion; earth physics.

---

* U.S. Department of Defense. Department of the Navy: Naval Research Advisory Committee. Basic Research in the Navy: Report to the Secretary of the Navy by the Naval Research Advisory Committee. Report prepared by Arthur D. Little, Inc. Vol. 1: Pp. xi+69. Vol. 2: Pp. i+102. (Washington, D.C.: Department of the Navy, 1959.)

It is not suggested, of course, that the U.S. Navy should attempt to cover all aspects of these fields, and it is recognized that, in planning research, use should be made of scientists and administrators from the universities and industry. Moreover, when a total programme has been prepared, a critical review is needed, to ensure that the total cost is within the budget. Although the report says comparatively little about the co-ordination of naval research in the United States with that of basic research for the other Services, apart from the admirably chosen examples of the way in which advances in basic science and technology have affected naval tactics and operations, these proposals demonstrate the dependence of naval efficiency on an adequate national effort in research and development, and the existence of appropriate means of ensuring that that effort is adequate and that its results are effectively communicated.

It is here that Prof. Blackett's lecture is so pertinent. He gives us much more than a thoughtful study of the influence of one man of outstanding ability. He indicates the qualities that are desirable in those, both within the Services and outside, who are called upon to decide on the programmes of research and the resources to be allocated to them. His lecture, too, is highly suggestive as to the conditions which favour the throwing up of such men and establishing co-operation and confidence between the Services and scientists and technologists. His comments both on the Defence Research Policy Committee and the Advisory Council on Scientific Policy, as well as on the importance of the Institute for Strategic Studies are also constructive, and it should be noted that Prof. Blackett considers that the Defence Research Policy Committee has proved a more effective instrument than the Advisory Council on Scientific Policy.

Whether, in fact, the Defence Research Policy Committee is still sufficient may well merit re-examination. It has been suggested that the system by which each of the three Services has a chief scientific adviser with a staff of scientists, and the Ministry of Defence a chief scientific adviser to the Government is insufficient, and that there should also be a scientific member of each of the boards or councils of the three Services and of the Chiefs of Staffs Committee. That seems, however, unlikely to be effective unless the other members of those bodies are capable of assessing the significance of scientific advice, and the solution of the problem may well turn on that of men and training as Prof. Blackett's lecture indicates, and the finding of men possessing the qualities which command respect from the Services and scientists alike and capable of understanding the issues involved and inspiring the co-operation required. Mr. F. J. Bellenger, in the debate on the Army Estimates on March 9, when urging the importance of senior officers in all the Services being equipped with scientific knowledge and training, rather implied that this is not yet generally the case.

Given those conditions—appropriate organization, an adequate supply of men of the high qualities, vision and sound judgment, as well as conditions which favour the informal contacts and discussions to which Admiral Hallett referred, with which any formal organization should be supported—it will still be difficult enough to reach wise decisions on strategy and tactics. Apart from the danger that political prejudice or uninformed judgments may take control, there is always the risk in this rapidly changing and complex technological world that matters of tactics may determine strategy, and even the policy behind strategy, and here such books as Alastair Buchan's "NATO in the 1960's: The Implications of Interdependence"* are valuable.

In this field and at this stage the scientific and technical aspects cannot be sharply separated from the political. All that the scientist or technologist as such can hope to do is to see that the former aspects are adequately and effectively presented, and that their implications are grasped. If as *The Economist* has suggested, the key question of our time is where in the civil field the investment of extra resources in research might pay the best dividends, or what is the scale of research and development it might be worth while devoting to particular industries or sectors of the economy, the question of priorities is equally vital in defence. Indeed, it is the factor which should decide what we can afford to spend on defence; and apart from any risk that our research effort generally may be affected by considerations of prestige rather than sound economy, the suggestion that too much effort has been put into nuclear energy, electronics and aircraft, and too little into machine tools and shipbuilding, should not be dismissed without examination.

Mr. Buchan's book is primarily an attempt to grapple with the problems which confront the North Atlantic Treaty Organization in its second decade. He seeks first to define those requirements and then examines the adequacy of existing arrangements and resources to meet those demands. In effect, he considers that the channelling of an increasing proportion of our resources into nuclear weapons has left us incapable of defending local or secondary interests by traditional methods and he maintains that conventional forces are not outmoded. He questions also the wisdom and utility of the policy which has given Britain an independent force with nuclear bombs and bombers. Deterrence, he argues, has replaced defence, and he would transfer to NATO the British independent nuclear force.

That view is not accepted by Prof. Blackett, who, in a comment appended to the book, rejects the idea of creating a European system of intermediate-range

---

* NATO in the 1960's: The Implications of Interdependence. By Alastair Buchan. Pp. xii+131. (London: Weidenfeld and Nicholson, Ltd., 1960.) 12s. 6d. net.

ballistic missile
technically anc
long-range bor
missile system
adequate and
France, and pr
following the
nuclear weapor
however, does
about the pror
tion within N
difficult to ac
interdependenc
and which incl
a small researc
year, to enabl
which, for any
be induced to

Mr. Buchan
enced thinking
his own conclu
showed a grow
importance of
even group of
United States
industrial base
weapons syste
deterrence. T
nized in the c
and also, thou
the dependen
resources of th
duplicating hi
lems here and
admitted, anc
ground betwee
to co-operatior
also in regarc
conventional
recruitment sc
yet. In the deb
the Civil Lor
Ewing, stress
reactor for te
components of
submarine prc
considerable r
research arrar
of the most p
Fitzroy Macle
appraisal of t
deterrent, quo
British contri
be far more use
weapons whi
threat, and o
likewise spok
weapons and
and conventic
is only spend
United States
armoury, he c
developments

s that such a system is
npossible, but that the
er-continental ballistic
ed States are, in fact,
nt state of affairs with
r countries eventually,
n producing their own
s dangerous. That view,
what Mr. Buchan urges
rdination and co-opera-
it might make it more
f the underpinning of
Buchan also requires,
iple, giving NATO itself
r example, £1 million a
ate lines of research in
tional government could
interest independently.
early profoundly influ-
licy, and whether or not
ted, the defence debates
n both of the increasing
hat no other country or
e free world, besides the
enough scientific and
he diversity of complex
maintain a strategy of
dence was widely recog-
Houses of Parliament,
y and more reluctantly,
on the technological
s. The improvidence of
work on defence prob-
d States was, however,
some welcome common
rties, notably in regard
portance of NATO, and
and the importance of
if the implications for
o have been realized as
y Estimates on March 7,
iralty, Mr. C. Ian Orr-
tance of the Dounreay
reactor design and the
machinery in the nuclear
n the same debate some
re expressed about the
r NATO. Perhaps two
eches were those of Sir
l, who urged the re-
stion of an independent
Cowley's opinion that the
peace of the world could
ections than in producing
useful because of their
Head on April 27, who
lue reliance on nuclear
e between such weapons
pointing out that Britain
of the expenditure of the
search developments and
far we could afford such
fears that it could only

be done by making our conventional forces ineffective.

Lord Shackleton, however, took a very contrary view, in referring in a House of Lords debate on May 3 to the decision to abandon the development of *Blue Streak* as a missile. Quoting Prof. W. R. Hawthorne's opinion, expressed at a meeting of the Parliamentary and Scientific Committee, that if we shut out a new technology or let it filter slowly through from some foreign country, we should reduce the resources of skill and experience upon which our designers can draw, Lord Shackleton was urging not so much development of the independent deterrent as of a space-research programme offering prospects of a major scientific and economic development. Lord Hailsham had said in the earlier debate on defence on March 9 that he was convinced that humanity must find a means of abolishing or controlling nuclear and other weapons, or sooner or later disaster would occur; but that the abolition of nuclear weapons must be considered in the context of general disarmament. On May 3 he pointed out that if by 'independent deterrent' we meant one of such power that by the use of it alone we could hope to engage one of the Great Powers on our own with hope of victory, in his judgment Britain has never had and is unlikely to have such deterrent. All we have at present is a significant part of the Western deterrent under our control.

Apart from linking this question of a nuclear deterrent with that of disarmament in general, Lord Hailsham's speech on May 3 is of interest for what he said about the close balance of the arguments both to start the development of *Blue Streak* as a missile and to stop it, the conditions of Anglo-American co-operation and his reply to Lord Shackleton on space research. Lord Hailsham said that we are now spending about 8 per cent of our gross national product on foreign aid or on defence, compared with 11 per cent by the United States. The question of space research, he said, should be approached with great caution, as we must be selective in what novel technologies we can develop, and if *Blue Streak* is to be developed for that purpose it would be a first consideration whether this might not be a co-operative enterprise. The decision to undertake space research, however, must be based on careful appreciation of the scientific and technological factors involved, and while Lord Hailsham agreed that space research may have important secondary effects on the rate of progress in such fields as electronics, metallurgy and telecommunications, Lord Hailsham was clearly averse to making any switch in our fully extended scientific effort without due forethought.

The harmonious working of the present system of defence research and development in Britain depends largely on the tact, efficiency and self-effacement of the staff of the Ministry of Defence. They create, indeed, an atmosphere and tradition for successful inter-Service negotiation and co-operation. What is clearly also required is something of the same atmosphere and tradition between defence and civil research, such as Sir Henry Tizard was so successful in inspiring. The Minister for Science has undoubtedly a large part to play, and the Government's ultimate decisions regarding *Blue Streak* and space research may well indicate also how effective the arrangements for co-ordinating civil and defence research and development are likely to be, now that the new Ministry has been established, and whether it is not imperative to re-examine urgently the functioning and relations of both the Defence Research Policy Committee and the Advisory Council on Scientific Policy. If the debates on the White Paper on Defence, on the Service Estimates and on the *Blue Streak* missile have done nothing else, they have demonstrated the need for informed and impartial discussion, especially in scientific and technical circles; and at the same time they have shown up the absence of much of the information upon which any such discussion must be based if it is to be worth while.

CONTROL OF SCIENTIFIC RESEARCH IN THE UNITED STATES

Science and State Government

A Study of the Scientific Activities of State Government Agencies in Six States. By Dr. Frederic N. Cleaveland. Pp. xvi+161. (Chapel Hill, N.C.: University of North Carolina Press; London: Oxford University Press, 1959. Published for the Institute for Research in Social Science.) 3.50 dollars; 28*s*. net.

To some extent, Dr. Cleaveland's study of the scientific activities of State Government Agencies in the six States of California, Connecticut, New Mexico, New York, North Carolina and Wisconsin is a complement of D. K. Price's "Government and Science", which was concerned essentially with the scientific activities of the Federal Government and the interaction of science and public policy. Dr. Cleaveland scarcely enters into those larger issues. For the British reader his book lacks the outstanding interest of Mr. Price's study; however, some at least of the experience he surveys bears on problems encountered in Great Britain. There is no clear parallel in British experience to the State system, though strong pressure has at times been exerted for the establishment by the Department of Scientific and Industrial Research of local research stations for Scotland or Wales. The six States covered by this report are already expending £1–15 million a year on scientific activities as compared with an estimate for 1960–61 of some £12·7 million for the Department of Scientific and Industrial Research, £5 million for the Agricultural Research Council, £4 million for the Medical Research Council and more than £65 million for universities and colleges, etc.

No local scientific expenditure of such magnitude is to be found in Great Britain, and although these sums are small against the Federal Government expenditure on scientific activities of approaching £1,000 million, they raise, as Dr. Cleaveland shows, important problems of co-ordination and balance. There are, for example, considerable variations in the expenditure in particular fields as between the six States; in agriculture it varied from a fifth to two-thirds of the State expenditure in that field, whereas in health, education and welfare it was usually less than 0·5 per cent, and only as much as 1 per cent in one State. In the development of resources and public works, it was 1 per cent or less in four of the States, but in the semi-arid States of California and New Mexico, with major problems of physical resources and significant mineral resources the figure was 1·7 and 2·8 per cent, respectively. Again, four States invested 3–4 per cent of the total expenditure on the State university in scientific activities, chiefly research, and in Wisconsin and in California this figure ran to 5·8 and 8·5 per cent, respectively, probably because of the extent to which these two States rely upon their universities for the provision of major research activities. In California, indeed, more than 92 per cent of the expenditure on scientific activities was on research, compared with 70–77·5 per cent in the remaining States. Expenditure on basic research in 1954 varied from less than 0·5 million dollars in New Mexico to 10·5 million dollars in California, or 16 per cent and 39·5 per cent of the budget for scientific activity compared with 25–33 per cent in the remaining four States, and some 40–50 per cent on applied research (70 per cent in New Mexico and 60 per cent in California). The study also indicated that State research efforts are heavily weighted in the direction of the biological sciences, physical sciences receiving only 20–30 per cent of research funds in four of the States, only 5 per cent in New York but nearly 50 per cent in New Mexico, compared with 87 per cent from the Federal Government's research and development expenditure.

There was some State expenditure on related scientific activities, such as scientific information, the training of scientific man-power and the planning and administration of research, and Dr Cleaveland found that the allocation of scientific man-power was in accordance with the picture of scientific activity provided by the analysis of expenditure, and his analysis of the role of the State university suggests that in some measure the idea of a regional university has found favour. Problems of administration, inter-government relations and the position of the scientist under the State Governments are also discussed, and in his concluding chapter Dr. Cleaveland presents his conclusions and points to certain weaknesses revealed by his study. As might be expected, one is a lack of balance in scientific activity, and another the limited use made of research as a means of aiding policy. Nevertheless, he suggests that scientific activity at the State-level is already assisting the practice of State Government in various ways, but it would appear that for the more effective utilization of scientific as well as national resources further assistance from Federal institutions such as the National Science Foundation, which has issued its own report on this survey, is needed. Of particular interest also is the picture given of the State universities and the pattern of their dependence on Federal and on State support; but the issues involved are not really discussed though they will largely determine the success or failure of the present effort to expand scientific and technological education in the United States. To the British reader some such examination of the factual data assembled in this survey would have been welcome, especially as here and there Dr. Cleaveland shows that he is fully competent to make such an appraisal.

R. BRIGHTMAN

MET
)RROSION

The Corrosior
)n of Metals
Scientific Prin
otical Applications. By
Dr. Ulick R
xi+1094. (London:
Edward Arnol
Ltd., 1960.) 140s. net.

IT is largely
Dr. Ulick
corrosion and
have achieved
careful to poin
of the subject
tories at the
his group at C
the electroche
firmly establisl
with either the
afford to ignor
fundamental
his school. No
editions of his
and Protection
facts and theo
and always w
scientific liter
familiar with
Metallic Corr
(and sometime
lectures.

Dr. Evans'
contains refere
high proportic
some of these
1959. For
chiefly as an
now incidente
paragraphs an
commentary.
gone to prod
references is i
with only that
been of impo
presents stim
For many, ho
lies in the arr
of the patter
books remain
have been so
is prefaced by
summarizing
of the book.

The first ch
and demonstr
ing of the sub
and public h
pure scientist
(756 pp.), the
the qualitativ
protection. I
on what he d
that is the wa
scale influenc
dissolution.
in which the
more detail,
ments upon w
two appendix
of 91 pages,
try, electroch

work and teaching of
he subject of metallic
in properly be said to
tus. Although, as he is
r book, extensive studies
le at a number of labora-
ntury, it was not until
n its work in 1922 that
wet corrosion became
t time, no one concerned
esults of corrosion could
us amount of first-class
shed by Dr. Evans and
fely ignore the successive
llic Corrosion, Passivity
so lucidly marshalled the
this important subject
ferences to the current
students, too, will be
ion "An Introduction to
has formed the basis
of their college corrosion

mpletely up to date. It
),500 published papers, a
pearing since 1950 and
as the early months of
t will, therefore, serve
k of sources, which are
t the ends of relevant
gether with much useful
ole selection which has
enormous number of
beneficial, for we are left
he author deems to have
ing his views or which
icting data and theories.
f advantage of the book
he material. Very little
, the matter—of earlier
he twenty-two chapters
self-contained, and each
synopsis which, besides
elates it to other parts

e nature of an apologia
tance of an understand-
rs, architects, economists
ies as well as for many
ext seventeen chapters
us his personal views on
corrosion, oxidation and
section is a new chapter
ystallographic' corrosion,
ace features on an atomic
nd distribution of metal
is four chapters (184 pp.)
aspects are discussed in
the laboratory measure-
based. Finally, there are
he incredibly short span
ntrated course in chemis-
lectrokinetics. Although

showing signs of hasty preparation, being marred by several misprints, these appendixes should prove of enormous help in providing the necessary scientific background for the 'non-technical' reader; and at least one electrochemist found them to constitute rather more than a refresher course. Perhaps, however, we could have had a little more about exchange currents and the differences between the hydrogen and oxygen reactions in this respect, in view of their important bearing on over-potential in corrosion and electroplating systems.

As well as re-arranging his material, the author has slightly expanded it (what was 800 pages in the 1948 edition of "Metallic Corrosion, Passivity and Protection" is now 940 pages), in particular as regards the conjoint action of stress and corrosion, hydrogen cracking and the corrosion of buried metals. Four chapters are devoted to oxidation, six to electrochemical corrosion, three to a consideration of practical environments (for example, boilers), three to conjoint effects (stress-corrosion, corrosion fatigue and fretting corrosion), three to corrosion protection (coatings and inhibitors) and there are two chapters on testing methods and the statistical treatment of data.

One could not wish for a more comprehensive or well-written book, and, despite the threefold increase in price since "Metallic Corrosion, Passivity and Protection" in 1948, there can be no doubt that it constitutes a 'must' for anyone hoping to keep abreast of corrosion science and practice.

J. M. WEST

PROGRESS IN NUCLEAR SCIENCE

Annual Review of Nuclear Science
Vol. 9. Edited by Emilio Segrè and Leonard I. Schiff, in association with Gerhart Friedlander and Walter E. Meyerhof. Pp. vii+625. (Palo Alto, Calif.: Annual Reviews, Inc., 1959. Published in co-operation with the National Research Council of the National Academy of Sciences.) 7 dollars.

THE ninth volume of this series maintains the high standard set in previous years. Wilkinson reviews the recent, and on the whole satisfactory, developments in the theoretical interpretation of nuclear photodisintegration experiments. The high-energy field is again prominent. Chew contributes a clear and concise discussion of the recent field theoretical approach to pion-nucleon interactions through dispersion relations and 'polology'. This is a difficult subject but of great importance for the understanding of high-energy interactions. High-energy nuclear reactions are discussed by Miller and Hudis. This embraces spallation, fragmentation and fission at 100 MeV. or more and includes a detailed compilation. Okun' (Moscow) discusses the weak interactions, that is the decay properties of the new strange particles. This is the portion of high-energy physics which is changing most rapidly. Konopinski contributes a most useful review of β-decay theory which is timely now that the violation of parity 'revolution' is complete. It complements Okun's article admirably.

Four reviews of very general interest are nuclear fission by Halpern, nuclear electronics by Kendall, plasma and fusion research by Post and fast reactors by Koch and Paxton. In all these subjects many interesting developments can be reported. An article on the economics of nuclear power by Lane is unfortunately only pertinent to the United States and so is of limited interest.

Two chemical contributions, technetium and astatine chemistry by Anders and solvent extraction by Freiser and Morrison record facts and techniques hitherto scattered through project reports. Three radiobiological articles as usual complete the volume: vertebrate radiobiology (embryology) by Rugh, biochemical effects of radiation by Ord and Stocken, and cellular radiobiology by Atwood. These demonstrate the continuing advance in this broad field.

E. B. PAUL

MASS, LENGTH AND TIME

An Introduction to the Physics of Mass, Length and Time

By Prof. Norman Feather. (Science and Mathematics Texts, No. 1.) Pp. ix+358. (Edinburgh: At the University Press, 1959. Distributed by Thomas Nelson and Sons, Ltd.) 18s. net.

THE early part of this excellent book deals with the history and philosophy of fundamental measurement, together with the practical problems of defining, preserving and reproducing standards. It is a fascinating story, told with scholarship and skill. The rest presents the usual matter of a course of Advanced Level General Certificate of Education standard in mechanics and general physics in an unpretentious and thoughtfully penetrating way.

Prof. Feather has, as he puts it, "disdained to use the calculus". This is not really hauteur, but a means of enforcing a pace of slow and careful reading; the modern student is all too fluent, and can use it slickly without thinking. At the same time, it can be argued that the moment you introduce the concepts of velocity and acceleration, draw a continuous graph, or use moment of inertia or impulse, you are really using the calculus, though not its notation. You do not remove the tune from a piece of music by writing it in tonic sol-fa. The author does unbend a little in the last chapter, in fact. But if he had not himself directed attention to this point specially, it would not have called for comment.

Newtonian mechanics, and what John Cox called "the winning of the principles", are clearly explained, with emphasis on the importance of the third law. A whole chapter is devoted to potential energy, which is really a much deeper matter than the usual elementary books suggest. Gravitation is treated historically, starting with the genesis of Newton's law and ending with the design problems of apparatus of the type devised by Cavendish. For the rest, the discussion of the struggles of Archimedes with the law of the lever, and that of surface tension in terms of interfacial energy and molecular attraction, are among the many stimulating treatments.

The general outlook of the book is more like that of "Norman Campbell" or "Pearson" or "Pohl" than that of the ordinary text-book, though teachers of sixth-form physics would do well to consider its possibilities for class use, and it would certainly be a valuable book for students to read. It puts the inquiring approach of the scientist before the factual knowledge of the examinee. The liveliness and effortless dry humour, fortified by a wealth of historical detail, make it very pleasant to read, and the publishers have produced it most attractively.

G. R. NOAKES

SPOTTING KETOSTEROIDS

Oxosteroids

The Use of Phenolic Hydrazides for Detection, Characterization and Estimation. By Bernard Camber. Pp. viii+79. (London: H. K. Lewis and Co., Ltd., 1960.) 12s. 6d. net.

WHAT we used to call 'ketosteroids' can usually be estimated by some modification of the Zimmerman reaction, and the colours given by different ketosteroids with alkali and *m*-dinitrobenzene have long been used in 'spotting' on paper chromatograms and in the test-tube as a rough guide to the position of the keto group in the steroid molecule in unidentified substances.

Dr. Camber is a medically trained man with an interest in chemistry. His little book is an account of his search to find a hydrazine derivative which would condense with known physiologically important ketosteroids to give hydrazones which could be used to provide a quantitative method replacing the Zimmerman procedure, to identify individual ketosteroids as spots after chromatography on paper and in the histology of steroid-containing tissue. After forty-one pages, he arrives at salicyclic acid hydrazide (salicoyl hydrazine), which readily gives, with ketosteroids, hydrazones that can be used for these purposes. The early part of the book has a short account of some methods used for steroid estimations and also details of Dr. Camber's less-useful derivatives of hydrazine. His finally chosen reagent is valuable, although the quantitative methods have not received exhaustive testing with urines and only preliminary histological work has been done. 'Spotting' on paper chromatograms is, however, well developed, giving useful information about steroids separated. The author is an ingenious experimenter, as is shown, for example, by his technique of spot testing in 'Cellophane'. It is also clear that he has enjoyed doing and expounding his work. He is perfectly frank in not pretending that his reagent is perfect for the purposes suggested: he gives details and obviously would prefer those interested to try it for themselves.

Workers in this field will be willing to buy this book for the 'know-how' which it contains. Full experimental details are given for all methods, qualitative and quantitative, recommended, including the preparation of a sufficiently pure sample of salicyclic acid hydrazide.

G. A. D. HASLEWOOD

STUDIES IN MARINE PHYSICS

The Gulf Stream

A Physical and Dynamical Description. By Henry Stommel. Pp. xiii+202. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1958.) 45s. net.

IN Europe, at least, marine biologists vastly outnumber marine physicists, and one of the things that has prevented physicists from becoming interested in the oceans is the difficulty of finding concise accounts of the problems written in the precise terms to which they are accustomed when dealing with modern science. Dr. Stommel is one of the leaders of a strong theoretical group in the eastern United States, who has spent many years studying the Gulf Stream, and his book gives a clear and

comprehensive
ledge. In the
main oceans, a
current system
problem is tha
widespread ph
why is the cur
strongest curr
the western and
The simple
of the forces d
that a steady
angular mome
balanced by t
the water mo
Earth that h
wind introduc
water northwa
anticlockwise
increases its o
Earth. To bal
suggests that t
thin poleward
region. An alt
the 'frictional
Dr. Stomm
mathematical
shows that t
boundary bet
so that it mi
nature of the
current as a
tentative new
caused by di
between one p
stimulating a
our knowledg
not belittle t
theoretical spe
more attention
the testing of
his book; he
account of the
summary of w
water, veloci
everything po
been put for
of the kind he
the study of t
add to what
value of the b

e present state of know-
o Ocean, as in the other
wind system produces a
e sense, and the main
ystem, which is a broad
ves the ocean currents,
o asymmetrical with its
into a narrow strip on
?
involves consideration
n's rotation, and the fact
be reached until the
the water by the wind is
vorticity which occur as
south into parts of the
angular rotation. The
spin, the movement of
ea of the Earth with less
more anticlockwise spin
omentum relative to the
ffect, the simplest theory
nal forces generated in a
t in the western marginal
y due to Charney replaces
ertial boundary layer.
led descriptions of the
sing these theories, and
really a flow along the
f cold and warm water,
to study the origin and
masses and to treat the
re. This leads him to a
circulation likely to be
mperature and salinity
an and another, and to a
ew of the whole state of
cal processes. He does
e of oceanography, nor
makes a strong plea that
e difficult middle ground,
This sets the pattern of
storical introduction, an
l to study the current, a
out the properties of the
nal changes, and does
e various ideas that have
a great deal of effort
cated is being devoted to
m, and although it must
n it will not reduce the

G. E. R. DEACON

THE TWC

Abstract Bib
Genetics t
Rubus and *R*
and Elizabeth
25 of the C
and Plantati
Royal: Com
45*s.*; 6.80 do

DR. R. L.
currant
and Miss E.
bibliography
such a work
the abstract
languages and

LANT BREEDING

Fruit Breeding and

. By Dr. R. L. Knight
nical Communication No.
Bureau of Horticulture
p. iii+254. (Farnham
icultural Bureaux, 1958.)

charge of raspberry and
East Malling since 1954,
t up a useful abstracted
Rubus. For the specialist
to be complete, but also
y of papers in foreign
urnals, must be sufficiently

detailed to be of value. The authors have only partially succeeded in this last respect. The bibliography is incomplete, and several recent important papers by British authors on the cytology and genetics of British forms of *Rubus* are unfortunately listed by title only. Some of the individual abstracts are good, for example, the salient features of the 76-page paper of Fassett on mass collections are condensed into ten lines. Some other abstracts appear to be condensations of earlier abstracts, and one wonders if these have been verified: for example, work by Downick is wrongly attributed to LaCour. Bibliographical errors are few: Zinno should read Jinno.

One disadvantage of a bibliography is that a newcomer is not readily able to assess the relative merits of the individual papers, and here the compilers have not helped. Although some papers, such as Spinks's on black currant breeding at Long Ashton, are fully abstracted, the length of an abstract provides little indication of a paper's scientific merits. This book would, therefore, have benefited from sieving. Some of the now worthless earlier papers could have been omitted, and the space used to provide the authors' comments on the more important ones.

A most unfortunate decision has been to mix the references of *Ribes* with *Rubus*. Two separate bibliographies with their own indices would have been an advantage, especially when surveying previous work on each genus, and in using the subject index.

Two appendixes are provided. That of a gene list for *Rubus* concerns only raspberry, but several genes are known in blackberry; it is perhaps unfortunate that the symbol *A* is given to *Amphorophora* resistance, as this had already been assigned to autumn flowering (not listed). Appendix II gives two linkage groups, of especial interest for until now it had seemed that all the tested genes in *Rubus* lie on one chromosome, and the remaining six chromosomes were possibly inert. No gene list is given for *Ribes*, although data are available in the omitted "Genetics of Garden Plants" (Crane and Lawrence). No list of chromosome numbers is provided, which would have been useful as there is no reference to Darlington and Wylie's "Chromosome Atlas".

A graph, calculated from the bibliography, clearly shows that breeders have been, and will be, more interested in raspberries, blackberries and kindred fruits, than in gooseberries and currants. Indeed, research with *Rubus* now considerably outstrips that for *Ribes*. This is partly because *Rubus* affords more genetically versatile experimental material, and partly from lack of interest in *Ribes* in North America, where *Ribes* cultivation is banned. Yet the considerable demand for black currant juice abroad provides the basis for the present policy at Mylnefield to breed high-yielding, uniform, early ripening varieties, to increase the acreage in the soft-fruit areas of the East of Scotland.

This expensive bibliography was already three years out of date when it went to press. Hence important new works like Watson's monograph on British forms of *Rubus* are not included. The publishers and authors might consider, therefore, issuing to purchasers a free mimeographed supplement bringing the list up to date. Generally this compilation will save time, but it is hoped that those who use it will not by-pass the originals, unless we may conclude that nowadays only summaries really need be published.

G. HASKELL

I.G.Y.

Year of Discovery—The Story of the International Geophysical Year. By Sydney Chapman. Pp. 112. (Ann Arbor: University of Michigan Press; London: The Mayflower Publishing Co., Ltd., 1959.) 40s.; 4.95 dollars.

THE International Geophysical Year, July 1, 1957–December 31, 1958, was the most successful example of co-operation between the nations there has ever been, and as well as being a landmark in the development of geophysics it may well be of significance in the present endeavours to increase international understanding. In his account of this enterprise, of the executive committee of which he was president, Prof. Sydney Chapman records how at first there was little enthusiasm for a successor to the two international polar years and then how the interest grew until International Geophysical Year committees from sixty-seven countries joined in and a wide variety of geophysical projects were undertaken, to be climaxed by the launching of the first Earth satellite on October 4, 1957.

But the book is not an account of the organization of the International Geophysical Year, important though this was. It is an excellent account of the scientific background of and the reasons for the projects undertaken.

Those familiar with Prof. Chapman's writings will not be surprised to know that this book is a model of scientific writing; the sentences are short and not encumbered by unnecessary words; a large number of useful facts about the Earth are to be found in the text; plates and diagrams illustrating the whole field of activity are included. It can therefore be recommended to students and to laymen who wish to acquaint themselves with what is known about the Earth, and there will be few, even among experts in geophysics, who will not learn something by reading it. S. K. RUNCORN

Progress in Semiconductors, Vol. 4

Edited by Dr. Alan F. Gibson, Prof. R. E. Burgess and Dr. F. A. Kröger. Pp. vii+291. (London: Heywood and Co., Ltd., 1960.) 63s. net.

THE series of review articles which make up the volumes of "Progress in Semiconductors" help very much to cut down the time which physicists, chemists, metallurgists and electronic engineers in this still rapidly expanding field have to spend reading the journals less familiar to them. Unfortunately the series can survey the whole field no more frequently than perhaps once every ten years.

The eight papers which make up the fourth volume are generally well written but expect quite a lot from the reader. The easiest to read are those on the oxidation of germanium surfaces (the Mott–Cabrera mechanism is ruled out for a clean surface), on internal field emission, which has been studied in *pn* junctions and in phosphors, and on the electrical effects of dislocations. In contrast a paper on negative mass demands some familiarity with quantum mechanics and another on avalanche multiplication demands confidence in expressions for the motion and scattering of electrons in high fields. A paper on noise in semiconductors shows that the components with spectral intensity $\propto$ (frequency)$^{-1}$ still need further study. The effect of dislocations on dielectric properties is studied in another paper in terms of ion movements, electron trapping and microwave observations. The last paper, of which A. F. Ioffe is co-author, directs attention to a large range of non-crystalline semiconductors including liquids, in which the carrier motion is very different from that in germanium and silicon. J. R. TILLMAN

Comprehensive Inorganic Chemistry

Edited by Prof. M. Cannon Sneed and Prof. Robert C. Brasted. Vol. 7: The Elements and Compounds of Group IVA. By Harold P. Klug and Prof. Robert C. Brasted. Pp. ix+302. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) *56s. 6d.*

THIS book is one of a series in which an attempt has been made to combine an encyclopædic treatment of the chemistry of the elements with the inculcation of the basic principles of chemistry. When one considers the extent and complexity of inorganic chemistry to-day, it is clear that a good deal of information must necessarily be omitted if a whole group is to be covered in a volume of this size. For example, the historical background of each element is cut to a minimum (but Cornish tin (page 212) certainly reached Rome before the Roman conquest of Britain), and it is, perhaps, a little surprising that the uses of carbon-14 are scarcely mentioned and, in view of their uses in atomic energy, some reference might well have been made to cadmium and cerium glasses. However, the descriptive chemistry of the elements covered in this volume is presented lucidly and the result is a not unpleasing text-book which should be useful to the university student and to the research chemist, for whom the numerous tables of physical data will be of considerable value. The book is well produced, and the index, so far as tested, is adequate. K. W. BAGNALL

Histochemistry

Theoretical and Applied. By A. G. Everson Pearse. Second edition. Pp. x+998+10 plates. (London: J. and A. Churchill, Ltd., 1960.) 110s. net.

THIS is a vast guide-book to the fields of histochemistry. Twenty-nine chapters and twenty-seven appendixes provide a comprehensive and up-to-date account of the subject. In the spirit of "Baedecker" the author has practised all the available methods and rejected those found wanting. This enormously enhances the value of the book, but had the further step of a star system been taken to classify the many methods, the novice would be better served. There have been so many improvements and extensions since the first edition of seven years ago that this is virtually a new and better book.

The chemical and physical backgrounds to the techniques have been given so far as is practicable in a book of finite size. Readers with special knowledge of the various aspects of the subject will no doubt find omissions, misunderstandings and misplaced emphasis, but I have found no serious cases in my own special fields. With this volume as a guide, cytochemists can travel hopefully but might be more sure that they would arrive safely if an extended and quantitative account of the hazards and errors of interpretation due to diffusion during fixation and reaction had been provided. The illustrations, especially the colour plates, make this an attractive book to use, but have undoubtedly added to its high cost. Inexcusably the book is shoddily cased, and with a covering unlikely to withstand the hard use this book will undoubtedly have in all histochemical laboratories. L. G. E. BELL

THE MARANGONI EFFECTS

By L. E. SCRIVEN* and C. V. STERNLING

neering Department, Shell Development Co., Emeryville, California

Cause o nce to, Surface ts

WITH the r Italian physicist Carlo
Marangon l Florence (1840–1925)
have been asso- tinct although related
surface effects. hese is movement in a
fluid interface. caused by local varia-
tions of interfac t are caused in turn by
differences in or temperature. The
second is the cor rst : it is the departure
from equilibrium is produced by exten-
sion or contract rface, that is, by dila-
tional deforma effects were correctly
explained in a ay nearly a hundred
years ago. A ormation about them
was reported b nd his contemporaries,
among whom v the foremost scientists
of the ninetee -Plateau, Gibbs, and
Rayleigh.

Certain aspec preading and dynamic
surface tension d to receive attention
in the physical c id interfaces, especially
as that subject foams and emulsions.
However, little been directed toward
quantitative un f these effects as they
affect the dyn r of fluid interfaces.
To-day there interest in this goal,
because of the g r of diverse, practically
important situa their influence is being
recognized. Fo s now known that local
variations of su may set into intricate
motion an entir uch as a drying coat of
paint. Again, i sciated that the differ-
ence between d uilibrium behaviour of
interfaces is re the paradoxical motion
under buoyancy les and drops in various
liquids.

ements

"On Certain ons Observable at the
Surfaces of W r Alcoholic Liquors",
published in 18 ish engineer and physi-
cist James Th ains the first correct
explanation of of a drop of alcohol on
the surface of l-known tears of strong
wine, and rel na. Thomson rightly
inferred that th f surface-tension-driven
flows were resp "numerous motions of
extremely won rs in fluids undergoing
evaporation" t d observed earlier with
the aid of a mic ilar microscopic studies
of convection vaporating drops were
made independ r[3].

Numerous f periments with surface
movements were erwards[4-7]; but Thomson's paper went unnoticed until van der Mensbrugghe's definitive memoir appeared in 1869 in a now obscure Belgian journal[8]. Van der Mensbrugghe reviewed all the earlier work, including the literature on the camphor dance dating back to 1686, and established that all the varied instances of surface movement were caused by local differences of interfacial tension. When Marangoni contested the priority of van der Mensbrugghe's finding[9], Thomson's paper again went unmentioned, and it is probably for this reason that the effect has come to bear Marangoni's name (cf. ref. 10).

The classic qualitative studies have been continued by more recent investigators: Marcelin devised surface engines[11], Loewenthal was fascinated by tears of strong wine[12], the Langmuirs discovered that surface movements enhance the rate of evaporation[13], and Jebsen-Marwedel found that surface-tension-driven flows critically affect mixing and wall erosion in glass-melting furnaces[14,15]. Photographs of tears of strong wine have recently appeared[16]. There have been discussions of the role of such flows in crystal growth[17,18], motion of protoplasm[19-21], transport of bacteria[21], surface fractionation[22], absorption and distillation[23], foam stability[24,25] and other phenomena[26,27]. Mention should be made of the thermodynamic theories of spreading of surface films[28].

The cellular convection patterns induced by surface tension that Varley[2] and others[3,19] saw were later the subject of Bénard's beautiful experiments[29,30]. Bénard's work inspired the Rayleigh–Jeffreys theory of convection currents induced by density variations in liquids heated from below. However, this theory is at variance with Bénard's experiments in several respects. From the new experiments of Block[31] and theoretical analysis of Pearson[32] it is now known that surface tension rather than density variations produced Bénard's cells. Meanwhile the Rayleigh–Jeffreys theory has been confirmed by other experiments to which it properly applies[33]. It is interesting that Sutherland was led to postulate density-induced convection currents in order to explain the surprisingly rapid attainment of equilibrium tension at certain newly formed gas-liquid interfaces[34]. Surface-tension-driven flows seem no less likely an explanation.

The periodic twitching of an air bubble in water, toward which a fine jet of alcohol is directed, seems to have been first described by Quincke[19], who showed that surface-tension-driven flow is responsible. Recently rediscovered in slightly different guise by Lewis and Pratt[35], the phenomenon has attracted great interest in the field of liquid-liquid extraction. A semi-quantitative theoretical analysis was made by Haydon and Davies[36,37]. Similar phenomena occur at all sorts of fluid interfaces across which material diffuses[38,39]. Notable is the extensive investigation by Wei[40]. This spontaneous agitation of the interface between two unequilibrated fluids, which has come to be known as 'interfacial turbulence', has not yet been taken into account in the classic theories of interphase mass transfer. In order to arrive at an adequate theory, it will be necessary to know precisely the conditions which give rise to interfacial turbulence as well as the details of the flows. We have considered the preliminary problem from the point of view of the theory of hydrodynamic stability, arriving at a partial understanding of the factors that determine 'Marangoni instability'—the onset of interfacial agitation driven by local variations of interfacial tension[41].

---

* Present addres ? Minnesota, Minneapolis 14,
Minnesota.

Our analysis shows how it is that some systems are stable with solute transfer in one direction across the interface yet unstable with transfer in the opposite direction (cf. ref. 42). It indicates the importance of solute diffusivity in the two phases, the viscosities of the fluids, the dependence of interfacial tension on composition, and other parameters. In at least some circumstances the phenomenon known as spontaneous emulsification seems to originate in interfacial-tension-driven flows[43].

Surface Elasticity and Viscosity

The resistance of a fluid interface to deformation was first noted by the blind Belgian physicist Joseph Plateau, famous for his researches on capillary action, especially the equilibrium configurations of liquid masses under the influence of surface tension (see his great treatise[44]). The different rates of damping of an oscillating compass needle suspended on one hand in the surface and on the other in the bulk of various liquids led Plateau to infer the existence of a 'superficial viscosity' peculiar to a liquid surface but analogous to the ordinary viscosity of fluids in bulk[44,45]. In so far as his needle subjected the surface to shear, Plateau's inference was substantially correct: since his time, measurements of shear viscosity and elasticity of surface films have become commonplace[25,46–51]. However, if surfaces of pure liquids have a peculiar resistance to shear, present experimental techniques are not sufficiently sensitive to detect it.

What Plateau did not appreciate is that virtually every liquid surface is contaminated with insoluble material to some degree, and that there exists an equilibrium between material dissolved in the bulk and adsorbed on the surface of solutions. Thus the advancing needle tended to concentrate contamination and adsorbed material ahead and to dilute them behind it. This produced a difference in surface tension on either side of the needle, the difference being of the proper sense to damp the motion.

Marangoni[52] first clearly recognized this effect in the experiments of Plateau, who remained unconvinced[53–55]. It remained for Gibbs to give it a completely satisfactory explanation[56]; hence the name, 'Plateau–Marangoni–Gibbs effect'[57]. There is a lucid and definitive paper on the subject by Lord Rayleigh[58], who made other valuable contributions to the understanding of surface movements and the resistance thereto[59–61]. The part played by the 'Plateau–Marangoni–Gibbs effect' in stabilizing free films and foams has long been recognized in a general way, often under the name 'Gibbs elasticity' (for example, ref. 25). But the "profound analysis of the act of thinning of a film" called for by Derjaguin and Titijevskaya[62] has not yet appeared. The mathematics of such an analysis is formidable, owing to the complicated velocity and concentration fields involved.

As Birkhoff observed in connexion with the 'rising-bubble paradox', the mechanics of real fluid interfaces is far less simple than the classical hydrodynamic treatments would suggest[63]. The paradox is that the motion under buoyancy of small bubbles and drops through a liquid is usually much closer to the behaviour of rigid spheres than to that expected for fluid spheres capable of internal circulation. But in systems cleansed of interfacially active material, the paradoxial behaviour does not occur, except with the smallest of bubbles and drops[63,64]. The seeming exception may be due to the extreme difficulty of eliminating the last traces of interfacial contamination[6,46,56,58,65]. If circulation of the bubble or drop is retarded or arrested, there must exist a force not contained in classical hydrodynamics which opposes the viscous traction exerted on its surface by the surrounding liquid; and because the viscous traction tends to expand the surface phase over the leading hemisphere and contract it behind, the 'Plateau–Marangoni–Gibbs effect' is sufficient to account for the existence of this force. The first to recognize this was Boussinesq[67], who showed that any viscous-like resistance to dilational deformation of the surface, whatever its origin, causes fluid spheres to move more slowly than expected from classical treatments, in which the possibility had been overlooked. Modern mathematical analyses have shown how the kinetics of adsorption of soluble surface-active materials can account for a 'dilational surface viscosity'[68,69]. The Marangoni effect mentioned above may also enter; for with mass transfer between the dispersed and continuous fluids, as occurs in liquid-liquid extraction and related operations, there may be a sufficiently high concentration—hence also interfacial tension—gradient in the proper direction along the interface to arrest or even reverse the internal circulation. The entire situation of drop circulation and the effects of surface-active materials was recently discussed by Linton and Sutherland[70].

The role of shear viscosity and elasticity of surface phases and of the 'Plateau–Marangoni–Gibbs effect' in other free boundary flows has been considered by at least a few hydrodynamicists after Aitken's discussion of the calming action of oil on capillary waves on the surface of water[71]. Specific reference should be made to the writings of Lamb[72], Levich (as cited by Fedosov[69]), and especially Oldroyd[73], whose theoretical work on the effect of surface properties in the rheological behaviour of emulsions is partly confirmed by the recent experiments of Nawab and Mason on the viscosity of dilute emulsions containing surfactants[74].

The resistance of fluid interfaces to deformation is manifest, though not yet completely understood, in the stagnation of portions of interfaces in certain liquid-liquid extraction[25,41,75], gas absorption[76], and vacuum distillation experiments[45,67].

Quantitative understanding of the dynamic behaviour of fluid interfaces requires that their mechanics be described mathematically. The earliest attempts at this seem to have been made by Tait, who considered the effect of flexural-rigidity of a surface on ripples in a viscous fluid[77], and by Basset, who examined certain consequences of interfacial behaviour that allows slip between two phases in contact[78]. The most useful description for approximating the behaviour of real interfaces is that begun

by Boussinesq,
analogue of the
In this model t
pletely charact
tension and tw
in flow : the sur
surface viscosity

It was this n
his explanation
recently was it u
flow, by Oldroy
materials inhib
from smooth to
this transition
question, Barr-
how to account
adopted Boussi
conditions at th
to account for a
active materials
thing was do
instability[41].

In the origina
alternative stat
the model inter
extent both co
is reasonable f
or when the in
it is violated in
we have genera-
describe the dy
undergoing con
The analysis le
tions on non-ste
tabulated are b
simple cases o
surfaces. The w
of further exten
all types of lin
which have, in
tory[17,25,38,50].

the two-dimensional
nal Newtonian fluid[67].
f the interface is com-
static (equilibrium)
overning its behaviour
sity and the dilational

ssinesq appealed to in
bubble paradox. Only
another free boundary
above. Surface-active
h of falling liquid films
In a new analysis of
hydrodynamic stability
of us have suggested
nce of surfactants : we
formulating boundary
of the film[40]. In order
ory influence of surface-
l turbulence, the same
nalysis of Marangoni

Boussinesq and in their
droyd's equation (4)[73],
ned to shape and total
While this restriction
aries in steady flows,
on is sufficiently high,
uations. Consequently
sq's equations so as to
wtonian fluid interface
in shape and extent[81].
rfacial boundary condi-
free boundaries. Also
tions for the relatively
ndrical, and spherical
suggests the possibility
be interfaces displaying
ic behaviour, many of
bserved in the labora-

---

[1] Thomson, J. (older
330 (1855); su
Action", "Ency.
New York, 187

elvin), *Phil. Mag.*, Ser. 4, 10,
Maxwell's article on "Capillary
s", ninth ed. (Samuel L. Hall,

[2] See Quekett, J.,
scope", third ed

e on the Use of the Micro-
, London, 1855).

[3] Weber, H. H., *A*
rff), 94, 447 (1855).

[4] du Bois-Reymond
Poggendorff), 104, 193 (1858).

[5] Ludtge, F. H. R.,
endorff), 137, 362 (1869).

[6] Quincke, G., *Ann*
ff), 139, 1 (1870).

[7] Tomlinson, C., *P*
(1869).
7, 528 (1864); *ibid.*, 38, 409

[8] Van der Mensbrug
34 (1869); *ibid*
Phil. Mag., Ser
couronnés L'Acad. Roy. Belg.,
summarized by C. Tomlinson,
ibid., 46, 376 (1873).

[9] Marangoni, C. G.
oggendorff), 143, 337 (1871).

[10] Bikerman, J. J.,
York, 1947).
y", 81 (Academic Press, New

[11] Marcelin, A., *Ann*
4, 459 (1925).

[12] Loewenthal, M., *F*
12, 462 (1931).

[13] Langmuir, L., and
J. Phys. Chem., 31, 1719 (1927).

[14] Jobson-Marwedel,
ds, 29, 233 (1956).

[15] Jobson-Marwedel,
Tech., 21, 436 (1937).

[16] Tress, H. J., *J. Sc*
89T (1954).

[17] See Bikerman, J.
Press, New Yo
stry", second ed., 84 (Academic

[18] Sears, G. W., *J. C*
49 (1957).

[19] Quincke, G., *Ann*
n), 35, 580 (1888).

[20] Buchsbaum, R., "
of Chicago Pre
Backbones", first ed., 20 (Univ.

[21] Mudd, S., and Mu
xp. Med., 40, 633, 647 (1924).

[22] Blank, M., and L
also Proc. Secon
Press, New Yo
s. Chem., 61, 1611 (1957); see
rface Activity, 1, 102 (Academic

[23] Zuiderweg, F. J.,
Chem. Eng. Sci., 9, 89 (1958).

[24] Ewers, W. E., a
697 (1952).
L., *Austral. J. Sci. Res.*, A, 5,

[25] Kitchener, J. A., and Cooper, C. F., *Quart. Rev.* (London), 13, 71 (1959).

[26] Hershey, A. V., *Phys. Rev.*, 56, 204 (1939).

[27] Skogen, N., *Amer. J. Phys.*, 26, 25 (1958).

[28] Harkins, W. D., "Physical Chemistry of Surface Films", 41, 95 (Reinhold, New York, 1952).

[29] Bénard, H., *Rev. générales Sci. pures et appliquées*, 11, 1261, 1309 (1900).

[30] Bénard, H., *Ann. Chim. Phys.*, Ser. 7, 23, 62 (1901).

[31] Block, M. J., *Nature*, 178, 650 (1956).

[32] Pearson, J. R. A., *J. Fluid Mech.*, 4, 489 (1958).

[33] Schmidt, R. J., and Milverton, S. W., *Proc. Roy. Soc.*, A, 152, 586 (1935).

[34] Sutherland, K. L., *Austral. J. Sci. Res.*, A, 5, 683 (1952).

[35] Lewis, J. B., and Pratt, H. R. C., *Nature*, 171, 1155 (1953).

[36] Haydon, D. A., *Proc. Roy. Soc.*, A, 243, 483 (1958).

[37] Davies, T. V., and Hayden, D. A., *Proc. Roy. Soc.*, A, 243, 492 (1958).

[38] Ward, A. F. H., and Brooks, L. H., *Trans. Faraday Soc.*, 48, 1124 (1952).

[39] Sigwart, K., and Nassenstein, H., *Ver. deut. Ing. Z.*, 98, 453 (1956).

[40] Wei, J. C., Sc.D. thesis in chem. eng., Mass. Inst. Tech. (1955). See also Sherwood, T. K., and Wei, J. C., *Ind. Eng. Chem.*, 49, 1030 (1957).

[41] Sternling, C. V., and Scriven, L. E., *Amer. Inst. Chem. Eng. J.*, 5, 514 (1959).

[42] Grassman, P., and Anderes, G., *Chem.-Ing.-Tech.*, 31, 154 (1959).

[43] Davies, J. T., and Haydon, D. A., Proc. Second Intern. Congr. Surface Activity, 1, 417 (Academic Press, New York, 1957).

[44] Plateau, J. A. F., "Statique expérimentale et théorique des liquides soumis aux seules forces moléculaires" (Gauthier-Villars, Paris, 1873).

[45] Plateau, J. A. F., *Mém. L'Acad. Roy. Belg.*, 37 (1869); summarized in *Phil. Mag.*, Ser. 4, 38, 445 (1869).

[46] Overbeck, A., *Ann. Phys.* (Wiedemann), 11, 634 (1880).

[47] Langmuir, I., and Schaefer, V. J., *J. Amer. Chem. Soc.*, 59, 2400 (1937).

[48] Harkins, W. D., and Kirkwood, J. G., *J. Chem. Phys.*, 6, 53 (1938).

[49] Ewers, W. E., and Sack, R. A., *Austral. J. Chem.*, 7, 40 (1954).

[50] Joly, M., *J. Coll. Sci.*, 11, 519 (1956).

[51] Boyd, G. E., and Vaslaw, F., *J. Coll. Sci.*, 13, 275 (1958).

[52] Marangoni, C. G. M., *Il Nuovo cimento*, Ser. 2, 5/6, 239 (1872).

[53] Plateau, J. A. F., *Bull. L'Acad. Belg.*, Ser. 2, 34, 404 (1872).

[54] Marangoni, C. G. M., *Il Nuovo cimento*, Ser. 3, 3, 50, 97, 193 (1878); summarized by *Beiblätter Ann. Phys.* (Poggendorff), 3, 842 (1879).

[55] Plateau, J. A. F., *Bull. L'Acad. Belg.*, Ser. 2, 48, 106 (1879).

[56] Gibbs, J. W., *Trans. Connecticut Acad.*, 3, 343 (1878); "Collected Works", 1, 269, 300 (Longmans, Green, New York, 1931).

[57] Derjaguin, B. V., and Titijevskaya, A. S., Proc. Second Intern. Congr. Surface Activity, 1, 211 (Academic Press, New York, 1957).

[58] Rayleigh (Strutt, J. W. S.), *Proc. Roy. Soc.*, 48, 127 (1890).

[59] Rayleigh (Strutt, J. W. S.), *Proc. Roy. Soc.*, 47, 281, 364 (1890).

[60] Rayleigh (Strutt, J. W. S.), *Phil. Mag.*, Ser. 5, 30, 386 (1890).

[61] Rayleigh (Strutt, J. W. S.), in the article on "Capillary Action", Encyclopaedia Britannica, eleventh ed. (Cambridge Univ. Press, 1910).

[62] Birkhoff, G., "Hydrodynamics", 34 (Dover Publications, New York, 1955).

[63] Haberman, W. L., and Morton, R. K., David Taylor Model Basin Report No. 802 (U.S. Navy, Washington, D.C., 1953).

[64] Schwindt, W., and Stuke, W., Proc. Second Intern. Congr. Surface Activity, 1, 482 (Academic Press, New York, 1957).

[65] Hickman, K. C. D., *Ind. Eng. Chem.*, 44, 1892 (1952).

[66] Hickman, K. C. D., and Torpey, W. A., *Ind. Eng. Chem.*, 46, 1446 (1954).

[67] Boussinesq, J., *Ann. Chim. Phys.*, Ser. 8, 29, 349 (1913).

[68] Frumkin, A. N., and Levich, V. G., *Zh. fiz. Khim.* (U.S.S.R.), 21, 1183 (1947).

[69] Fedosov, A. I., *Zh. fiz. Khim.* (U.S.S.R.), 30, 223 (1956).

[70] Linton, M., and Sutherland, K. L., Proc. Second Intern. Congr. Surface Activity, 1, 494 (Academic Press, New York, 1957).

[71] Aitken, J., *Proc. Roy. Soc. Edin.*, 12, 56 (1882/83).

[72] Lamb, H., "Hydrodynamics", sixth ed., 601, 631 (Dover Publications, New York, 1945).

[73] Oldroyd, J. G., *Proc. Roy. Soc.*, A, 232, 567 (1955).

[74] Nawab, M. A., and Mason, S. G., *Trans. Faraday Soc.*, 54, 1712 (1958).

[75] Boye-Christensen, G., and Terjesen, S. G., *Chem. Eng. Sci.*, 9, 225 (1959).

[76] Scriven, L. E., and Pigford, R. L., *Amer. Inst. Chem. Eng. J.*, 4, 439 (1958).

[77] Tait, P. G., *Proc. Roy. Soc. Edin.*, 17, 110 (1890).

[78] Basset, A. B., "Treatise on Hydrodynamics", 2, 248, 270 (Bell, London, 1888). See also Arnold, H. D., *Phil. Mag.*, Ser. 6, 22, 755 (1911).

[79] Brauer, H., V. D. I.-Forschungsheft 457, supp. to *Forschung Gebiete Ingenieurwesens*, B, 22 (1956).

[80] Sternling, C. V., and Barr-David, F. H., paper submitted to *Amer. Inst. Chem. Eng. J.*

[81] Scriven, L. E., *Chem. Eng. Sci.* (In the press).

PART-TIME COURSES IN FURTHER EDUCATION

By J. HEYWOOD
Norwood Technical College, London, S.E.27

THE correctness of the comment in *Nature* of February 6 on the Crowther Report is shown by the attitude of both the Government and the Opposition in their discussions. Too little attention has been paid by the Committee to the problems of day release teaching and student difficulties in technical colleges, nor has this been related to the secondary modern school leaver. *Nature* rightly suggests that little consideration has been given to the lower streams of the secondary modern school.

A recent survey (which it is hoped will be published in detail later this year) supports the view that there are a number of students who will not benefit by any form of further education. Table 1 gives the percentage pass mark of a first-year intake studying eventually for the Radio Trades Board's examinations. The examination was on calculations taught in a 24-hr. course of basic arithmetic and algebra. When studied with the corresponding results of first-year intakes over the preceding three years a safe assumption is that those students scoring below 40 per cent in similar tests do not benefit from this type of education. Schedule *B* of Table 1 gives the practical marks for the same period. These are also typical of all the intakes, and there is not necessarily an increasing practical ability with the decline in marks gained in the theoretical examinations. Inquiries made at other technical colleges confirm this view. However, these inquiries also suggest a further subdivision in the classification of apprentices. This is referred to in items 3*a* and 3*b* of Table 2. The results of this particular survey indicate that it is impossible to classify the rejects from 3*a* as students who would have benefited by following a course of studies more appropriate to 3*b*. There are a large number of persons in semi-technical occupations who do not benefit by further education. The fact that many students are quite obviously unsuited for the careers they have chosen is both the fault of the employer and the careers specialist in the school and may influence the mobility of labour more than would be anticipated.

However, studies of the teaching methods applied to groups 3*a* and 3*b* arising from an examination of the problems of wastage in group 3*a* suggests that entirely different approaches are required for the two groups and that those in group 3*a* would benefit from a year's full-time study of their subject. Group 3*b*, into which fall trades such as carpentry, plumbing, automobile engineering, apparently gain more from an apprenticeship with day release over a period of five years than do those in group 3*a* (for example, those students who pursue radio and television servicing courses), where the wastage over the first three years is large. Table 3 shows the decline in student attendance over the three years which is necessary for the Radio Servicing Certificate. The main causes of wastage are as follows: (1) insufficient ability to cope with studies; (2) refusal of the employer to allow more than one or two years part-time education; (3) change of occupation: (*a*) within the trade but to an employer who does not allow day release, (*b*) to employment in another trade; (4) completion of articles during the period of study; (5) decline of interest on the part of the student.

The wastage due to apparent low intelligence quotient was considerably reduced by changing the teaching methods from one year to the next. Following up in the third year with the improved methods of teaching did not, however, maintain the pass percentage, thereby supporting the view that there is a minimum level of intelligence quotient required for satisfactory attendance on this type of course. Further support for this view is gained from Table 1, where only one of the three students referred from the previous year to repeat the course passed the calculations examination.

Table 1. MARKS OBTAINED BY FIRST-YEAR STUDENTS IN INTERNAL CALCULATIONS AND PRACTICAL EXAMINATIONS

Student	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
Schedule *A*	84	77	73	70*	68	55	55	48	48	48	45	39*	37	27	*a*
Schedule *B*	60	70	70	60	50	50	40	40	50	60	50	50	40	20	
Schedule *C*	45	50	50	60	45	45	50	75	40	40	35	50	30	25	

* Students repeating the same year of studies; *a*, student absent but unlikely to pass examination on basis of previous marks.
Percentage pass = 42·8 per cent. Percentage pass on a simple average = 57 per cent.
Schedule *A*, calculations examination; schedule *B*, practical examination; schedule *C*, previous terms practical marks.

Table 2. CLASSIFICATION OF APPRENTICES COMPARED WITH THE LEVELS OF QUALIFICATION SUGGESTED IN THE CROWTHER REPORT

Schedule *A* Classification of apprenticeship	Schedule *B* Type of further education	Schedule *C* Levels of qualification for industry
(1) Graduate	Within industry	Technologist
(2) Student	Sandwich or part-time day	Technologist
		Technician
(3) Trade:		
(*a*) Technician, for example, radio and electronic servicing	Part-time day or evening over 4 or 5 years	Craftsman
(*b*) Craftsman or artisan, for example, building plumbing		Craftsman
(4) Operative	Short period of industrial training	Operative

Table 3. ILLUSTRATION OF THE DECLINE IN ATTENDANCE OF PART-TIME DAY RELEASE STUDENTS OVER THE THREE YEAR PERIOD OF THE RADIO SERVICING COURSE

Course	First-year enrolment (per cent)	Per cent passing end of first-year test	Second-year enrolment (per cent)	Per cent passing intermediate certificate	Third-year enrolment (per cent)
A	100	36	36	36	18·1
B	100	42·[illegible]	31·5	21 05	21·05
C	100	20·4	20·0	continuing	

N.B. The percentages refer to the original first-year enrolment and thus to the same groups of students. They do not refer in later years to students entering the course with exemptions from previous parts of the course. Average number in each intake = 14.

Table 4 ILLUSTR
THERE WILL BE GENA

T THAT IT IS UNLIKELY THAT
ATTAINMENT OVER A LENGTHY
OURSE

Table 4 gives the e
at the same time of

obtained by the same students
hree-year radio servicing course

Student
First year
Second year
External exam.
Third year

C	D	E
55	46	55
37	50	45
P	P	P
48	40	48

The external exar
All internal examina

at the end of the second year.
by the same teacher.

Students are
in the trade.
on articles or n-
middle of their
end of the thi
certificate in r
(or will not)
important feat
has been studi
increase with t
ticeship, nor d
an important
theory papers i
of marks gaine
years is given
support for th
increase the wa
aptitude. The
employers to ac
a shorter perio-
attend a full-tir
they commence
for about two
continue with

of their precise position
know whether they are
mence the course in the
and many towards the
stion the value of the
remuneration they will
g the certificate. An
servicing course which
ctical ability does not
years spent on appren-
ly help theory, which is
there are two written
tion. A typical sample
ne students over three
ere is thus considerable
long part-time courses
students of this type of
would be to encourage
for apprenticeship over
order to allow them to
urther education before
ceship, which would be
which time they would
ation.

Table 5. ANALYSIS OF PART-TIME EVENING INTAKE SEPTEMBER 1959
Total intake, 63. 61 inquiries made. Wastage assessed for April 1, 1960

Student category	Percentage of total intake	Average age
(1) Students under 21, in trade	21 3	17 4
(2) Students under 21, in industry	21 3	17·8
(3) Students under 21, not in trade or industry	1·6	17 0
(4) Students over 21, in trade	19 6	—
(5) Students over 21, in industry	16 2	—
(6) Students over 21, not in trade or industry	20 0	—
(7) Total per cent of students with less than 50 per cent attendance	31 0	—
(8) Students under 21 with less than 50 per cent attendance	18 01	—

Finally, support for this idea is obtained from an analysis of wastage on evening courses. Table 5 gives the data for a first-year course enrolled in September 1959. The wastage at the time of writing is one-third of the total intake, but of the twenty-six students under twenty-one who are eligible for part-time day release free only seven have stopped attending, but studies of past wastage suggest that this figure will have doubled by the end of the second year. It seems clear that some form of test should be adopted with the view of establishing the worthwhileness of sending a boy on a part-time course in addition to Mr. Thompson's (*The Times*, April 3, Parliamentary Secretary to the Minister of Education) consideration that day-release should possibly become a legal right.

I am indebted to Mr. G. L. Danielson, head of the Department of Telecommunications Engineering, Norwood Technical College, for permission to publish some of the results of this survey.

IETY OF GENERAL MICROBIOLOGY

MICROBIAL SYSTEMATICS GROUP

VERY few
bacterial t
There are man
obvious is that
in terms of ev
in dealing with
more difficult,
bacteria. Agai
in gross morph
serological char
and measuring
the taxonomist's
and perhaps m
no agreed theor
sophy which c
chemist, ecolog
alike into a un
were not enough
indifference to
tions for nomen
themselves and
cultures, partly
the various ty
For historical

s would dispute that
a very confused state.
this. One of the most
al approach interpreted
has been so successful
its and animals, is much
npossible, to apply to
tively small differences
certain significance of
difficulty of discovering
roperties have all made
midable. Furthermore,
of all, there has been
tion, no overall philo-
e findings of the bio-
gist and immunologist
ic scheme. As if this
n added to it a cavalier
nally accepted conven-
part of bacteriologists
nplete absence of type
ure to use and support
lections of the world.
taxonomy of bacteria

especially has been carried on as isolated fragments of other disciplines such as medicine or dairying, with the result that the same micro-organism has been known by a different name in each field, and not infrequently their identity has never been realized. Many taxonomic schemes have been devised but have been only cherished by their authors, while others such as Bergey's scheme have been tolerated with much vexation and disappointment for want of something better. Little wonder then that a despairing spirit has pervaded the subject and that Topley and Wilson should comment that "the bacteriologist himself has not in general troubled overmuch as to the validity of a system which has developed rather as a result of luck than of cunning"[1].

In the past few years, however, there has been a renewed interest in taxonomy associated with new ideas and concepts which have stemmed from two main sources, biosystematics and quantitative taxonomy. Some drastic changes in the underlying philosophy of taxonomy are now being proposed. Some of these centre on the nature and definition of taxonomic groups. It is being realized that bacterial taxonomic groups need not be treated as though they are necessarily phylogenetic. Other developments are based on the assertion that every feature has equal weight in the creation of valid taxonomic groupings. These developments are coming to be called the 'Adansonian method' after the botanist Michel Adanson (1727–1806), who first proposed this concept. By liberating biologists from the impracticable task of allocating different weights to different features it has been possible to develop the use of multivariate analysis employing electronic computors to give some measure of the elusive property which all biologists recognize under such phrases as 'overall similarity', 'affinity' or 'natural resemblance'.

Microbiologists may perhaps compliment themselves on the eagerness with which they are exploring these developments and indeed devising new taxonomic techniques of their own. The outlook in microbial classification has greatly changed and it was this which led to the invitation of a wide range of workers in microbiology, botany, zoology, statistics, biochemistry and electronic computing to attend an informal meeting to discuss these new points of view. The meeting was held on January 12, 1960, at the National Collection of Type Cultures at Colindale, London.

Dr. P. H. A. Sneath (National Institute for Medical Research, London) introduced the subject of quantitative taxonomy and summarized the present position on Adansonian methods. He emphasized the distinction between identification methods, that is those intended to distinguish existing taxonomic groups, and Adansonian multivariate techniques designed to create the taxonomic groups.

Dr. G. D. Floodgate (Torry Research Station, Aberdeen) discussed the problems of anyone trying to do bacterial taxonomy. He mentioned that the accurate identification of bacteria was no mere academic exercise, but a necessity for anyone involved in such fields as the ecology of the soil or the sea; and that identification is impossible when there are neither satisfactory bacterial taxa nor a coherent theory of taxonomy. Despite advances in theoretical taxonomy, there was still the problem of selection of features for taxonomic use, and of course the perennial problem of standardizing the techniques. He also thought that not enough had been done on the theory of hierarchies, and on whether to split taxa or bring them together.

Mr. J. S. L. Gilmour (Botanic Garden, Cambridge) found the Adansonian approach to be very interesting and of wide application—it has even been applied by anthropologists to myths and legends. He agreed that Adansonian methods yield valuable taxonomies for general purposes, but he cautioned against an 'absolutist' approach on the grounds that one must always make some selection of attributes of living creatures, and this selection is always guided by what one is interested in. The mathematical analyses are thus only summaries of mutually agreed classifications based on attributes selected for a particular purpose, and should not be thought of as expressing, in any sense, 'ultimate realities'.

Dr. S. T. Cowan (National Collection of Type Cultures, Colindale) discussed the problem of rank, and pointed out that this is commonly a matter of opinion even when agreement has been reached on taxonomic relations. In addition, the isolation between the different practical sides of microbiology—medical, industrial, agricultural and so on—has badly hampered a unified taxonomy. Dr. G. C. Ainsworth (Commonwealth Mycological Institute, Kew) suggested that agreement might eventually be reached on mathematical values for differentiating between species. Dr A. J. Cain (Department of Zoology, Oxford) made a plea for a simple nomenclature with few rules, and mentioned the advantages of uninomial names. Dr. C. H. Andrewes (National Institute for Medical Research, London) pointed out that some virologists were now considering the possibility of doing this for the viruses.

Dr. R. R. Sokal (University of Kansas and University College, London) then defended the practice of equal weighting of features for the creation of taxonomic groupings, pointing out that it is well-nigh impossible to justify differential importance of features on any rational grounds, whether genetic, adaptive or phyletic. Attempts to do so were vitiated by unsuspected logical fallacies which have only recently been challenged. He also pointed out that Adansonian methods led to a very stable taxonomy.

Dr. M. Ingram (Low Temperature Research Station, Cambridge) was doubtful whether the equal weighting of features would lead to a better classification than that where the features are weighted.

Dr. N. J. Berridge (National Institute for Research in Dairying, Reading) and Dr. C. S. Cummins (London Hospital Medical College) described recent techniques using paper chromatography which enabled the composition of bacterial extracts and of cell walls to be applied to taxonomy. The use of infra-red spectroscopy was also mentioned. Dr. Cain pointed out that such methods give a flood of new characters which must be co-ordinated with previous taxonomic knowledge. He instanced the comparative serology of birds. Dr. Ainsworth mentioned that recent nutritional and physiological studies had confirmed the taxonomic results obtained by the traditional morphological approach to certain groups of fungi.

In addition to the above there was some very lively discussion in which almost everyone present took part, and which ranged over a very wide field including methods of mathematical analysis, sampling methods, nomenclature, genetics and serology.

As a result of this discussion it was agreed that it would be very useful to form a Group of those interested in microbial systematics within the Society of General Microbiology. Accordingly, with the approval of the Committee of the Society, the Group was constituted at a meeting held in London on April 12, 1960. Drs. Cowan, Sneath and Shewan were asked to act as a small committee to organize the activities of the Group, and Dr. Sneath agreed to be the secretary. The purpose of the group is to promote the advancement of microbial systematics by providing a common meeting ground for those interested in the field. It is envisaged that the Group will hold discussions, arrange for the interchange of information and ideas between microbial taxonomists and taxonomists in other fields of biology and, in general, to assist its members to make the best contribution to this field that they may. Membership of the group is open to all members of the Society of General Microbiology. Visitors will, of course, always be welcome at any meetings the Group may hold. Anyone wishing to be kept in touch with the Group's activities, or desiring further information, is invited to contact Dr. P. H. A. Sneath, National Institute for Medical Research, The Ridgeway, Mill Hill, London, N.W.7.

---

[1] Topley and Wilson, "Principles of Bacteriology and Immunity", fourth ed., 1, p. 370 (Edward Arnold, Ltd., London).

CTIVITY OF SOILS, PLANTS AND BONES

SIR ERNEST MARSDEN, C.M.G., C.B.E., M.C., F.R.S.
Dominion Physical Laboratory, New Zealand

IN an earlier
the α-ray a
materials such
contribution g
sions, particu
radioactivities
radiation haza
In the first
identify the r
high recorded
slow-growing
and under hig
Cymstwyth in
The former ha
250 μμc./gm.
similar to the
lead, and indee
has been ident
pulse analyses
and by Mayne
Considering
this grass is gr
plant concent
expected that
trated by the
carried out by
confirmed this
the soil was 7
p.p.m. on an
was 700 p.p.m
dry weight or
had a *p*H of
under these ac
is perhaps und
duced grass co
hope, Durham
calcium 3·34
showed an α-
with a lead co
the normal acti
Kingdom (with
1–4 μμc./gm. a
from the thori
from Reading
ashed 20 mont
60 per cent, pr
possibly radio
necessary in fu
I have arrived
Royal Cancer I
have had an c
Burton and N.
also to discuss
record and to s
[See pp. 208
is obvious th
ments on ashe
by foliar absor
-F and the in
records will be
The uptake
roots may no

vations were recorded of
ious naturally occurring
lants, etc.; the present
bservations and discus-
dence of high natural
be expected to produce

now been possible to
sponsible for the very
e ash of grass from a
ure at about 1,500 ft.
litions at such places as
owdale and Rookhope.
many-fold in activity to
to a curve reasonably
lonium-210, from radio-
lide in the same sample
wholly polonium from
y U. Facchini in Milan

ity of the soil on which
n., this is a remarkable
it might therefore be
would also be concen-
the soil. Tests kindly
the N.Z. Soil Bureau,
He found the lead in
oven-dry weight or 150
the grass ash, the lead
nat' 90 p.p.m. on oven-
n an ash basis. The soil
eable calcium 2·7, and
tions the uptake of lead
Tests of a similarly pro-
Scott Russell at Rook-
*p*H 3·3, exchangeable
vity of soil 9 μμc./gm.
54 μμc./gm. grass ash
p p.m. By comparison
d pastures of the United
il *p*H) is of the order of
25 per cent contribution
evertheless, two samples
Princetown collected and
creased in α-activity by
growth of polonium and
e care in ashing will be
he foregoing was written
ute of Cancer Research,
on, for further work and
see a paper by W. H.
Jature, 186, 584; 1960),
with Prof. W. V. May-
hed paper by C. R. Hill.
is issue.—EDITORS.] It
owland areas measure-
influenced considerably
allout of radium-D and
nfall thereon. All my
ccordingly.)
lants from soils through
same principles as the

uptake of lead. The dilution is such that the radium may not be an assemblage of cations. As in the case of strontium-90, the calcium ratio is of interest. Two experiments by the N.Z. Grasslands Institute may be quoted. In the first, 'Brown Top' was grown on the same soil, *p*H unlimed 5·4, limed 5·6. The α-activity per gram of ash was 1·7 μμc./gm. unlimed, 1·22 limed, a significant decrease. In another experiment on a severely leached acid podzol at Kaikohe, activity 5·4 μμc./gm. 15 cwt. superphosphate per acre was added generally nearly two years ago, accompanied by (1) 20 cwt. lime (66 per cent $CaCO_3$); (2) 60 cwt. lime; (3) a lime pile. In case (1), the *p*H at 0–3 in. became 5·2 and cation exchange capacity 7·2, and ryegrass grown on it gave 2·8 μμc./gm. ash and White clover 3·1. In case (2), the *p*H became 6·1 and cation exchange capacity 9·5, while ryegrass gave 2·8 and White clover 3·2. In case (3), the *p*H was 7·4, ryegrass 3·3 and clover 3·9 μμc./gm., with 9 and 18 per cent contribution by thorium, respectively. The average lime (CaO) content of the ryegrass ash was 6·75 per cent and of the clover 15·25 per cent, so that expressed as per gram calcium the ryegrass gave twice the pick-up of clover, although on dry-matter basis clover gave roughly 10 per cent more than ryegrass (ash/dry-matter = 0·1). This latter may be contributed to by a correspondingly increased portion from thorium products, 18 per cent as against 9 per cent, although long statistical counting would be necessary to test this point sufficiently. One needs, perhaps, experiments with basic slag instead of superphosphate to avoid definitely the radium carried with the latter. A sample of the lime used gave an α-activity of 3·5 μμc./gm. with some 60 per cent contribution from thorium products.

In another series of field tests in the United Kingdom on five different soil types, the ashes of ryegrass and lucerne gave, in each case, approximately the same α-ray activity. I do not have calcium/ash determinations.

Measurements were also made of wheats grown in the United Kingdom, New Zealand and Victoria (Australia). Total variations of nearly 20 : 1 were observed in the α-activity per gram ash, the activity being mainly controlled by *p*H and calcium exchange availability status, with genetic variety as a significant, but quantitatively less important factor. It is worthy of note in passing that the average soils growing wheat and pasture in the United Kingdom appear to have a markedly higher *p*H and corresponding lime status than the soils of New Zealand. This is possibly the influence of extensive greywacke wheat-growing soils in the latter with *p*H about 5·5, but it results in a very different degree of proportional uptake of radium and presumably of strontium-90 from soil. This factor may also have a bearing on the high results (*Nature*, September 12, 1959) of strontium-90 pick-up reported in the case of the acid soils at Tatyoon, Victoria. Similarly, such considerations in relation to foodstuffs and water may need to be taken into account in interpretating the interesting observations on inhabitants living on the acid granite soils

Table 1

	Material	Ash (per cent of wet weight)	Activity of ash (μμc./gm.)
Niue	Taro (4)	0·8	50–300 CaO 6·1 per cent
Niue	Cassava (2)	1·05	19 CaO 4·0 per cent
Niue	Yam (2)	0·6	5·3
Niue	Kumera (4)	0·7	1·7 to 12
Niue	Banana (1)	—	c. 1·2
Fiji	Taro (1)	1·0	0·6 (some thorium)
Raratonga	Taro (1)	1·0	0·6
New Zealand	Potatoes (1)	0·7	0·6
United Kingdom	Wheat	1·8	c. 0·9
New Zealand	Wheat	1·42	c. 2·3

In the above the first four figures refer to roots. The leaves of taro showed little activity. Kumeras from some parts of Niue showed little activity.

of New York State[3]. It is intended to deal with the various results on wheat and cereals in conjunction with E. D. Greer, of the British Flour Millers Research Association, with whom I collaborated in this section of the work.

In the previous paper, reference was made to the high activity of the soils of Niue Island (long. 19° S., lat. 170° W.), and although the advent of a destructive hurricane has delayed an extended personal visit for observations, yet the readily given help of the administrative officials concerned and particularly of the agricultural officer, F. W. Van Westendorp, has enabled many useful samples to be collected and interesting data to be assembled. Moreover, by courtesy of the Royal Navy (New Zealand), Lieut. A. Mitchell, during a brief visit of H.M.N.Z.S. *Royalist*, made a survey of external γ-radiation and recorded values up to 0·13 mr./hr. over a large area of soil, or some twelve times normal elsewhere. This measurement was taken in the open air. The soil content of radium would correspond to several times this value, as the radon, etc., is given off very readily under natural conditions at Niue.

A variety of ashes of plants grown on the agricultural area of Niue gave the equilibrium activities (1 month) shown in Table 1. Figures in brackets refer to number of samples tested.

In all Niue cases the plant activity is due mainly to radium, though further work is called for, as after nine months the above values were increased 30 per cent in the case of taro, kumera and cassava and more in the case of yam. It may be due to radium-D or other nuclide which produces an α-ray product. Unfortunately, measurements of soil *p*H, etc., were not readily possible, though a general survey of the soils is, I understand, in course of publication by the N.Z. Soil Bureau, and values are of the order 7. Small pieces of coral are disseminated through many of the soils, and it is probable that *p*H was not uniform.

The main foodstuff consumed (80 per cent) by the Niueans is taro, which is seen to be very radioactive indeed, particularly if related to calcium; and since the soil is porous and the drinking water supply is roof-collected rain water, the taro was formerly, except for limited supplies of flying fish, the main source of calcium for bone-growth and maintenance. During the past thirty years, however, increasing supplies of skim milk powder have been consumed, containing calcium of negligible activity. Reconstituted milk is now given to all school children.

Activity of Soil and Origin

As to the parent soil, although only one chemical analysis for uranium has been carried out, giving 59 p.p.m., estimations were made by observing the growth of activity after dissolving with acid and igniting so as to compare the growth of radon and products with similarly treated uranium minerals. Measurements by γ-rays on one soil sample so treated gave 30-fold increase when the radium had attained equilibrium, indicating little uranium-X. In the case of α-rays, typical rough figures for the ratio of activity after a month to initial value were: standard uranium mineral, 1·85; island phosphates, 1·95; Niue soil, 3–4; Niue taro ash, 4; bones of Niue 'bush' hen, 5.

In interpreting these figures, there is uncertainty in the amount of polonium present or driven off by heat—since most of the soils readily give off emanation. Moreover, with the thick-layer counting method used, the greater ranges of radon, radium, radium-A and -C, in comparison with uranium, ionium and radium needs to be taken into account. For example, if the activity is wholly due to ionium + radium in equilibrium with one-third equilibrium polonium, the ratio should be approximately 3. Uranium analyses and radon determinations are needed or a pulse analyser which will resolve uranium-II, ionium and radium. It is obvious, however, from the above that the radium in the soil is several times greater than that supported by the uranium present. It may possibly be that the radium is in excess even compared with its ionium parent. It was at first suspected that the uranium-235/uranium-238 ratio might be higher than the usual 1 : 139. This was negatived later by tests in the United Kingdom with a mass spectrograph on one sample; but in the meantime tests for the daughter products of uranium-235, that is, actinium, had proved interesting. The output from the scintillation photomultiplier was divided and the two channels counted in the manner used by Turner, Radley and Mayneord (*loc. cit.*), but with an interval of about 0·005 sec. in the subsidiary channel instead of 0·32 sec. as used for the determination of doubles due to thoron and thorium-A. The idea was to obtain a measure of actinium-A (half-life 0·002 sec.) and thus of the actinium family.

The results are shown in Fig. 1. No attempt is made at this stage to denote statistical limits of accuracy. Enough doubles were measured in each case to justify the general placing of the points on the graph. Before using the method quantitatively, some study of material distribution, particle size, and spaces in the capsule are called for. At the rates used, the number of spurious apparent doubles should be approximately related linearly to count-rate[4], as indeed is shown by the figures for the various plutonium and other sources not carrying actinium. Incidentally, the plutonium was obtained from ashed bones of small experimental animals—into which plutonium had been injected. As expected, uranium mineral shows residual doubles due to its content of actinium; Travancore sand a lesser number. The soil samples from Niue, etc., do not appear at first sight very abnormal, but it must be appreciated that the content of uranium is far from sufficient to support the other nuclides which contribute to the rate observed, so that the Niue soils must carry excess actinium. However, probably an equally interesting result is that obtained with fossil phosphates such as Nauru, which although as noted above are reasonably in equilibrium as regards uranium-238–radium, etc., indicate an excess of actinium. In Fig. 1, the positions of the points are approximate, but taken together the evidence seems definite and

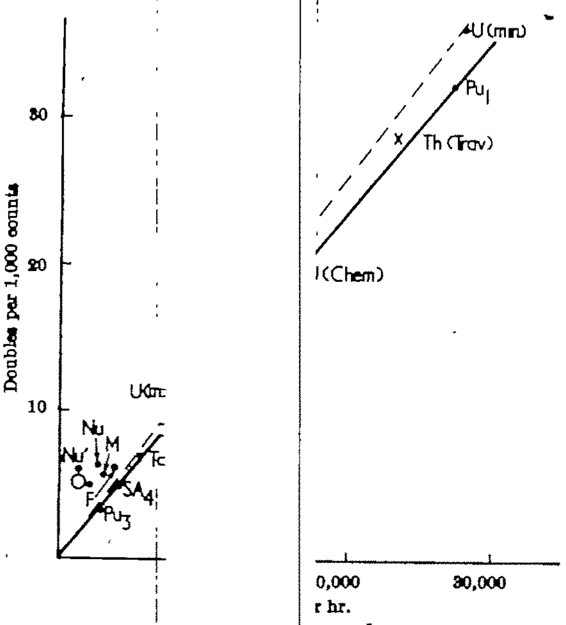


Fig. 1. Key N
ated by heat; O

= Nauru phosphate de-eman-
F = Florida; SA_4 = Cymst-
polonium)

the question
chemical and r
is being mad
spectroscopy.

Based on fo
land lagoon f
Pleistocene, p
rounded by d
supporting it is
coral limestone
supposed soil-
time period o
and that of io
to find the sou
ably these are
may be that th
radioactivity o
latter being th
stone in each
cating similar
content of the
rainfall of so
Although the
highly radioac-
shower may n
the radioactivi
weathering an
some material
and retain cer
foam. We ma
enriched by su
and zoo-plank
A. T. Wilson[3]
activity from
In a voyage
Tasmania Star
daily from a fe
ately boiled to
α-ray measure
results were s
probably due
doubles observ

tigation by the newer
n methods. An attempt
antime by gamma-ray

age of the raised main-
Niue is at least early
llion years. Niue is sur-
l the volcanic material
vered above sea-level by
yet know the age of the
nic shower. The half-
n is only 12,500 years,
ears, and it is desirable
adionuclides, as presum-
an the raised lagoon. It
rity in the origins of the
d island phosphates, the
. The underlying lime-
innacle formations indi-
soils have a phosphate
er cent and with a warm
leaching-rate is high.
Pacific phonolites are
./gm.), yet the volcanic
source of the whole of
ne source, after excessive
h lime and sea, etc., of
llite which can scavenge
ides from sea spray or
gine such sea spray to be
and fragmental phyto-
shore as envisaged by
y have extracted radio-

acific last year in S.S.
ea water were collected
he surface and immedi-
stainless steel pan and
n the dried salt. The
h (0·15 μμc./gm.), and
rom place to place the
spond to a contribution

of the thorium family, variable but of the order of 50 per cent. The results were checked on material collected later, during a Pacific voyage by H.M.N.Z.S. *Royalist*, and also on samples at different depths collected by the N.Z. Oceanographic Institute. Moreover, tests were made of the activities of some of A. T. Wilson's foam samples and of mussels and certain sea organisms, and in some cases enhanced activities were found. The results are not sufficient, nor was the material well enough classified; but they do show that the above suggestions merit the making of tests of sea-surface organic matter at Niue, etc., and the gathering of more experimental information on the geochronological aspects of ionium and actinium. Tests of limestone from shell moulds and from pits showed much radium leached from above. This distribution is being investigated.

Activity of Bones and Radiation Hazard

It is natural to extend the observations to the activities of human bones and body organs, but so far opportunities have not presented themselves. Thanks to the Niue Island Dental Service, however, a good supply of teeth has been made available for comparison with teeth from other localities. The average activity of Niue teeth per gram ash was some ten times that of teeth of Londoners, as was confirmed also by measurements at the Institute of Cancer Research by Miss M. Duggan. The average of twenty Niuean teeth was 1·8 μμc./gm. Samples from Hastings (New Zealand), where the soil and water are well supplied with lime, gave a value 0·32, Raratonga 0·2, Lower Hutt (where low-activity calcined lime is added to the artesian water to bring the pH to 85) 0·4, Auckland, Wellington and Sydney, N.S.W., c. 0·7. In all cases the activity is mainly due to radium—in Niue, almost wholly so. The relative contribution by food supplies and water supplies to teeth and skeletal radium is not yet known. Independently of lime fortification, the flour in the United Kingdom contains considerably less radium per gm. ash than in New Zealand or Australia. However, the above results are to be taken as approximate—they relate to a few samples only; there is possibly an age relationship. Thus the teeth of ten adults of age seventy, kindly supplied by the superintendent of the United Dental Hospital, Sydney, gave a preliminary average of 0·4 μμc./gm., whereas unerupted teeth of children aged twelve gave a value of 1·0 and erupted children's teeth of about the same age 0 5. Breakfast foods from Australia were examined, and no case of added radioactive material was found, as was the case in two brands from the United Kingdom. The relative low activity of teeth of elderly people may have a similar explanation to that given in my earlier article and relating to sheep of forty years ago, or some deposited nuclide which decays with time.

Teeth extracted from skeletons found in limestone caves of Niue, but of unknown age, gave the same value as present inhabitants, indicating presumably that the radioactivity has been a feature of Niue for at least a few hundred years. It is reported that fine grains of charcoal have been found in underground caves into which surface water readily drains. If so, and if these are connected with the effects of an ash shower, it should be possible to obtain a date by carbon-14 methods.

Probably the most interesting results obtained were those of the bones of hens. The bones of nondescript breed, so-called 'bush' hens, fed on the country, plus a certain amount of local dried coconut, gave 60 $\mu\mu$c./gm. bone ash. This, in humans, would be greater than accepted tolerance. The bones of recently imported Rhode Island hens at the prison farm and fed on wheaten mash imported from New Zealand, gave a value of 24, while a single sample of the contents of two eggs from the latter gave a value of 4·4. If this latter result is confirmed, it will correspond with the discrimination or reduction in activity of the foetal offspring in the case of the cow and ewe, as recorded in my previous article. It appears that the same discrimination may not occur in the case of humans, though it is said to occur in the strontium-90/calcium ratio, but the activity of normal human bones is in any event only about a tenth of those of cows, sheep and rabbits.

The Niueans appear to be healthy and vigorous, though somewhat sparer than the other Polynesian groups, to which they are racially related. Probably they have to work harder. With such a small population, namely 4,500, great care is necessary in treatment of statistics of cancerous conditions or of congenital malformations or impairments which might be associated with the large background γ-radiation and food α-activity. Similarly, regarding the occurrence of plant mutations—these are indeed observed in bananas and other plants, but there is as yet no comparative data from other Pacific islands showing less natural activity.

One might expect the possibility of an abnormal sex ratio, and this question is being looked into by the School of Demography, Canberra, which has made a close study of Pacific Island populations. As to fertility, the following figures deduced from a report kindly made available by Drs. McCarthy and Marples, of Otago, may be significant. These authors visited a village in Niue in 1955 for the purpose of investigating certain blood conditions and incidentally noticed the predominance of childless marriages and were led to a close investigation of a group of 100 cases. At that time the high radioactivity of Niue was not known. The figures are: childless marriages, 19 per cent; stillbirths, 6·1 per cent; infant deaths, 9·8 per cent; deaths 1–3 yr., 6·35 per cent. Figures for marriages about 1925 were higher than the more recent; in fact, the infant mortality is now much lower, but an improvement had occurred before the advent of antibiotics for treatment of venereal disease, etc. It is possible that the distribution of skim milk from the hospital, which started nearly thirty years ago, has in some cases had the effect by replacing the calcium from taro with its high radium/calcium ratio by calcium of milk with negligible radium content. Similar evidence might be deduced from the history of a certain hamlet of Fatiau, of 85 persons, established some eighty years ago, the inhabitants of which, knowing nothing of radioactivity, yet were constrained to move as a whole ten years ago to a more wind-exposed site, Vaiea, 2 miles away, because of unknown but feared causes of infertility and infant mortality. However, I am well aware of some of the pitfalls of such statistics; epidemics of influenza or measles can in these islands make great differences in the figures in particular quinquennia; and similarly fashions in diagnosis, etc., change. But if the causes of low fertility are contributed to by high local radioactivity, may it not be that in the Darwinian sense selective breeding of resistant types has taken place? It would appear that Niue has been populated for fully a thousand years. There is ample evidence that different strains of small animals differ markedly in resistance to radiation.

It is hoped to plan carefully and carry out an investigation of these problems during the coming year, and suggestions and help are invited to this end. If the results of Gentry and Bulin (*loc. cit.*) are due to other than selective population migration, then these questions are very important indeed.

In conclusion, I would like to thank all those who have kindly assisted so freely, in particular, W. H. Ward, director of the laboratories at the Dominion Physical Laboratory, for providing laboratory space, etc.; A. H. Allen and Mr. Penton, of the Electronics Division, for improvements to the apparatus; Dr. J. K. Dixon, of the Soil Bureau, for useful soil discussions; and the staff of the Coal Survey Laboratory and Dominion Laboratory Division for ashing facilities and analyses; the secretary of the N.Z. Island Territories Department and the Niuean Administrator for advice on Niue matters; the agricultural officer, F. W. van Westendorp, for provision of samples; and lastly, the manager and officers of the Blue Star Line for facilities to make measurements on board ship during three voyages. The ships proved to have low contamination and background activity, and enabled reliable measurements to be made more easily than on land.

---

[1] *Nature*, **183**, 924 (1959).

[2] *Nature*, **184**, 667 (1959).

[3] Gentry, J. T., and Bulin, G. V., *Amer. J. Pub. Health*, **49**, No. 4, (April 1959).

[4] Marsden and Barrett, *Proc. Phys. Soc.*, **23**, 367 (1911).

[5] *Nature*, **184**, 99 (1959).

OBITUARIES

Sir Robert McCarrison, C.I.E.

MAJOR-GENERAL SIR ROBERT McCARRISON, who died in Oxford on May 18 at the age of eighty-two, was a pioneer of nutritional research whose scientific reputation was even greater abroad than in Great Britain. Particularly is he remembered in India, where he spent much of his life.

After graduating M.B. at Belfast in 1900, McCarrison immediately entered the Indian Medical Service. At his first station he encountered and investigated what he correctly believed to be a fever transmitted by the sand-fly (*Phlebotomus*), and then he began a classical investigation of goitre and cretinism in the foothills of the Himalayas. He noticed the connexion between polluted water and endemic goitre, and he produced this condition in himself and volunteers by drinking the suspended matter of grossly polluted water.

He then tur eriberi in particular, and
nutritional d meral. Little work on
these lines had ndia, though McCarrison
was particular by the work of McCay
(1912) on the f dietary protein. His
approach was successful; he realized
that single die s were unlikely to occur
in man, and t might well be produced
by combined lo he fed lower animals
such as rats or poor diets being used by
various tribes, in the animals diseases
similar to thos occurring in such tribes.
This type of a very different from that
of Hopkins, M is and others, who were
feeding lower purified diets. Both
approaches we d it is surprising that
short-sighted led criticism at McCar-
rison's method med up in these words:
"My own met ther hand, has been to
observe the m ymptomatic and patho-
logical effects c on the animal body as a
whole, and the in what forms of human
illness might r attributed to it". This
approach led t pers on the pathogenesis
of deficiency d

He met criti from scientific colleagues
but also from Department. His work
was frequently much he paid for him-
self. In 192 hgow visited India as
chairman of t mission on Agriculture,
and insisted or McCarrison's work. The
Commission re mportance and promise
of what he wa moor; and in 1929 his
unit was made trition Research Labor-
atories, now m abad.

In 1935, Mc d and settled in Oxford.
He and Lady who survives him, kept
open house, an stant visitors, especially
in the form of ldren and distinguished
scientists from ring the Second World
War, McCarris rman of various com-
mittees, and du he was the first director
of postgraduat ation in the University.
His academic e many, and he was
knighted in 19

His more im were edited by me and
presented to h *rift* on his seventy-fifth
birthday. Not m more than a telegram
from the Mini h of India, Rajkumari
Amrit Kaur, ex ratitude of that country
for his great ser ence of human nutrition
and the advan public health.

H. M. SINCLAIR

chofield

ROBERT K COFIELD, reader in soil
science in the Oxford, died on June 8,
at the age of fi

He entered e, Cambridge, in 1919,
obtained a firs of the Natural Sciences
Tripos, and th country dancing. In a
testimonial, J. '. . . was impressed by
the promise he ad ideas and the energy
and skill to t experiment". Already
interested in sics, Schofield sought
research experi lloid Science Laboratory,
and his first tw h E. K. Rideal) were on
the kinetic theory of surface films. After two years at Durham (1926–28) as lecturer in physics, he joined B. A. Keen at Rothamsted Experimental Station with an introductory description from I. O. Masson that fitted Schofield throughout his life: "As a physicist he is all round. He is a very nice fellow indeed, full of go and good spirits, and we all like him."

Schofield spent twenty-seven years at Rothamsted, succeeding Keen as head of the Physics Department in 1949, and then took charge of the much bigger Chemistry Department on the death of E. M. Crowther in 1954. Two years later he moved to the Department of Agriculture, Oxford, so returning to the academic atmosphere for which he always had a great affection.

Though his early Rothamsted work was mainly on the rheology of clays and similar materials, done in collaboration with G. W. Scott Blair, by 1935 he had also published papers on proteins, on the diffuse double layer—and on soil water. One of these was "Schofield (1935)", perhaps the most quoted reference in the literature of soil science. Others have expanded his thermodynamical treatment—a few think they have improved it—but "The *pF* of the water in soil" still remains the basis of any worth-while discussion of soil–water equilibrium. Leaving problems of bulk movement to those interested in drainage and evaporation, Schofield concentrated on the behaviour of water as an electrolyte in contact with the charged faces and edges of clay particles. His ideas on the ionic forces in water films were used in physical studies of soil structure, soil permeability and soil rheology; and in chemical problems of soil acidity, cation exchange, and the availability of nutrients.

There will be widespread regret that he did not write a synoptic survey of this work and of his ideas for its future development, but even without it Schofield leaves behind him an enviable world reputation in soil science and related technologies. Part of this was attained through his publications (more than eighty as sole or joint author), and part through an extremely wide range of personal contacts. There seemed to be no limit to his fund of ideas, and they were passed on liberally to anyone willing to listen. As a consequence, he was much in demand, nationally and internationally, for committee work and for discussion meetings. Selecting only a few events and activities in his career, Schofield was chairman of the Colour Group of the Physical Society; for six months, 1951–52, he was visiting professor at Cornell University; at the time of his death he was president of the British Society of Soil Science, and chairman of Commission I of the International Society; and, specially pleasing to him, he had an honorary doctorate conferred on him in Lisbon in 1956.

Throughout a very busy life, his main interest outside science was in country dancing, and he was an enthusiastic performer and administrator in the English Folk Dance and Song Society; at the time of his death he was 'Master Squire of the Oxford Morris Men'.

In his combination of qualities as man and as scholar, Schofield was unique and irreplaceable. He leaves behind a host of grateful friends, at Rothamsted, in Oxford, and elsewhere, all proud of their association with him.

H. L. PENMAN

NEWS and VIEWS

Mathematical Physics at Birmingham :
Prof. S. Mandelstam

Dr. Stanley Mandelstam, who has been appointed to a new chair of mathematical physics in the Department of Mathematical Physics of the University of Birmingham, comes from South Africa, where he graduated in engineering and in science (physics and mathematics) in the University of the Witwatersrand. As a student he was a co-author, with W. Yourgrau, of a book on the "Variational Principles in Dynamics and Quantum Theory". It was published by Pitman in 1955. He took Part 2 of the Natural Sciences Tripos and Part 3 of the Mathematics Tripos in Cambridge, and his Ph.D. in mathematical physics in Birmingham in 1956, and he has since carried out research in Birmingham, Columbia and Berkeley. His first original papers were concerned with quantum field theory and with the phenomenological description of pion production in nucleon–nucleon collisions. He is best known, however, for a new method in quantum field theory, now known as the Mandelstam representation, in which the general analytical approach of dispersion relations is generalized to the treatment of a scattering or reaction amplitude as a function both of the energy and the momentum transfer. This method has had a profound influence on the work of many authors in the past few years, and Dr. Mandelstam has published himself a number of investigations, some in collaboration with G. F. Chew, and others in which an attempt is made to derive from this a complete solution of the problem of the mutual scattering of π mesons, which from this point of view would seem to be the simplest problem in high-energy physics.

Applied Mathematics at Bangor :
Prof. D. R. Davies

Dr. David Rowland Davies has been appointed to the newly created chair of applied mathematics in the University College of North Wales, Bangor. Dr. Davies graduated in mathematics at the Imperial College of Science and Technology (University of London), where he afterwards studied for the degrees of M.Sc. and Ph.D. More recently, in 1958, he was awarded the degree of D.Sc. by the University of London. After a brief period as a meteorological officer in the Royal Air Force, Davies turned to university teaching as a career in 1946 and held posts at Liverpool, Southampton and Aberystwyth before taking a lectureship at Sheffield in 1949. He was there promoted to a senior lectureship in 1956 and appointed reader in applied mathematics in 1959. Davies has maintained his early interest in meteorology and is a Fellow of the Royal Meteorological Society and of the Royal Astronomical Society. His research interests have concentrated on atmospheric diffusion, evaporation from limited, saturated areas, and on heat-transfer in laminar and turbulent boundary layers, and he is the author of numerous papers on these topics. In Sheffield he has generated interest in this research, and his research students know him as a stimulating and enthusiastic, if demanding, leader ; at the same time, he is recognized as an inspiring teacher at the undergraduate level. As a Welshman by birth, it is not inappropriate that Davies should return to the Principality as the first holder of a new chair.

Zoology at the University of Leeds :
Prof. E. A. Spaul

Prof. E. A. Spaul, whose retirement from the chair of zoology in the University of Leeds takes place this summer, has been well known both in the North of England and in London for his active and valuable membership of many committees and examining bodies. He left school at the beginning of the First World War was commissioned, and remained on active service until 1918. He took part in many of the historic battles, and towards the end of the War he was transferred to gas warfare. After the War, he set himself the double task of graduating in zoology and at the same being a member of the teaching staff of the Zoology Department of Birkbeck College under Prof. Gordon Jackson. This was a time when interest in hormones was acute, and he ultimately gained his Ph.D. and D.Sc. for a study of pituitary action in amphibians. He was one of the first zoologists to move into the now active field of comparative endocrinology. He remained a member of the staff of the Zoology Department of Birkbeck College, rising to the position of reader, until 1933, when he was appointed to the chair of zoology in Leeds. While still retaining his interest in endocrinology, he then turned his attention mainly to teaching, to administration and to the encouragement of research by the younger people in his Department. In addition, he always encouraged sport, particularly rugby and hockey, among the students. He himself in his younger days was a brilliant rugby player, and recently he has for many years been chairman of the Committee in charge of the Leeds University Sports Grounds. Both he and his wife, who has also been most active on a variety of committees, will be greatly missed in Leeds.

Dr. J. M. Dodd

Dr. J. M. Dodd, who will succeed Prof. E. A. Spaul at Leeds, was educated at the White House School, Brampton, in Cumberland, and at the University of Liverpool. After graduating in zoology in 1938, Dodd taught for a short time at Cardigan Grammar School, and thereafter was on active service in the R.A.F. during the War. At demobilization, Dodd went as assistant lecturer to the Zoology Department of the University of Aberdeen, and here he came in contact with the Hogben school of comparative endocrinologists ; Dodd's own work in this field stems from this time. A year later, in 1947, the late Sir D'Arcy Thompson appointed Dodd as lecturer to the Zoology Department of the University of St. Andrews, his particular charge being to resuscitate the Gatty Marine Laboratory, which had been asleep for the previous thirty years. From 1947 to the present date, Dodd has worked in St. Andrews, being appointed reader in zoology in 1957 and director of the 'Gatty' in 1959.

Dr. Dodd
record of ac
The Gatty
truly resusci
which time
and a resear
main stream
thyroid–gona
brates. He
supported fin
by the Unive
M. I. H. Dod
trained many
has progresse
at Leeds is a
his abilities a
St. Andrews
personal and

U.S. Nation
Associates

The followi
of the U.S.
E. A. Brun,
the Ecole N
Sir Cyril Hin
and professo
Oxford ; Dr.
Section, Ins
Academy of
of physics in
Leloir, resea
Facultad de
sity of Buen

Science and
Sahara

The Scient
for Africa Sa
has pointed
the recent art
Territories of
May 14, p.
members of t
of a scientif
responsible i
they are dr
"members of
able, so far a
authority on
direct interes
also being p
geographical
countries an
"Vacancies
Council itself
tions by the
is thus a
primary alleg
for the bene
qualified to
Governments
Co-operation
This Comm
an inter-gove
to-day, besid
France, Sout
Rhodesia and
South Africa
independent

ds leaving an impressive
ind him in St. Andrews.
tory has been well and
ast thirteen years, during
ensions have been built
established. Dr. Dodd's
concerns the pituitary–
s of cold-blooded verte-
widely in this field and,
Nuffield Foundation and
ntifically by his wife, Dr.
an endocrinologist, he has
ents while his own work
appointment to the chair
ll-deserved recognition of
eacher. His colleagues at
of their own loss, both
their loss is Leeds' gain.

of Sciences: Foreign

lected Foreign Associates
lemy of Sciences: Prof.
ronautical engineering in
ieure de l'Aeronautique ;
dent of the Royal Society
y in the University of
, head of the Theoretical
ysical Problems of the
U.S.S.R., and professor
of Moscow ; Prof. L. F.
of biochemistry in the
tas y Naturales, Univer-

in Africa South of the

to the Scientific Council
hara, Dr. E. T. Verdier,
ference to the Council in
Research in the Overseas
Commonwealth" (*Nature*,
make it clear that the
chosen as representatives
and that they are not
the country from which
nstitution provides that
all be eminent scientists
ween them to speak with
ranches of the sciences of
th of the Sahara, regard
le representation of the
of Africa and of the
concerned". Further,
l shall be filled by the
nfirmation of its nomina-
overnments". The Council
endent scientists whose
advancement of science
and as such it is well
nsellor to the member
mmission for Technical
h of the Sahara.
inct from the Council, is
anization which includes
ginal members (Belgium,
(now the Federation of
Portugal, the Union of
ed Kingdom), the newly
na, Liberia, Guinea and
the Cameroons. The Scientific Council/Commission is financed by the member Governments on a percentage basis, each in its own currency, the United Kingdom and France contributing the biggest percentage (just under 20) of the total cost in 1960 of about £250,000, which is distributed over some fifteen separate budgets. Dr. Verdier testifies that whatever else the Scientific Council has accomplished in the ten years of its existence, in spite of rapid changes in Africa, it still provides a common meeting place where representatives of its member Governments, whether scientists or not, can discuss technical matters of importance to the continent of Africa without being hampered by other considerations which often make international co-operation so difficult.

The International Council of Scientific Unions

The Year Book of the International Council of Scientific Unions for 1960, besides a Calendar of Arrangements for 1960, lists the staff of the Secretariat, members of the Bureau and the Executive Board, as well as the National and Scientific Members of the Council and the countries adhering to the Unions (Pp. 109. The Hague: International Council of Scientific Unions, 1960). Details are also given of the membership of the special committees, joint commission, and executive bodies of the permanent services of the International Council. With the statutes and by-laws of the Council, the rules and charters for the special committees and permanent services, the particulars of the commissions of the Unions, of the relations of the Council with the specialized agencies of the United Nations, the list of addresses of international organizations, and the alphabetical list of members of the joint commission and other organizations of the Council and of the officers of the Scientific Unions, the Year Book is a most useful reference work for scientists and others engaged in international scientific activities. The Treasurer's report and financial statement issued as a separate paper show an excess of income over expenditure for the year ended December 31, 1959, of 17,568 dollars (Pp. 12. The Hague: International Council of Scientific Unions, 1960).

Irrigation in Great Britain

The second report to the Central Advisory Water Committee of the Sub-committee on Growing Demand for Water must be one of the shortest official reports on record (Pp. 5. London: H.M. Stationery Office, 1960. 6*d*. net). Extending to two pages only, the first deals with the appointment and terms of reference of the sub-committee and explains that the document is an interim report on uncontrolled abstractions of surface water, with special reference to irrigation water for agriculture. The second page proposes the early introduction of a temporary method of control through the river boards in view of the risk that growing abstractions will seriously deplete the natural flow of rivers at the time when they will be at their lowest levels. A detailed report is promised at some future date on the ultimate method of control, and this will doubtless reveal a selection of the data which has led to the early publication of the sub-committee's conclusion. While the sub-committee also recognizes that ultimately "provision should be made for conservation and storage so that water would be available for all legitimate purposes", the urgency of this need is only being realized slowly in Great Britain. So far H.M. Central Advisory Water Committee has only been prepared to look forward as far as 1965. In contrast, the United States Select Committee on National Water Resources is evaluating water needs for 1980 and beyond to the year 2000 on the basis of low, medium and high-level population increases.

If British national policy is to secure the maximum food output from the agricultural industry, farmers in south-east England should be actively encouraged, rather than discouraged, to irrigate; and although some form of temporary control of abstractions may now be advisable because of lack of foresight in the past, the time has surely arrived when a much more positive approach to the whole question of water conservation and supply in Great Britain is desirable so that the maximum benefit may be derived from the ample precipitation available.

Optics and Spectroscopy

Optics and Spectroscopy is now added to the list of full English translations of Russian scientific journals; it is published in the United States on the initiative of the Optical Society (6, No. 1. Translation of the Russian journal *Optika i Spektroskopiya*. Pp. iv+84. Published monthly. Subscription rate 25 dollars plus 3 dollars for postage. This rate includes the Journal of the Optical Society of America. New York: American Institute of Physics, 1959). This gives a welcome guarantee of the standards to be adopted. Five volumes of the original, in Russian, have already appeared, and the translations of the sixth and subsequent volumes will only be available as a joint subscription with the *Journal of the Optical Society of America*. In both the five previous volumes in Russian and the present translated issue, the coverage of the journal has corresponded quite closely with that of the *Journal of the Optical Society of America*, except for a surprising absence of papers on instrumental optics, diffraction and coherence problems. On the other hand, atomic and molecular spectroscopy, luminescence and optical properties of materials are all fully represented. From many sources it is known that very extensive work in instrumental optics is done in the Soviet Union, and it would be of great benefit to both optics and physics generally if the relevant publications were not only made known but also published in translation. It is not stated whether separate reprints of these translations will be sold. If not, it is to be regretted, for both the content of the papers in the present issue, and the excellence of the translations, will create a demand for them.

Bibliography of Indian Scientific and Technical Publications

In connexion with an exhibition in February 1960 of scientific and technical books published in India, organized by the Council of Scientific and Industrial Research, India, the National Library, Calcutta, has compiled a bibliography of Indian Scientific and Technical Publications (Pp. xii+195. New Delhi: Council of Scientific and Industrial Research, 1960. Rs. 25). The bibliography is based mainly on publications supplied in response to requests addressed to publishers, universities, research institutions, etc., and supplemented from information or material in possession of the National Library. Resources for compilation of a bibliography in the usual way were not available and it is proposed to supplement the present bibliography by such a compilation later. The present material is in two parts, the first containing the entries in the Indian languages, and the second the entries in English. Publications are arranged according to the Dewey Decimal Classification, and there is a consolidated subject index to both parts and separate alphabetical author indexes to each part. Of the English publications, 493 relate to agriculture, 315 to engineering, 119 to mathematics, and 100 to physics

The South African Museum

The *Annals of the South African Museum*, Vol. 45, Part 3, contains Part 5 of Prof. J. H. Day's detailed work on the polychaete fauna of South Africa. The present contribution deals with errant species dredged off the Cape coasts and is the first account of those organisms which occur below tide-marks. The prime object of this dredging survey is to determine distribution patterns around the southern part of Africa. Both the Hydrographic Section of the South African Navy and the Lamont Geological Observatory have provided facilities for the collection of material, though the bulk was obtained by members of the Department working from small boats during university vacations. The paper is illustrated with text figures.

Preservation of Films of Historical Value

The National Film Archive, created twenty-five years ago to undertake the permanent preservation of selected moving pictures of historical importance, either as works of film-art or as records of the life of our time, has now issued Part II of its published catalogue, "Silent Non-Fiction Films 1895–1934", to which Sir Arthur Elton contributes a foreword (British Film Institute. National Film Archive Catalogue, Part 2. Pp. x+195+12 plates. 15*s*.). The first volume ("Silent News Films, 1895–1933") was published in 1951, and a third, devoted to silent fiction films, is in preparation. The 1,054 entries are arranged chronologically under the country of origin, using wherever possible the date of release and the original release title, and the length and a short synopsis are also given. The great majority—727—of the entries are from Great Britain, and there is also an alphabetical index to film titles and a subject index.

The Archive, which is financed out of the Government grant made annually to the British Film Institute and administered by a committee appointed by the Governors of the Institute, has also issued a booklet describing the work of the Archive (The National Film Archive. Pp. 16. London: British Film Institute, 1960. 2*s*. 6*d*.). This has now built up a collection of 6,000 films, apart from newsreel material, covering the period 1895 to the present day and representing the work of more than thirty countries. Individual *bona fide* students engaged in some approved work or research may view preservation copies on an "Editola" in the Archive's premises under the supervision of the Archive's staff, and, with permission of the owners and under such conditions as they may stipulate, certain films may be shown in the National Film Theatre of the British Film Institute. Where the owners of historically important films are willing to allow them to be used for study by schools, universities, adult education groups and film societies, duplicate copies are made for hire through the British Film Institute's distribution service, and more than 200 films are available for distribution in this way. It is emphasized that the National Film Archive is a national film museum,

being one of the
world, grouped t
of archives with
to the permanen
value, and it is
the work of the
within the film

forty throughout the
nternational federation
s in Paris, and devoted
of films of historical
function to duplicate
tion libraries existing

"Clean Air Ye

A useful fea
1960" is an out
which came intc
with details of r
estimates of th
show that more
emitted yearly
half a million t
from the railwa
chimneys contri
900,000 tons of
Sulphur dioxide
fuel oils, total
fires contribute
Book" contains
which have smc
in operation or
cerned, Hayes
more smokeless
Another feature
of the struggle a
1273 when the t
as being "prejuc
can be obtained
Air, Palace Char
price 2*s*. 4*d*. inc

ean Air Year Book for
of the Clean Air Act
wo years ago, together
nd by-laws. The latest
Britain's atmosphere
on tons of smoke are
fires compared with
stry and 100,000 tons
other hand, domestic
),000 tons out of the
st that are emitted.
rom all solid fuels and
s, to which domestic
ion tons. The "Year
st of local authorities
as or smokeless zones
far as acreage is con-
n in Middlesex have
y other town or city.
e chronological history
lution which began in
prohibited in London
". The "Year Book"
onal Society for Clean
Street, London, S.W.1,
).

The Scottish F ssociation

The annual r
Studies Associat
general meeting
P. F. Holmes,
Centre, spoke o
modern educatic
number of cours
make arrangeme
student-days fel
gow: Scottish F
ment of Botany,
paid ordinary r
was 534 and the
Bursary Schem
members of loc
as bursars. Hal
planned for th
Garth; four we
Fellowship, Ltd
battle Abbey.
the importance
problems, and c
increase in the
districts and th
techniques for t
devised and e
children. The
admirable illustr
Geography of t
lands in Miniatu
compiled by m
Studies Field C
summers of 19

of the Scottish Field
to the eleventh annual
May 7, at which Mr.
e Malham Tarn Field
nce of field studies in
slight reduction in the
it was not possible to
sie, and the number of
o 2,972 (Pp. 28. Glas-
ssociation, c/o Depart-
ty, 1960. 2*s*. 6*d*.). The
n December 31, 1959,
ffiliated bodies 33. The
successfully and 61
cieties attended courses
courses arranged were
s own field centre at
tion with the Holiday
tels, and two at New-
, Mr. Holmes stressed
rstanding of country
keeping pace with the
eople visiting country
of normal class-room
New methods must be
studies for younger
is accompanied by an
Dr. Joy Tivy on "The
a: the Central High-
material collected and
various Geographical
nded Garth during the

Rock Shelter Paintings near Bauchi in Northern Nigeria

During an investigation in the area around Geji, not far from Bauchi, Hamo Sassoon, deputy director of the Nigerian Department of Antiquities, found several painted rock-shelters. Of these the most important was near Geji itself. Four styles of painting were determined: there is a naturalistic style, the painting being made in solid red pigment; two series in a more diagrammatic style; and another series once again in solid red pigment, but much less naturalistic than the first. Antelopes, cows, monkeys, men and a horse are depicted. This last, which occurs in one of the diagrammatic series, is important, as it would seem that the horse would not have been known at Geji before about A.D. 1500. Only two superpositions can be observed and they happen not to be very helpful. It is not, then, possible to determine the relative ages of the four series, and as to an absolute date one can only say that one of the diagrammatic series cannot be earlier than A.D. 1500. Although the drawings are protected from the weather by an overhanging rock, it is very unlikely that any rock-shelter paintings can be of any vast antiquity. Precipitation and subsequent evaporation degrade the walls and any paintings tend to disappear. Only in deep caves, where conditions have not changed for long periods, can one expect survival. But the newly found paintings in Nigeria are of considerable interest. The local inhabitants have no idea who made them, but they do attribute magic qualities to them.

Relaxin

In a paper presented before the American Society of Biological Chemists in Atlantic City, N.J., Edward H. Frieden, of the Arthur G. Rotch Laboratory, Boston, Mass., has reported his analyses of relaxin (United States Department of Health, Education, and Welfare: Public Health Service. Publication No. 739: Highlights of Research Progress in General Medical Sciences, 1959. Pp. v+23. (Washington, D.C.: Government Printing Office, 1960.) 15 cents). Relaxin is secreted by the ovaries and apparently serves to relax the uterus during childbirth. Previous work by Frieden had indicated that relaxin was composed of a single molecular series; he now suggests that there are three components. The relaxin preparations, isolated from the ovaries of pregnant sows, were separated in a solvent system of 2-butanol and 0·2 per cent trichloracetic acid. A total of 355 transfers was made, with the relaxin compounds spread rather uniformly over 50 tubes. Pooled material from this distribution was re-run in the same solvent system, separating the three components. The amino-acid contents of the components were determined by paper chromatography of their acid hydrolysates and were found to be qualitatively identical. They included cystine, aspartic acid, glutamic acid, glycine, serine, histidine, lysine, arginine, alanine, valine, theonine, leucine and *iso*leucine.

U.S. National Centre of Atmospheric Research

Dr. Walter Orr Roberts, of the High Altitude Observatory, Boulder, Colorado, has been appointed director of a (U.S.) National Centre of Atmospheric Research. The National Science Foundation has granted 500,000 dollars to the University Corporation on Atmospheric Research to assist in establishing the Centre, which will consist of a central scientific group to stimulate and supplement university research. It will also provide facility management for what may become a large and widely dispersed research effort. Research programmes to be undertaken by the group will probably fall into four categories: atmospheric motions, energy exchange processes in the atmosphere, water substance in the atmosphere, and physical phenomena in the atmosphere. It is probable, however, that the staff will require about a year of investigation and exploratory work before deciding upon specific long-term research projects.

Oliver Memorial Fund Award

The Committee of the Oliver Memorial Fund has announced that it intends making its fourteenth annual award of the value of £50 to a British subject whose original work, or services in connexion with blood transfusion, is considered to be a notable contribution to the research, organization or donor aspect of this subject. Applications and communications directing attention to suitable candidates should be submitted before September 30, and should be sent to the honorary secretary, Mrs. F. E. Bedborough, 105 New Park Avenue, London, N.13.

University News : London

The title of professor of physics in the University of London has been conferred on Dr. E. H. S. Burhop in respect of his post at University College.

Queen Elizabeth College has received a grant from the Leverhulme Trust Fund of £3,800 over a period of two years to enable a sociological research programme to be started in the Department of Nutrition. The work will be carried out by Dr. Paul Morpurgo, who has been appointed Leverhulme Research Fellow in the Sociology of Nutrition for two years as from October 1.

A Wellcome Research Fellowship has been awarded to Dr. Angela E. R. Taylor to enable her to undertake in the Department of Biology research on the metabolic requirements of helminths, using radioactive tracers.

The London Research Foundation is making a grant to Queen Elizabeth College of £56,000 over a period of seven years to further the research work of the Department of Nutrition, with special reference to its work on fertility control.

Announcements

Dr. J. M. Winterbottom has been appointed director of the Percy Fitzpatrick Institute of African Ornithology as from September 1. The new building, on the campus of the University of Cape Town, which is to house the Institute, is now completed.

The Roentgen Prize of the Justus Liebig University of Giessen has been awarded to Mr. J. B. Adams, acting director-general of CERN (Geneva) and director of CERN'S proton synchrotron division.

The Langley Medal of the Smithsonian Institution, Washington, has been awarded posthumously to the rocket pioneer, Dr. Robert H. Goddard, who died in 1945, for the rocket experiments he started half a century ago at Clark University.

The Warner Memorial Medal of the Textile Institute has been awarded to Prof. C. S. Whewell, professor of textile technology in the University of Leeds. The Warner Medal is awarded in recognition of outstanding work in textile science and technology, the results of which have been published, and particularly for work published in the *Journal of the Textile Institute*.

The Science Museum Library has recently been presented with a collection of Japanese scientific and technical books and dictionaries on behalf of the Prime Minister of Japan, Mr. Nobusuke Kishi. The Library, as the result of this presentation, now possesses a very complete collection of such recent books in English or with English summaries, in addition to a large number of current Japanese scientific and technical periodicals.

The Faraday Society is organizing a general discussion on "The Physical Chemistry of Aerosols", which will be held at the University of Bristol during September 13–15. Further information can be obtained from the Assistant Secretary, Faraday Society, 6 Gray's Inn Square, London, W.C.1.

The eighth International Congress of Blood Transfusion is to be held in Tokyo during September 12–15. Further information can be obtained from Tomio Ogata, Blood Transfusion Research Laboratory, Japanese Red Cross Society, Shibuya, Tokyo.

La Società Italiana di Fisica is organizing an International Summer Course on "Solid State Physics" at the 'Centro Studi Nucleari di Ispra' during September 5–24. Further information can be obtained from Prof. G. Polvani, Società Italiana di Fisica, Via Saldini, 50, Milano.

The tenth International Congress of Applied Mechanics will be held in the Congress Building at Stressa during August 31–September 7. Further information can be obtained from the Secretary of the International Committee, Prof. Mekelweg 2, Delft.

An International Congress for Logic, Methodology and Philosophy of Science will be held at Stanford University, California, during August 24–September 2, under the auspices of the International Union for History and Philosophy of Science. Further information can be obtained from Prof. Patrick Suppes, Serra House, Stanford University, Stanford, California.

The fifth International Congress on Nutrition will be held in Washington, D.C., during September 1–7, and will be organized under the auspices of the International Union of Nutritional Sciences, the American Institute of Nutrition and the U.S. National Committee, International Union of Nutritional Sciences of the National Academy of Sciences–National Research Council. Further information can be obtained from the Secretariat of the Congress, 9650 Wisconsin Avenue, Washington 14, D.C.

The Extra-mural Department of the University of Manchester, on behalf of the Department of Physics of the Manchester College of Science and Technology, is holding a summer school in Modern Methods of Crystal Structure Determination during August 29–September 9. The school has been arranged to follow the meeting in Cambridge of the International Union of Crystallography. Further information can be obtained from Prof. H. Lipson, Manchester College of Science and Technology, Sackville Street, Manchester, 1.

INTE IAL ASSOCIATION FOR THE PROTECTION OF INDUSTRIAL PROPERTY

THE Intern
of Industri
gress in Lond
be said to be a
the work with
national rights
and industrial
distinct from '
in artistic and
blood of an i
such as Britain
these rights ab
lively interest
the trading, e
these rights m

Members of
A.I.P.P.I. from
professional m
lawyers, and
rights in this fi
tion, which w
harmony with
Union set up
Paris Conventi
the most impo
and trade m
because of the
manufacturer
his inventions
the Conventio
such protectio
vention laid d
law in the sig
treatment in
marks were gi
At present fort
Union. The o
diplomatic con
Washington in
in 1934, and i

The Associat
over the world
number of me
elected preside
There are now
work is to imp
its operation
the Bureau o
diplomatic co
and practice
countries. S
gradually, and
be continuous
ments have be
work. It is t
put forward f
diplomatic co
the result of th
Association an
merce, consist-
industrial prop
day-to-day w
problems crea

tion for the Protection
d its twenty-fourth con-
30–June 4. It cannot
ssociation, for although
ncerned, namely, inter-
inventions, trade marks
'industrial property' as
perty', which is rights
right), is the very life-
manufacturing country
t in the maintenance of
y nil. Nevertheless, the
f the few who recognize
financial importance of
public indifference.
tion (often known as
form of its name) are
rialists, such as patent
firms with considerable
research. The Associa-
. 1897, works in close
the Industrial Property
al treaty known as the
is Convention (which is
nal treaty in the patent
founded and agreed
difficulties confronting a
who wanted to protect
abroad. Indeed, before
the task of obtaining
impossible. The Con-
ciples which were made
ies, whereby reciprocal
s for patents and trade
onals of these countries.
ries are members of the
ion has been revised at
in Brussels in 1900, in
ague in 1925, in London
58.
bout 2,300 members all
where there are a large
ational groups, with an
ecretary and treasurer.
h groups. Its primary
of the Convention and
y suggesting, through
ial Property Union at
endments in the law
dustrial property in all
can only be achieved
world the effort must
Already many improve-
sult of the Association's
nearly all the proposals
m and adopted by the
ed to above have been
fficial bodies such as the
ional Chamber of Com-
lo of specialists in the
are constantly, in their
ing the difficulties and
national manufacturing
rivalry, and who, by their experience and special knowledge, are best able to suggest remedies.

The officers of the national groups meet several times each year at various international centres, and the Association discusses the problems arising at congresses held in alternate years, different countries acting as hosts. Since the War, the Association has held congresses at The Hague (1947), Paris (1950), Vienna (1952), Brussels (1954), Washington (1956), Stockholm (1958), and now London (1960). The previous congresses held in London were in 1898, 1912 and 1932. Prior to the Second World War, the congresses were rather small affairs, but international interest in industrial property has grown so considerably that attendance and the number of countries interested have increased greatly. At the recent congresses, about 600 delegates have attended, with their ladies. In London, the number increased still further to about 700 and the total of participants (including ladies) was more than 1,400, representing thirty-eight countries. There were representatives from the Governments of sixteen countries, five intergovernment organizations and four international associations. The Government representatives were mostly heads of national patent offices and ministries corresponding to the Board of Trade in Britain.

The London Congress was held under the patronage of H.R.H. Prince Philip, and under the presidency of Sir John Hanbury-Williams.

At the working sessions, held in St. Pancras Assembly Rooms, simultaneous translation of papers in English, French and German was arranged. The following problems were discussed: termination of rights to register trade marks owing to non-use; cancellation of the registration of a trade mark at any time upon proof of abandonment; trade marks or trade names with extended protection; suppression or limitation of trade mark rights after a certain period of use; revocation of patents for non-working; effects on industrial property rights of national and international rules providing for free competition; competence of arbitrators and enforcement of their awards in matters of contracts relating to industrial property; method and preparation of a study of the unification of patent laws; restrictions of the right of the patentee for reasons of public interest; temporary protection at exhibitions; extension of periods expiring on a public holiday; international protection of works of applied art, designs and models; revision of the "Arrangement" of The Hague concerning the international deposit of industrial designs and models; licensing of trade marks; translation of trade marks.

All these problems were fully and freely discussed by the delegates, and in due course the recommendations of the Congress on them will be published and submitted to the Bureau of the Industrial Property Union for the next diplomatic conference, which, so far as The Hague "Arrangement" for industrial designs and models is concerned, will be held at The Hague in November next.

On the social side of the congress week, the inaugural ceremony of its opening was held at the

Royal Festival Hall on May 30, presided over by the Lord High Chancellor, the Right Hon. the Viscount Kilmuir; on May 31, a Government reception was held at Lancaster House under the auspices of the Board of Trade, which was also attended by Prince Philip; on June 2 the delegates attended a gala performance of "The Barber of Seville" at the Royal Opera House; and on June 3 the closing banquet was held in the Great Hall of the Royal Courts of Justice (by permission of the Lord Chancellor and the Minister of Works), followed by a ball in the Halls of the Middle and Inner Temples (by permission of the Benchers of the Middle Temple and Inner Temple).

In consequence of the earnest representations of the German Group, it was agreed that the next Congress of the International Association for the Protection of Industrial Property be held in Berlin in 1963. The Japanese Group also made strong representations that the Congress following the Berlin one be held in Tokyo in 1966, especially as the Association has never yet met in Asia. In view of the decision to hold the next Congress in Berlin, an invitation was sent to Peter von Siemens, of Werner von Siemens, Erlangen, to succeed Sir John Hanbury-Williams as president.

The permanent officers of the International Association are: *Secretary-General*, Eugène Blum; *Assistant Secretary-General*, Dr. Rudolf Blum, of Zurich, the headquarters of the Association. *Reporter General*, M. Paul Mathely (Paris); and *Treasurer General*, M. Jaques Bede (Brussels). The president of the British Group is Mr. G. W. Tookey, Q.C., the joint secretaries, Mr. Michael Hesketh-Prichard (chartered patent agent) and Mr. Martin H. Lowry (solicitor), and the treasurer Mr. L. A. Ellwood (solicitor). The president of the German Group, which will be responsible generally for the organization and running of the next Congress, is Herr H. G. Heine (patent agent), and the secretary, Herr Moser von Filseck (advocate).

H. C. MILLER

PARASITES AS ENEMIES AND ALLIES

THE Spring Meeting of the Parasitology Group of the Institute of Biology was held during April 6–8 in the new buildings of the Liverpool School of Tropical Medicine, by kind arrangement with Prof. W. E. Kershaw. This was the second annual meeting of its kind, and was attended by about a hundred biologists with widely differing interests in parasitology.

Twenty offered papers were concerned with a variety of disciplines and of animal parasites, ranging from studies on the biology of the tapeworm larva, *Cysticercus bovis* (P. H. Silverman), to mitochondrial enzymes in relation to malaria (B. G. Maegraith) and a mathematical analysis of populations of helminths in wild and domesticated animals (H. D. Crofton). The invited speaker, Prof. T. H. Davey, surveyed the role and status of parasites in his discourse on "Parasites as Enemies and Allies".

In the rapidly developing field of physiology of parasites, R. L. Muller presented his experiments on glycogen metabolism in *Haplometra cylindracea* and showed this fluke to be an obligate aerobe—a nice correlation with its habitat in the lung of the frog. Investigations into the growth patterns of certain tapeworms, undertaken by C. A. Hopkins, revealed that during growth the plerocercoid larva doubles its weight every 24 hr., and that it becomes infective before reaching its maximum size. Under the stimulus of transmission to the definitive host, exponential growth is resumed until maturation of the worm. Hopkins suggested that at maturation a growth-inhibiting substance is produced which, because of linear growth and the lack of a circulatory system, does not affect the anterior region of the worm. The proteolytic activity of extracts prepared from *Entamoeba histolytica* and the optimum conditions for proteolysis were reported by R. A. Neal.

Histochemical studies included the distribution of nucleic acids in normal and in akinetoplastic strains of *Trypanosoma evansi* by J. R. Baker. D. L. Lee showed that the ovijector of *Thelastoma bulhoesi*, a nematode inhabiting the hind-gut of the cockroach, secretes a mucoprotein responsible for the sticky covering of the eggs. Certain aspects of the behaviour of parasites were treated by F. Hawking and M. J. Worms, who described responses of microfilaria counts of *Monnigofilaria setariosa* to external stimuli applied to the host, the mongoose, and who discussed reasons for the periodic migrations of microfilariae into the peripheral blood.

A knowledge of the life-cycle of a parasite is fundamentally important to epidemiological studies of parasitic diseases, and work by T. E. Gibson on the development of eggs and larvae of two species of sheep nematode, *Nematodirus battus* and *N. filicollis*, and on pasture population densities has allowed grazing management methods to be devised which enable complete control of the disease. The density of parasite populations is also important in the case of ducks harbouring the acanthocephalan *Polymorphus minutus*, which under certain conditions can cause serious losses, and H. B. N. Hynes gave an account of the way in which the parasite spreads by means of its intermediate host, *Gammarus* spp., from an infected flock penned on to a small stream.

An example of how a population of parasites may serve as an indicator of different zoogeographical populations of host was illustrated by Z. Kabata. Whiting inhabiting the North Sea to the north of the Dogger Bank harbour abundant *Ceratomyxa* in the gall bladder, whereas fish to the south are infected with *Myxidium*. There are also differences in the myxosporidian fauna of these fish from the Faeroes and of the haddock from these areas.

Parasitic infections may evoke immune reactions in the host, and this host-reaction can be utilized to test for the presence of the parasite. R. J. Terry, D. Poynter and P. H. Silverman reviewed and appraised the value of various haematological and serological techniques employed in diagnostic tests. Further uses of host-reaction in detecting the presence of a parasite were reported by S. F. M. Davies and L. P. Joyner, who found that in chicks with a sub-lethal

infection of the
ments of the
sensitive mean
observations on
E. necatrix inf
reduction in th
mild anaemia an
distinguished.
A host anima
by parasites, an
of the rabbit
retortaeformis,
of the adult wo
worms at the
new infestation
spontaneous eli
known as self-c
the nematode
investigated th
place at self-cu
agglutination an
techniques. Th
there is a mark
the main antig
released by lar
The susceptib
influenced by t
established in t
action between
studied by J.
infested with *N*
ratti and mice
churis muris.
attack by anim
an animal host,

ria tenella, the measure-
mia provided a more
the parasite than do
ate of the chicks. In
er, there is a marked
accompanied by only
is may thus be readily

sistance to infestation
showed that resistance
tode, *Trichostrongylus*
ted by the elimination
of development of the
ge or by preventing a
ing established. The
arasites from the host
in sheep infested with
ntortus. E. J. Soulsby
reactions which take
lement fixation, haem-
gar diffusion precipitin
icates that at this time
ical response and that
on is from substances
the third moult.
to infestation may be
other parasites already
he nature of the inter-
rrent infestations was
in rats experimentally
muris and *Strongyloides*
ris tetraptera and *Tri-*
ility of plant hosts to
different from that of
es between varieties of

chrysanthemum in susceptibility to attack by eelworms were discussed by H. R. Wallace. The behaviour of eelworms on the outside of the plant, the invasion of the leaves through the stomata and movement of the worms within the leaf were described. The evidence supports the theory that varietal variation in susceptibility is related to hypersensitivity of the leaf tissues to eelworm invasion.

The degree of host-specificity shown by a parasite may be important in the epidemiology of human disease, as in the case of a pathogen harboured by both man and his domestic animals. F. E. G. Cox posed the question, "Is *Balantidium coli* a zoonosis ?" and presented data suggesting that this protozoan normally found in pigs is not, contrary to common belief, easily acquired by man except possibly in certain nutritionally deficient states. Another group of protozoans, the 'Limax' *Amœbae*, have frequently been reported as parasites of both invertebrates and vertebrates, including man, and they are also abundant in the soil. Although these animals are similar morphologically they show great differences in their physiology and micro-anatomy and these differences are reflected in the ecology of the individual species. K. Vickerman submitted evidence that some of these 'Limax' *Amœbae* are facultative parasites closely related to soil-occurring forms, whereas others are obligate parasites more closely resembling the Endamoebidae.

A group of short papers and demonstrations described the work in progress at the Liverpool School of Tropical Medicine, and these together with three other laboratory demonstrations concluded the meeting. The proceedings of this meeting will not be published in full.

J. MAHON

HOUSE CROPS RESEARCH INSTITUTE

THE Glassh
hampton,
May 17, more
The laboratori
the morning, an
growers availed
the work in pro
the Institute's
director, Mr. F.
assembled gues
of the Institut
plans, and direc
particular inte
afternoon a nu
arranged in the
room sheds.
In the tomat
Mr. L. A. Darby
character of t
known standa
Craig', was sho
the ripening d
back'. A paral
plants which h
but with the
freedom from
best-known of
have yet to be

earch Institute, Little-
s annual open day on
red visitors attending.
for inspection during
g research workers and
this opportunity to see
scuss aspects of it with
ff. After lunch, the
ve a brief report to the
s on the development
st year and on future
o some lines of work of
ortance. During the
l demonstrations were
glasshouses and mush-

gramme undertaken by
ion of the even-ripening
rieties into two well-
Potentate' and 'Ailsa
t of this is to eliminate
nly known as 'green-
ogramme has produced
ct habit of 'Baby Lea'
e and shape, and the
of 'Moneymaker', the
rieties. The new types
lding ability, but it is

hoped they will prove valuable to the grower as a means of producing better quality fruit.

The main variety trials were concerned with the further evaluation of selections descended from hybrids with the compact-habit (short internode) 'Baby Lea' variety, and include some which have attracted a good deal of interest among growers. Some of this material is being subjected to wide screening on growers' holdings and experiment stations this year.

Of interest in connexion with the tomato-breeding programme and other work at the Institute was a demonstration by the statistician (Mr. D. Cooke) of the results of a survey carried out in 1959 of the varieties of tomato grown commercially. From a 10 per cent sample of growers seventy distinct varieties were recorded, the four most commonly grown, according to total acreage, being 'Moneymaker', which occupied 32 per cent of the 2,067 acres estimated to have been grown in Great Britain in 1959, 'Potentate' (17 per cent), 'Ware Cross' (15 per cent) and 'Ailsa Craig' (6 per cent). Within this general pattern, however, there were marked differences according to district and time of planting.

The Chemistry Department, under Dr. G. W. Winsor, demonstrated some aspects of its work on plant nutrition, composition and biochemistry. The nutrition trials now cover the tomato, carnation, lettuce and early-flowering chrysanthemums, and the Department is closely associated with studies on bulb nutrition at the Ministry of Agriculture's Experimental Husbandry Farm at Kirton, in Lincolnshire. The special demonstration for the day was on the subject of carnation nutrition, the first experiment, extending over two years, having just been completed. This factorial trial, testing three levels of nitrogen and two of potash in the presence or absence of added phosphate, magnesium or calcium, making forty-eight different combinations of fertilizer treatment in all, showed a beneficial response to phosphate and nitrogen in terms of total flower production, and splitting of the calyces was more marked at low nitrogen-levels. A more complete assessment of the results will be possible when the numerous soil and tissue samples taken during the course of the experiment have been analysed. Visitors were able to see the second experiment on this subject which had just been planted; this is another factorial trial comprising four levels of nitrogen and three levels of potash supplied in liquid feeds, superimposed on four levels of phosphate and two levels of lime incorporated in the planting compost.

Other subjects dealt with by the Chemistry Department were the problem of manganese toxicity and the effect of soil salinity on plant growth. Symptoms of manganese toxicity had been observed on tomato, carnation and lettuce, and the disorder appears to arise when considerable amounts of soluble and exchangeable manganese are released from glasshouse soils sterilized by steaming. For the soil salinity studies a reliable and convenient method for the fairly rapid determination of salt concentration in the presence of sparingly soluble salts such as calcium sulphate, which commonly accumulate in glasshouse soils, is being sought.

The Chemistry Department is devoting a good deal of attention to studying the composition of tomato fruit. Rapid methods have been developed for the analysis of relatively large numbers of fruit samples, and much information is being accumulated on the relation between fruit composition and manurial levels, variety and environmental conditions. Special attention is being paid to the problems of fruit quality in relation to fruit composition, and it is hoped that the information being obtained will serve as the basis of an approach to the problem of fruit flavour. Although there is much still to be learned as to the primary cause of fruit disorders, such as 'blotchy ripening', it is clear that their development ultimately depends on some departure from the normal biochemical processes of fruit ripening. Studies of certain enzymic processes in tomato fruit have therefore been undertaken, starting with the pectic enzymes associated with the softening of tomato fruit during ripening. Limited exploratory work on the effects of ripening of certain enzyme inhibitors injected into tomato fruit is also in progress, the object being to gain some insight into the mechanisms by which rates of ripening are controlled in the fruit.

The environmental factors which influence ripening disorders in the tomato fruit have also been investigated by the Plant Physiology Department, under Dr. E. R. Leonard, and experiments were shown in which the effects of subjecting fruit tissues to different levels of temperature, while the plants remain at house temperature, were being studied with particular reference to fruit coloration.

Work on the growth of the tomato has been carried a stage further, and plants were seen growing in glass chambers in which the environment, including day-length, is partially controlled. Weekly measurements of roots, stems, leaves and fruit were being made on these plants, as well as daily counts of anthesis. In an accompanying experiment the relation between growth and development of tomato plants and the age of the plant and time of year was being further investigated, with special reference to the development of the first truss.

Work on virus diseases was a particular feature of displays by the Plant Pathology Division, under Dr. L. Broadbent. A number of diseases of flowers and ornamentals which are being studied were demonstrated, as well as attempts to free stock plants of chrysanthemum and carnation from virus diseases by heat therapy or meristem culture. The investigation of tobacco mosaic virus on the tomato, a serious problem to the grower, has been intensified, and several critical experiments on various aspects of the problem were in progress. Special attention is being paid to the sources of infection in commercial glasshouse practice, and experiments are being carried out to determine the relative importance of seed, infected residues in the soil, infected structures and tools, infected clothing and smoking tobacco. An attempt is also being made to assess the loss from infection under glass, using a moderately severe strain of tomato mosaic virus inoculated into two varieties, 'Potentate' and 'Moneymaker', at three stages in plant growth. The experiment was planted in mid-February, and by the open day there were marked differences in growth and fruit set between early-infected plants and the remainder, all the inoculated plants being still healthy.

Also within the programme of the Plant Pathology Division was a demonstration of the work on the 'watery stipe' disease of the cultivated mushroom, undertaken in the Mycology Department under Mr. P. H. Williams. Recent experiments have shown beyond doubt the transmissibility of this disease, and the infective principle in a diseased mycelium, which is always characterized by abnormally poor growth, can be passed to a healthy one simply by growing the two together. The further finding that infectivity can be eliminated from diseased cultures by a process akin to heat therapy raises the intriguing possibility that a virus may be responsible for the mushroom disorder, and virological techniques are being employed with the view of finding out if this is so.

Other work on cultural aspects of the mushroom is undertaken by the Horticultural Department under Mr. G. F. Sheard, and specially constructed chambers for studying the effect of environmental conditions on fruiting and development of the mushroom were on view. In these chambers, of which there are eight, each with 4 sq. ft. of growing area, temperature, relative humidity and ventilation-rate can be varied independently.

Among crop protection problems under study was a comparison of chemical soil sterilizing agents, including the newly introduced metham-sodium (sodium methyldithiocarbamate), with the traditional steaming method. This experiment has shown that on a soil free from serious soil-borne diseases, yet needing sterilizing to restore fertility, chemicals can be as effective as steaming, treated plots giving about a 20 per cent increase in crop over the untreated controls. The long-term effects of repeated applications of

chemicals need,
distribution of t
down and poss
investigated in t
The problem c
the glasshouse r
Koch), which is
Lea Valley on c
operative project

l, however, and the
the soil, their break-
ic effects are being

acaricides shown by
(*Tetranychus urticae*
ous proportions in the
being tackled as a co-
rotection Department,

under Mr. W. H. Read, and the Entomology Department, under Dr. N. W. Hussey. This work involves the testing of Lea Valley strains of the mite for cross-resistance to other acaricides to assess the practicability of increasing the range of materials in use. This is to be followed by large-scale trials later this year to investigate control of the pest by physical and biological agencies to which it is unlikely to develop resistance.

F. W. TOOVEY

SCIE CHING IN SECONDARY MODERN SCHOOLS

SERIOUS defi
teachers, lab
many secondary
results of a surve
Association. Th
attend secondar
them serious sho
returned the ques
no teaching in sc
there were no t
were no teache
teaching science.
The material
more than 1,50
pared with a tot
existing in 1958
throughout by t
mittee of the Sc
The Committe
laboratory for e
schools of 301–60
than 600. The
the conditions u

provision of science
science equipment in
ls are revealed in the
y the Science Masters'
the nation's children
ools, yet in many of
vealed. Many schools
ng that they provided
ht no science because
ies, 33 because there
who were capable of

y was collected from
es. The return com-
00 schools of this type
gation was conducted
Modern Schools' Com-
Association.
t there should be one
in the school, two for
three for those of more
that on investigating
ence was being taught

in secondary modern schools, 47 per cent are obliged to teach all or part of their science under unsatisfactory conditions.

The investigation revealed that only one science teacher in six in a secondary modern school is a graduate, while about one in six has "no pretensions at all to science qualifications". Only 34 per cent of the schools considered that they were adequately staffed for teaching science. Special account is taken in the survey of head teachers' opinions on the most important needs to improve science teaching. Their orders of priority are more science teachers, more laboratory accommodation, and more equipment.

The statistical return suggests that, in 65 per cent of the schools concerned in the survey, more science staff are needed. The booklet comments: "It follows that in the country as a whole no fewer than 2,500 schools need science teachers and in some cases more than one teacher will be required".

Copies of the booklet are available, price 1*s*., from Mr. D. M. Chillingworth, The Village College, Swavesey, Cambridgeshire.

NTIFIC RESEARCH IN EAST AFRICA

JUST over half
High Commi
African Researc
some £706,466 w
on the Desert
Meteorological I
Directorate of C
expenditure in 1
£567,863 was re
Government in
or direct Exche
work of these r
the East Africa
Organization, th
the Fishery Rese
for Medical Res
published under
59", but no refer
curtailment of
reduction of sc
Commission's or
torial financial c
and Fisheries Or
to the reductio

ort of the East Africa
deals with the East
le Services, on which
ith a further £212,962
y, £270,812 on the
nd £470,645 on the
ut of a total recurrent
07,933, towards which
the United Kingdom
lopment and Welfare
Some account of the
izations, for example
nd Forestry Research
esearch Organization,
tion and the Institute
cluded in the reports
lonial Research 1958–
in that report to the
rammes through the
t some of the High
consequence of terri-
st African Agriculture
ort, for example, refers
blishment of research

officers from 28 to 23 and of scientific assistants from 20 to 14, chiefly in the Divisions concerned with soil fertility, soil chemistry and soil classification, with the result that the Organization is not always able to co-operate effectively with the Territorial Departments. The Trypanosomiasis Research Organization also refers to reduction in staff, and the Meteorological Department has found the difficulty of recruiting staff from Britain to constitute a formidable obstacle in its programme of expansion. On the other hand, help is being received from the Rockefeller Foundation for agricultural research in East Africa, and the Nuffield Foundation is financing further research on the physiology of drought resistance in crops, and on the improvement of the nitrogen status of tropical soils by suitable use of indigenous tropical legumes.

The work of the Agriculture and Forestry Research Organization has included work on the increase of crop-yields by reducing the damage done by pests and diseases, such as the study of 'stem pitting' of *arabica* coffee, a survey of the nematodes of the principal East African crops, the development of a strain of maize resistant to the virus disease known as 'streak', and also work on the effect of drought on the growth of plants and the water requirements of irrigated crops. Forestry research also has been concerned with the effect of forests on water supplies, as well as the best methods of raising seedling trees in the nursery and for planting out in the forest, and the protection of East African forests against insect attack, particularly by timber borers, and the use of ultrasonic and gamma-radiographic techniques to detect attack and to measure the severity of attack are being examined. In the Veterinary Research Organization, the Division of Virus Diseases achieved interesting and important results in its investigation of rinderpest. Good progress was made in research on swine fever, and work on East Coast fever continued; but the work of the Division of Bacterial Diseases was hindered by shortage of staff.

---

* East Africa High
100. (Nairobi: Gov

nual Report, 1959. Pp. iv+
960.) Sh. 5.

The reorganization of the East African Trypanosomiasis Research Organization is well advanced, and all research disciplines are being concentrated at Tororo in Uganda. Studies on the trypanosomes are being developed mainly towards an understanding of immunology and the routine testing of new drugs for cattle prophylaxis is now to be the concern of the Territories, and the Research Organization is recruiting workers for fundamental studies on drug resistance. The Marine Fisheries Research Organization continued its work on tuna longlining and the North Kenya banks survey, and an investigation of the potential prawn fishing of the estuarine waters of Tanganyika was commenced.

The Pare–Taveta malaria scheme of the East African Institute of Malaria and Vector-borne Diseases, which ended in June 1959, has shown that malaria transmission can be reduced to a very low level but not completely arrested, as a result of four years residual spraying of houses, in an area of hyperendemic malaria. The dispersion and longevity of *Anopheles gambiae* were studied mainly by introducing radioisotopes into the larval breeding pans. The completion of the 120-ft. steel tower in the Mpanga forest enabled the Virus Research Institute to expand considerably its work on the biology of mosquitoes and other blood-sucking flying insects, and the analysis of data collected over the past fifteen years indicates that while in some species of mosquito the biting pattern is uniform over a very wide area, in others the pattern varies according to locality, environment or even level in the forest. The East African Leprosy Research Centre commenced a therapeutic trial of 'Etisul', and surveys of leprosy clinics in Uganda and Kenya confirmed the low proportion of true lepromatous cases.

The East African Industrial Research Organization completed its projects on the mechanical drying of coffee and on the control of arsenic in the production of cement copper. The Meteorological Department continued its investigation on the use of cetyl alcohol to reduce evaporation from water surfaces, and a two-year programme of forecasting research was commenced in June 1959 to gain knowledge of the rain-producing agencies operative in East Africa and the improvement of weather forecasting generally. Progress is being made in the study of the strong winds which occur at high levels in tropical and sub-tropical latitudes. The Desert Locust Survey reports on control operations against swarms in the Somaliland Protectorate, January–June 1959 and July–October 1959, and in Turkana, April–May 1959, and on campaigns against hopper of the short-rains generation in the Somali peninsula conducted in the Ogaden. Reference is made in the report to the problems created for the Directorate of Civil Aviation by the introduction of jet airliners and to the difficulty of recruiting suitably trained and experienced officers capable of maintaining standards

SUICIDE: A NEGLECTED PROBLEM

THE incidence of suicide is on the whole low in the less-developed countries, high in the more; and in some countries of very high living standards it has become a problem of considerable proportions. Between the ages of fifteen and forty-four it is the second most important cause of death in Japan, the third in Germany, Denmark, Sweden and Switzerland, and the fourth in Canada, Australia and the United States. It is also an important cause of death between the ages of forty-five and sixty-four*.

In the United States some 16,000 people commit suicide every year, as compared with 14,000 who die from tuberculosis and 40,000 who die from motor accidents; in England and Wales the number of suicides, approximately 5,000 annually, is nearly as great as the number of those who die from pulmonary tuberculosis, and slightly exceeds the number who die from motor accidents. More men commit suicide than women, and, as age increases, the preponderance of male suicides becomes greater.

Durkeim, in his classic study of suicide, divided suicide into three types: the altruistic, in which the individual's life is rigorously controlled by the customs and beliefs of a rigid society, and who commits suicide for religious or political reasons; the egoistical, in which he is insufficiently integrated into society; and the anomic, in which he is insufficiently regulated by society and his adjustment may be upset by economic catastrophes or sudden wealth.

Inherent disposition plays an important part in suicides. The stresses of loneliness and friendlessness act with selective severity on those predisposed to mental illness, and these are often the individuals who commit suicide. Cause and effect are not easy to distinguish. Do individuals, for example, who commit or attempt to commit suicide drift into isolated environments because of the illness that drives them to take their own lives, or are certain environments conducive to suicidal tendencies? Alternatively, is loneliness both a consequence of mental ill-health and a factor increasing the chances of suicide? The whole problem of suicide is extremely complex; the causes are not well understood.

Statistical data about suicide are among the most clear-cut epidemiological facts in the whole field of psychiatry, and should lend themselves to intensive inquiry. It might then be possible to understand more clearly why there are striking differences in incidence between the more-or-less developed countries, between communities of different religious denominations, and between urban and rural areas. It should then be possible to prevent attempts at suicide, and provide those who attempted but failed with efficient after-care or social support.

---

* *WHO Chronicle*, 14, No. 5 (May 1960).

AL TIVITY OF CERTAIN BOTANICAL MATERIALS

V. V. MAYNEORD, R. C. TURNER and J. M. RADLEY

Physics Department, Institute of Cancer Research :
Royal Cancer Hospital, London, S.W.3

THE data i his article result from
continuati of investigations aimed
at defining the sent levels of naturally
occurring radio and his environment$^{1-4}$.
Previously we cerned with the direct
intake of natur y by man, and this has
led inevitably t e activity of foods and
waters and to a range of plant and
animal materia lemonstrated the great
variations in le ctivity to be found in
different foods now led us to make
measurements plants, some of which
are used direct ods while others, such
as grasses, form food of animals, which
in turn themsel man food.

Knowledge of lpha activities of plants
has become m another point of
view connected ng of nuclear installa-
tions. The im arly detection of any
emission of ra erial from such sites
demands that natural activity in the
neighbourhood defined prior to the
commencement n. Furthermore, in
defining these t must be possible to
identify the alp aterials present, and to
be able to diffe een the natural radio-
activities due t nd thorium series and
that due to art ed alpha emitters such
as plutonium-2

We have foun ation of plant materials
one of very gre and from a large mass
of experiments s we have therefore
selected data ill ossible answers to one
or two fundam s.

The measure l alpha activity, the
assessments of ontributions made by
the uranium an series and the precise
identification o s present have been
carried out usi previously reported^{1,4}.
A number of th matts and grasses were
assay samples the Radiobiological
Laboratory of ral Research Council.
These grasses w the form of specimens
of mineral ash muffle furnace treat-
ment of the orig at 550° C. some months
previously. Ot ls, fruit and vegetation
were provided inster Hospital Medical
School Expedit- Africa in 1958. This
material comp s of fruit, leaf, twig,
bark and root f of species together with
the correspond f soil. The fruit and
vegetation sam iced to ash at 650° C.
and serial mea ed over many months
made on the as

The soils and e been measured in the
raw state, altho ecimens have also been
ashed and the s compared with the
values for the r again over long periods
of time subseq s.

Study of the reduction, produced by ashing, of alpha activity due to the uranium series and of the rate of recovery of this activity during the succeeding months has provided valuable information as to the presence of specific members such as lead-210 and polonium-210 in many of the matt and vegetation specimens. Further evidence of the presence of polonium-210 has been provided by an alpha-ray spectroscopic technique^{4}. Serial measurements have, in addition, provided evidence of growth of alpha activity due to the thorium series in numbers of the specimens of vegetation.

Measurement of more than fifty specimens of soils, sands and chalks from different parts of Great Britain and from Central Africa revealed values of total alpha activity ranging over a factor of only 5 to 1 for soils and about 8 to 1 for sands.

Table 1 lists the values found for a few selected specimens including the maximum and minimum activities so far observed in each category. Assuming that radioactive equilibrium exists in both series, the soil uranium contents range from 0·5 to 2·3 and the thorium contents from 0·6 to 3·0 μμc./gm. soil.

Table 1. Soil Activities in μμc /gm. Raw Soil

Ref.	Origin	T.A.A.	U-238	Th-232	Th/U
9	Central Africa	20·6	1·4	1·6	1·1
11	,, ,,	25·2	1·5	2·2	1·5
14	,, ,,	26·2	2·2	1·5	0·7
22	,, ,,	11·1	0·7	0·9	1·3
23	,, ,,	23·8	1·5	2·8	1·9
24	,, ,,	15·7	0·2	2·0	10·0
27	,, ,,	15·6	1·1	1·1	1·0
28	,, ,,	19·8	1·6	1·2	0·8
29	,, ,,	21·2	1·9	1·0	0·5
30	,, ,,	18·1	1·5	1·0	0·7
31	,, ,,	23·4	1·3	3·0	2·3
SA1	Wales	13·0	0·4	1·7	4·2
SA4	,,	11·0	0·3	1·4	4·7
SA6	Devon	36·0	2·3	3·0	1·3
SA9	Scotland	7·7	0·5	0·6	1·2
SA12	Ireland	11·0	0·5	1·2	2·4
SA22	Berkshire	15·5	0·9	1·3	1·4
	Cornwall	20·0	0·8	2·8	3·0
	Cornwall	10·0	0·4	1·1	2·5
Sand 1	Isle of Wight	6·0	0·4	0·4	1·0
Sand 2	Cornwall	50·0	2·5	5·0	2·0
Chalk 1	Surrey	0·9	0·06	0·06	1·0
Chalk 2	Kent	0·8	0·07	0·04	0·5

The values observed for chalks are relatively much lower, with little difference between specimens of different origin.

Six months or so after sealing the soil samples the majority showed small increases of 5–6 per cent in their alpha activities, presumably due to reduction of loss of radon and hence to a slight build-up of radon and the later members of the uranium series.

The specimens of raw matt showed initial values of total alpha activity ranging from 8 to 28 μμc. per gm. a few days after sealing, but in the subsequent months marked differences were observed between the behaviour of the various samples.

Table 2. Activities of Raw Matts in µµc./gm.

Ref.	Origin	T.A.A.		U-series		Th-series	
		$t = 0$	$t = 100$	$t = 0$	$t = 100$	$t = 0$	$t = 100$
*SA*1	Wales	13·0	13·0	4·8	—	8·4	—
*SA*4	Wales	11·0	12·3	9·4	10·5	1·8	1·8
*SA*6	Devon	28·0	31·1	15·0	18·1	13·0	13·0
*SA*12	Ireland	9·4	9·4	4·0	—	5·4	—
*SA*23	Berks	8·0	10·4	3·7	6·1	4·3	4·3
*SA*24	Berks	8·2	12·2	5·8	6·6	2·9	5·6

Table 2 gives the values of alpha activity and the relative contributions from the two natural series observed in a few of the specimens at time $t = 0$ (soon after sealing the sample) and 100 days later. Three types of behaviour are illustrated.

In samples *SA*1 and *SA*12 no change was observed in their activities after 100 days, whereas in *SA*4, *SA*6 and *SA*23 the total alpha activities rose, due to increased activity of the uranium series with the contribution from the thorium series remaining unchanged. In *SA*24 there is increased uranium series activity and an even more striking rise in activity due to the thorium series. Evidently the matts may have either or both of the two natural series in a state of radioactive equilibrium or disequilibrium, and the alpha activity of any particular specimen may vary appreciably with time after sampling.

An aliquot of *SA*4 matt showing increased uranium series activity with time was reduced to mineral ash in a muffle furnace and a series of measurements carried out on the ash during the following twelve months.

Table 3 summarizes the results of these observations. A concentration of 7·26 times was achieved by ashing, and the figures for the raw matt activity in column 4 have been derived by dividing the values of ash activity in column 3 by this factor. Column 2 gives the values observed directly on the raw matt sample.

Table 3. Recovery of Matt Activity after Ashing Specimen *SA*4

Days after sealing	Total alpha activity µµc. per gm.		
	Raw matt by direct measurement	Matt ash	Raw matt value from ash value and concentration
0	11·0	13·6	1·9
28	11·5	24·0	3·3
100	12·3	43·0	5·9
150	—	53·0	7·3
335	12·5	64·6	8·9

It will be seen that immediately after ashing the estimated alpha activity of raw matt as deduced from the ash value (column 4) was only 17 per cent of the value observed directly (column 2) for the raw matt. After 28 days when the radon, radium *A* and radium *C′* lost in the ashing process have recovered to equilibrium with the radium-226 present, the ash activity is still only 29 per cent of the expected value. The ash activity continued to increase and is still rising after 335 days from the time of ashing.

Using the ash activities of column 3 and assuming that the increase in alpha activity after 28 days is due to the growth of a single alpha emitter, it is easy to calculate that the half-life of this emitter would be about 150 days and we deduce that the nuclide concerned is almost certainly polonium-210. If this is the case, the final value which will be reached by the polonium-210 can be shown to be 78·0 µµc. per gm. ash and the equilibrium total alpha activity to be 92·7 µµc. per gm. ash. This latter figure corresponds to a raw matt activity of 12·8 µµc. per gm., which has very nearly been reached by the direct measurements on the raw matt given in column 2.

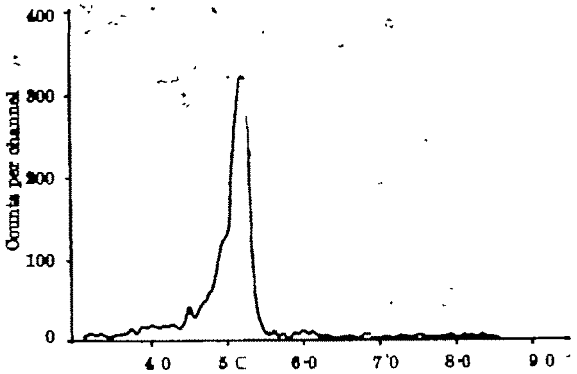


Fig. 1. Alpha-ray spectrum of *SA*4 matt ash

Furthermore, the constant portion of the activity of the ash after 28 days can be shown to be 14·7 µµc. per gm., of which 2·9 µµc. is due to radium-226. Hence the radium *D* (lead-210) content of the matt is a factor of 78·0/2·9, that is, 27 times higher than the radium-226 level.

In other words, 84 per cent of the alpha activity of this matt specimen is apparently due to the single nuclide polonium-210 existing in or near equilibrium with its parent lead-210, which itself is present at a much higher level of activity than radium-226.

Fig. 1 shows the alpha-ray spectrum of this particular matt ash and clearly indicates that a single alpha emitter is responsible for the majority of the activity and that its energy is approximately 5·3 MeV., the energy of the polonium-210 alpha particle.

Table 4. Grass Ash Activities in µµc./gm. Ash

Ref.	Origin	T.A.A.	Ra-series	Th-series
*SA*1	Wales	9·6	5·6	4·0
*SA*6	Devon	11·0	8·2	2·8
*SA*9	Scotland	21·0	16·0	5·0
*SA*12	Ireland	9·7	6·4	3·3
*SA*22	Berks	1·1	0·9	0·2
*SA*23	Berks	5·2	4·1	1·1
*SA*24	Berks	2·8	1·8	1·0
*D*69	Wales	67·0	64·0	3·0
*D*154	Wales	85·0	79·0	6·0

Table 4 lists the total alpha activities and the relative contents of the two natural series observed in specimens of grass ash made available to us many months after ashing. It will be seen that the total alpha activities range from 1·1 to 85·0 µµc. per gm. ash—a factor of almost 80 to 1. The higher values were found in specimens derived from Wales and Scotland, and in these cases the alpha activity is very largely due to the radium series which contributes up to 90 per cent of the total alpha activity.

It will be seen from comparison of Tables 1 and 4 that no simple relation is apparent between the natural activity of a particular specimen of grass and the activity of the soil in which it grows.

Table 5 gives the results of serial observations on six samples of grass ash at 30, 100 and 180 days subsequent to ashing. No evidence of change of thorium series activity was observed in these specimens, whereas the radium series content in each case

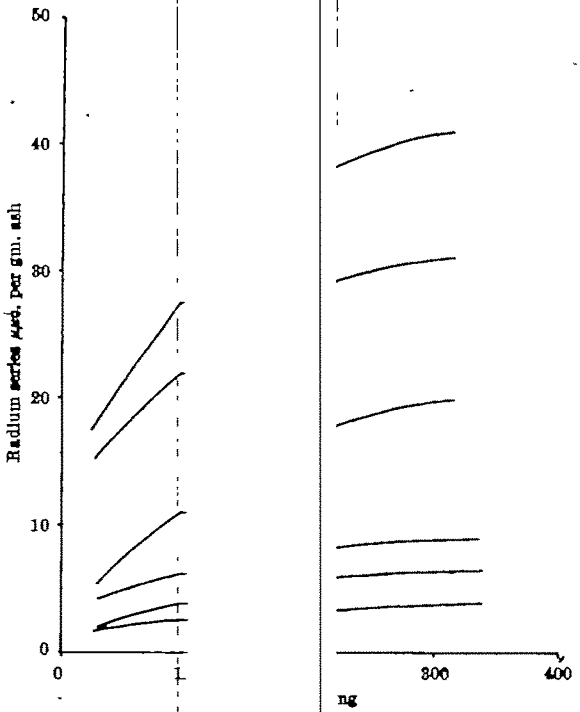


Fig. 2. Inc

grass ash specimens

increased with t
after ashing. Aft
radium C′ lost
equilibrium with
Assuming that th
to the growth of
half-life of this e
rate of growth o
and is given in t

rising some 300 days
radon, radium A and
g will have reached
26 present in the ash.
rise in activity is due
-emitting nuclide, the
n calculated from the
ach specimen (Fig. 2)
of Table 5.

Table 5. G

s in μμc./gm. Ash

Ref.	Origin	T	um series 100 days	180 days	Calculated half-life in days
JC1	Wales		11 4	16·2	151
JC2	Wales		22 4	27 9	152
T	Wales		28·4	36·4	145
CM	Berks		2·55	3·02	142
W5	Cumberland		3·60	5·60	143
W8	Cumberland		6·3	7 8	126

The mean half
is 143 days and t
that the rise of a
build-up of polon
to equilibrium w
existing in the gra
than radium-226.

Table 6 gives
various parts of
together with the
It will be seen the
higher values of
much lower level
be any correlatio
species of fruit a
plant has grown.

Table 7 illustra
observed in a few
first four samples

for the six specimens
em to be little doubt
0 days is due to the
n the ashing process,
ear half-life lead-210
igher level of activity

a activities found in
from Central Africa
he soil in each case.
the bark possess the
he fruit usually at a
does not appear to
activity of different
e soil in which the

ses of alpha activity
mens of leaf ash, the
ical increases due to

the radium series and the remaining three due to the thorium series.

Assuming that the rise of activity of the radium series is due to the growth in activity of a single alpha emitter, the half-life of this nuclide has been calculated from the data of Table 7. The values are respectively 163, 139, 124 and 167 days with a mean half-life of 148 days. Once again there would appear to be little doubt of the phenomenon being due to the growth of polonium-210 to equilibrium with its parent lead-210.

The increases of thorium series activity appear to be linear up to the latest time of observation—300 days after ashing—indicating the growth of an alpha emitter the half-life of which is much longer than 300 days. The thorium series contains only three members with half-lives longer than 300 days, namely, the head of the series thorium-232, its daughter radium-228 (half-life 6·7 years) followed by thorium-228 (half-life 1·9 years). During the whole of our investigations on human, animal and plant tissues no evidence has yet been found, even by alpha spectroscopy, of the presence of thorium-232 in such materials.

In the absence of thorium-232 at a higher level of activity than its daughter radium-228, there remains only one possible explanation for the growth of activity due to the thorium series at the rates indicated in Table 7, that is, by the growth of thorium-228, and hence of all the subsequent short-lived members of the series, towards equilibrium with its parent radium-228.

If radium-228, not itself an alpha emitter, exists in the leaf ash at a level of activity higher than its daughter thorium-228, then the observed increases in thorium series activity are explained. This in turn implies that the plant takes up the radium isotopes in preference to thorium and is in agreement with our earlier findings for human and animal tissues and for plant foods. In all these cases the radium contents are invariably in excess of the thorium levels, in spite of the greater abundance of the latter in the soil.

One of the outstanding features of these observations is the very wide range of natural alpha activities found in vegetation compared with that in the corresponding specimens of soil. We recognize the

Table 6. T.A.A. 10^{-14} c./gm. Raw at 30 Days

Specimen	Soil	Fruit	Leaf	Twigs	Trunk	Bark	Root
Banana	2,060	0 8	83 0	—	—	—	—
Manioc 1	2,520	—	28 5	—	26·8	—	13 5
Manioc 2	2,840	—	8 4	—	—	12·4	1 8
Coconut	1,110	1 0	—	—	—	135 0	—
Paw-paw	2,880	3 5	26 7	—	12 6	—	—
Coffee	1,270	6 5	8 4	—	—	27 9	—
Rubber	1,560	2 3	9·7	17 8	—	13 4	—
Cocoa	1,980	1 8	21 2	13 9	—	28·4	—
Cotton	2,120	7 6	52 0	29 4	—	—	—
Pommes-sur-terre	1,810	1 4	12 8	—	—	—	—

Table 7. Activities in μμc./gm. Ash

Specimen	Radium series			Thorium series		
	30 days	100 days	300 days	0 days	100 days	300 days
Coffee leaf	1 6	3 6	6 9			
Pommes-sur-terre leaf	3 0	5·0	8 0			
Manioc leaf	3 2	5·8	9 6			
Rubber leaf	3 7	7 8	14 1			
Cotton leaf				2 6	4 4	8 4
Cocoa leaf				0 8	1·6	3 4
Paw-paw leaf				2·2	3·3	5 5

difficulty of obtaining representative samples of such materials; but it is clear that no simple general correlation exists between the plant and soil activities.

It has been interesting to observe the widespread and often predominant activity in vegetation due to polonium-210 which appears to be present in specimens ranging from British grasses to plants of various species from Central Africa. It is evident that this substance or one of its precursors such as radon-222 or lead-210 may be taken up directly from the soil. It has been shown by Jaki and Hess[7] that even moderate rainfall can restrict the rate of escape of radon-222 from the surface of the soil, and it is clear that in areas of high rainfall this factor could result in concentrations of lead-210 and in turn polonium-210 being produced in the top layer.

A linear relationship between the alpha activity of grasses and the annual rainfall has been demonstrated by our colleague, Mr. C. R. Hill[8], and suggests that polonium-210 or one of its precursors may also be taken up directly from rain. The relative importance of the contributions resulting from these two mechanisms presumably varies from site to site, depending on parameters such as species of plant, soil drainage characteristics, depth of the water table below the surface and probably many other factors.

The complexity arising from the evident preference of vegetation for radium rather than thorium isotopes together with uncertainty of the degree of radioactive equilibrium existing in the plant–matt–soil system at any particular time renders generalization dangerous.

We have so far little information concerning variation of the natural alpha activity of plant materials with season, rate of growth and many other parameters. It is clear that in order to define the alpha activity of vegetation on or near a given site, complex sampling procedures are necessary, followed by serial measurements spread over a considerable time.

We express our gratitude to the Westminster Hospital Medical School Expedition, 1958, for making available to us the range of soil and plant materials from Central Africa. We would also like to thank Dr. R. Scott Russell, director of the Radiobiological Laboratory of the Agricultural Research Council, for providing the numerous assay samples of soils, matts and grasses. Finally, we wish to thank our colleagues, Mr. C. R. Hill and Miss Mary Duggan, of this Department, for their assistance during these investigations.

[1] Turner, R. C., Radley, J. M., and Mayneord, W. V., *Brit. J. Radiol.*, 31, 397 (1958).
[2] Turner, R. C., Radley, J. M., and Mayneord, W. V., *Nature*, 181, 518 (1958).
[3] Turner, R. C., Radley, J. M., and Mayneord, W. V., *Health Phys.*, 1, 268 (1958).
[4] Mayneord, W. V., Radley, J. M., and Turner, R. C., Second United Nations Conference on the Peaceful Uses of Atomic Energy. *A*/Conf./15/*P*41 (1958).
[5] Mayneord, W. V., Radley, J. M., and Turner, R. C., *Strahlentherapie*, 110, 431 (1959).
[6] Mayneord, W. V., and Hill, C. R., *Nature* 184, 667 (1959).
[7] Jaki, S. L., and Hess, V. F., *J. Geophys. Res.*, 63, 373 (1958).
[8] Hill, C. R. (following article).

LEAD-210 AND POLONIUM-210 IN GRASS

By C. R. HILL

Physics Department, Institute of Cancer Research
Royal Cancer Hospital, London, S.W.3

In recent publications from this Department[1,2] it has been shown that the α-activity observed in certain samples of grass is largely due to the presence of polonium-210 (radium *F*), accompanied by its parent lead-210 (radium *D*). In the present communication evidence is presented that suggests that a large part of such activity may originate as a decay product of atmospheric radon (Table 1), which is afterwards deposited on to the grass by rainfall.

Table 1. THE LONG-LIVED DECAY PRODUCTS OF RADON-222

Nuclide	Half-life	Mode of decay
^{210}Pb (Ra D)	22 yr.	$\beta\gamma$
^{210}Bi (Ra E)	5 day	β
^{210}Po (Ra F)	138 day	α
^{206}Pb	stable	

Samples of grass and topsoil were collected during the first week of December 1959 from twenty well-separated points in the southern part of Great Britain, chosen to provide a wide variety of soil and rainfall conditions. Total α-activity measurements[3] were made on the dried grass and soil samples and also on a number of grass ashes. Observation of the build-up of polonium-210, following its volatilization on ashing, has confirmed that the α-activity measured in the grass samples was again due mainly to this nuclide. A similar increase in α-activity with time was observed in the case of the unashed dry grass samples, but from a relatively higher initial level, indicating that the polonium-210 in the grass at the time of collection had already reached between 35 and 80 per cent equilibrium with its parent lead-210.

In Fig. 1 the measured total specific α-activities of the individual dry grass samples (extrapolated to the condition of equilibrium between polonium-210 and lead-210 and hence an approximate measure of the respective lead-210 concentrations) are plotted against the values of mean annual rainfall at the sites of collection. A linear relation is clearly suggested, the value of the correlation coefficient being 0·87. The lead-210 concentrations have also been found to be related to the β- and γ-activities due to fission products[4] for which, as is well known, the predominant mechanism of deposition is wash-out in rainfall. No correlation was found between the total α-activity of the grass and that of the soil.

To account for these observations, two possible mechanisms might be postulated: (*a*) uptake of lead-210, or one of its short-lived precursors from the soil, and (*b*) direct deposition in rain of a partial equilibrium mixture of lead-210, bismuth-210 and polonium-210, produced by decay of atmospheric radon-222. While uptake from the soil probably occurs to some extent, the observed correlation with rainfall and with fission product activity suggests that direct deposition must be important. As shown below, such evidence is supported by the similarity between the observed levels of lead-210 activity in grass and those that might be expected on the basis

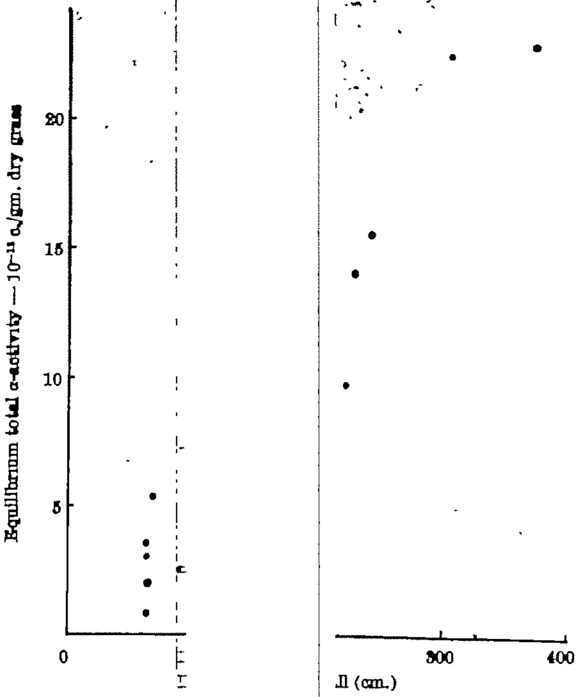


Fig. 1. Varia of α-activity in grass

of present knowle
of atmospheric
observed: (*a*) t
fined mainly to
atmosphere, and
total lead in a
times greater t
mineral origin.

As is well know
by the land surf
this gas is ther
Radioactive dec
short-lived daug
lead-210, which
surface. Burton
gated this proce
that the mean r
content of the
weeks, a period
mixing to occur
half-life of 22 ye
that the mean r
at Harwell, com
year, is 1,650
agreement with
atmospheric lea
rate of release o
and its concentr
sphere.

Since apprecia
occur, it seems
lead-210 in rainv
by local variatio
therefore conclu
tion of lead-210
place at a rate o
each 100 cm. of
period that prec
the yields of gra
estimated to hav

ndance and behaviour
n addition, we have
y appears to be con-
plant exposed to the
ratio of lead-210 to
s ash may be twenty
ge value for lead of

s released continuously
rth, and a reservoir of
d in the atmosphere.
eric radon-222 and its
m the formation of
turns to the Earth's
have recently investi-
tail and have shown
of the total lead-210
sphere is about four
ppreciable atmospheric
ared to its radioactive
rkers have also shown
on of lead-210 in rain
ean rainfall of 73 cm./
/year, in reasonable
te of production of
d from data on the
m the Earth's surface
ribution in the atmo-

o mixing is known to
the concentration of
affected significantly
ion-rate, and we may
ove data that deposi-
n Great Britain takes
× 10^{-12} c./m.^{2}/year for
. In the three-month
ction of our samples,
us collection points are
range 20–200 gm./m.^{2}

(dry weight), and precipitation in this period was 23 per cent of the mean annual value. On the extreme assumption of complete retention of activity by the grass following deposition in rain, values of specific activity could thus have been expected to occur in the range 2·6–26 × 10^{-12} c./gm. of dry grass for each 100 cm. of annual rainfall. It is therefore apparent that, within the rather wide limits of uncertainty inherent in the above assumptions, the levels of lead-210 observed in grass (Fig. 1) are comparable with those that might have been expected as a result of deposition from the atmosphere.

Uptake of Polonium-210 by Sheep

The recognition that polonium-210 occurs as a natural contaminant of grass has suggested the investigation of its possible uptake by herbivores. At the same time that the above grass samples were collected, samples of lamb kidney, stated to be of local origin, were purchased from several shops in each of two Welsh market towns close to areas of high rainfall. Total α-activity was measured on minced, acetone-dried tissue and, in two cases, tissue samples from the cortex and medulla were measured separately. Results of these measurements are given in Table 2.

Table 2. α-ACTIVITY MEASURED IN DRIED LAMB KIDNEY (10^{-12} C. PER GM. WET TISSUE)

Whole kidney	Cortex	Medulla
1·79	—	—
1·76	1·97	1 10
1 67	2·38	0 66
0 09	—	—
0·12	—	—
0 68	—	—

Alpha spectroscopy[1] was carried out on one sample of whole kidney and the spectrum found to consist of a single line with an energy value corresponding to that of polonium-210. Confirmation that this is the nuclide responsible, and that it occurs in the absence of lead-210, was provided by observations of the decay of total α-activity. The observed localization of activity in the cortex, which is a known characteristic of polonium[6], gives further support to this finding. It is of interest that studies on man, rabbits and rats have shown that between 5 and 15 per cent of the total body burden of polonium may be present in the kidneys[6].

Conclusion

It appears that an important contribution to the observed α-activity of grass may be provided by a process of 'natural fall-out' in which lead-210, resulting from decay of atmospheric radon, together with a fraction of the equilibrium amount of its descendant polonium-210, are deposited by rainfall directly on to foliage. Metabolic uptake of part of this activity by sheep is indicated by the presence in the kidney of polonium-210.

I wish to acknowledge the support and encouragement of Prof. W. V. Mayneord, in whose Department this work was carried out. I am also indebted to Mr. C. L. Day, of the Chester Beatty Institute, who kindly carried out an estimate of the lead content of a sample of grass ash.

---

[1] Mayneord, W. V., and Hill, C. R., *Nature*, **184**, 667 (1959).

[2] Mayneord, W. V., Turner, R. C., and Radley, J. M. (previous communication).

[3] Turner, R. C., Radley, J. M., and Mayneord, W. V., *Brit. J. Radiol.*, **31**, 397 (1958).

[4] Bentley, B. R., Burton, L. K., and Hill, C. R. (to be published).

[5] Burton, W. M., and Stewart, N. G., *Nature*, **186**, 584 (1960).

[6] Fink, R. M. (ed.), "Biological Studies with Polonium, Radium and Plutonium" (McGraw-Hill, 1950).

PARALLELISM OF CHANGES PRODUCED BY COOLING AND BY DRUGS KNOWN TO AFFECT ADRENERGIC MECHANISMS

By Prof. ELEANOR ZAIMIS

Department of Pharmacology, Royal Free Hospital School of Medicine, London, W.C.1

RESERPINE, guanethidine, bretylium, tyramine, amphetamine, ephedrine and dichloro*iso*prenaline are all substances known either to mimic or to modify adrenergic mechanisms, and their modes of action, still uncertain, have stimulated much work and discussion. During a comparative study of the effects of these drugs on skeletal muscle and on mechanisms mediated either through cholinergic or adrenergic components of the autonomic nervous system, it has been found that the responses obtained from animals at normal temperatures under the influence of these drugs were very similar to those obtained in untreated animals at lowered body-temperatures.

All the experiments have been carried out on cats under chloralose anaesthesia, and when effects of cooling were studied body-temperature was lowered either by the circulation of cold water through a fine rubber bag inserted into the abdominal cavity or by keeping the anaesthetized animal on an unheated operating table. Under anaesthesia, the body- and especially the muscle-temperature of cats tends to fall very rapidly[1]. Both methods produced a rather slow but steady fall in body-temperature without perceptible shivering. Two types of experiments have been performed: in the first the animal was pre-treated for one or several days with the drug under study; in the second, the drug was administered during the actual experiment. The results with tyramine, ephedrine and dichloro*iso*prenaline are from acute experiments only, those with guanethidine, bretylium and amphetamine from both acute and 'pretreated' and those with reserpine from 'pretreated' only.

It is well known that lowered body-temperatures markedly modify physiological processes and alter the effects produced by pharmacologically active substances. For example, induced hypothermia is usually accompanied by a fall in blood pressure and bradycardia. The responses of various drugs are either increased and prolonged or reduced. Throughout the present experiments the following responses have been compared in normal and pretreated animals at various body-temperatures: (1) the effects of adrenaline, noradrenaline, *iso*prenaline and acetylcholine on blood pressure; (2) the contraction of the nictitating membrane elicited by stimulation of the cut peripheral stump of the cervical sympathetic; (3) the effect of vagal stimulation on the heart; for this the left vagus nerve was divided in the neck and the peripheral end, separated from the sympathetic, was excited electrically; (4) the effect of a blocking dose of decamethonium on skeletal muscles.

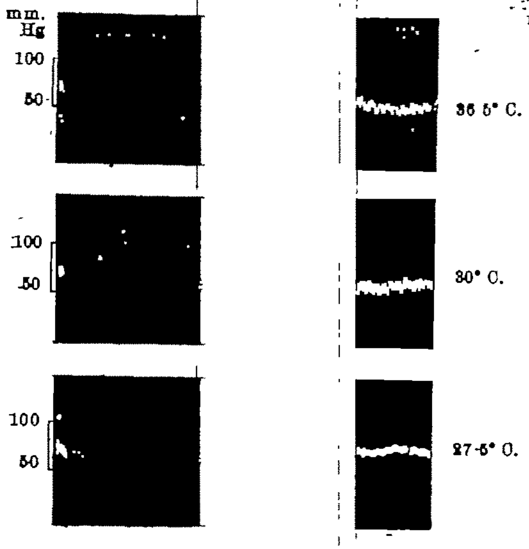
Cooling

Fig. 1 shows typical results from an untreated animal at various body-temperatures. In this particular experiment the blood pressure of the animal was initially relatively low, and therefore cooling produced a marked bradycardia without further lowering of blood pressure. As cooling proceeds, the onset of the response to adrenaline, noradrenaline, *iso*prenaline and acetylcholine is slowed, the magnitude of the response increases and the duration of action is prolonged. Over the temperature-range examined (39°–26° C.) the magnitude of these responses undergoes a diphasic change: it increases down to about 30° C., but below this temperature starts decreasing. The response to adrenaline is nearly always more affected than that to noradrenaline. On the other hand, the responses of the heart to vagal stimulation and the block produced by decamethonium increase as temperature decreases. Lowered muscle temperature is known to increase, in both animals and man, the magnitude of the effect of depolarizing drugs and markedly prolong their duration of action[2,3]. These changes appear to be independent of the actual metabolic fate of the drug; for example, decamethonium is a substance which is not destroyed in the body, whereas suxamethonium, another depolarizing drug, is rapidly hydrolysed. Cooling, however, prolongs the block produced by decamethonium, more than, or at least as much as, that produced by suxamethonium.

At lowered body-temperature various substances, but especially *iso*prenaline and adrenaline, initiate a phasic variation in the blood-pressure pattern (Fig. 1) possibly due to the initiation of phasic variations in the tone of the peripheral blood vessels.

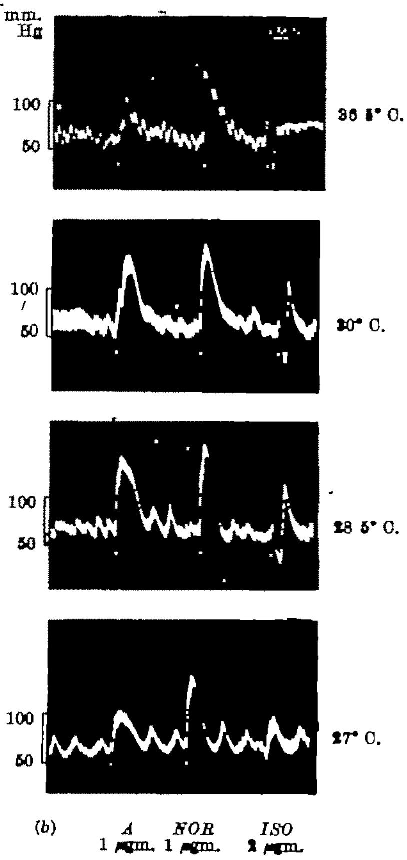
Reserpine, Guanethidine, Amphetamine, Ephedrine, Bretylium, Tyramine and Dichloro*iso*prenaline

In animals treated either acutely or chronically with any of the above compounds, the effect of vagal stimulation on the heart, the duration of the decamethonium block, and the response of blood pressure to acetylcholine are all increased (Figs. 2–5). The magnitude of these changes is, of course, influenced by the duration of the pretreatment and the dose. The fall in blood pressure produced by *iso*prenaline is also increased in the presence of all these drugs with the exception of dichloro*iso*prenaline, a drug known to antagonize the action of *iso*prenaline[4]. An interesting point is that the effect of dichloro*iso*prenaline on vagal stimulation, acetylcholine and the duration of the decamethonium block appears before *iso*prenaline is antagonized. A phasic variation in the blood pressure pattern appeared regularly again, either spontaneously or initiated by *iso*prenaline, adrenaline and to a lesser degree by noradrenaline. In contrast, the rise in blood pressure produced by adrenaline and noradrenaline ranged from a marked potentiation to more or less complete abolition depending on the drug administered, the dose and the duration of the pretreatment. For example, in acute experiments with tyramine, amphetamine and ephedrine at normal body-temperature, there was an initial reduction of the responses of the blood pressure to both adrenaline and noradrenaline. Throughout this work it was quite obvious that a fall in body-temperature as small as 2–3° C appreciably affected all responses. Great care, therefore, was taken to



(a) *L.V.S.*

CH
gm.

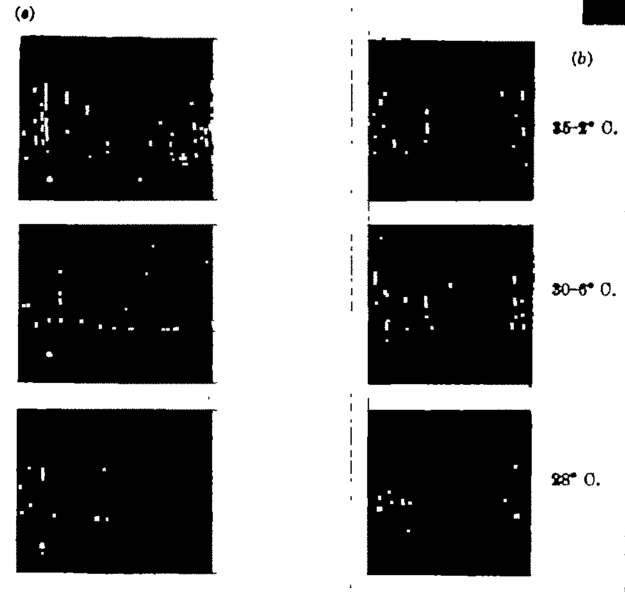


(b) *A* 1 μgm. *NOR* 1 μgm. *ISO* 2 μgm.

Fig. 1. Cat, 3·2 kg (*L.V.S.*), acetylch noradrenaline (*NC* decamethonium (muscle-temperatur blood-pressure ; (tractions In this recordings of maxi anterior muscle in tion delivered once vagus stimulat

stimulation naline (*A*), (*ISO*) and body- and cordings of muscle con- racings are the tibialis et stimula- *V.S.* = left) sec.

(c)



DEC 70 μgm.

ensure that the normal body-temperature of the cat, which ranges between 37° and 38° C., was kept constant. Independent of the change produced, however, the effect on adrenaline was nearly always more marked than that on noradrenaline.

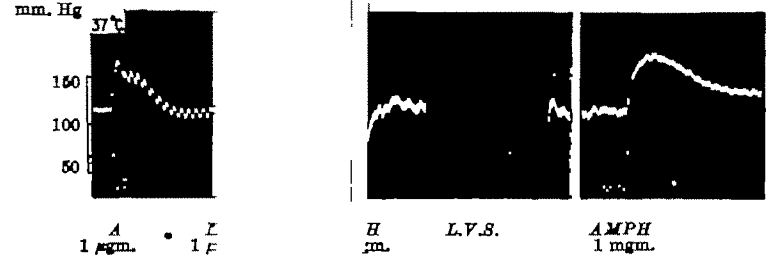
Of the various drugs used, reserpine has produced changes most closely resembling those observed after cooling; the various responses were markedly increased and prolonged even with doses of reserpine which had no apparent effect on the function of adrenergic nerves. The doses used ranged from 5 μgm. to 1 mgm. per kgm. body-weight, and the duration of the pretreatment from one to ten days. Even with a dose as low as 5 μgm. per kgm. administered for five days, the changes produced were quite marked (Fig. 4). In animals treated with reserpine, the administration of small doses of guanethidine, amphetamine or ephedrine further potentiated the various effects.

For the remaining compounds the range of doses used is given in Table 1.

Table 1

	Pretreatment (mgm./kgm.)	Acute (mgm./kgm.)
Guanethidine	0 2–10	1–5
Bretylium	2–20	3–20
Amphetamine	2	0 1–2
Ephedrine		0 3–2
Tyramine		0 1–1
Dichloroisoprenaline		1–4

In the animals pretreated with guanethidine or with bretylium, the potentiating effects appeared long before the blockade of adrenergic neurones. On the other hand, amphetamine and ephedrine were still producing their usual rise in blood pressure in the presence of large doses of guanethidine and bretylium and long after the adrenergic neurones had been blocked (Fig. 2).



A 1 μgm. *I* 1 μ *H* gm. *L.V.S.* *AMPH* 1 mgm.

Fig. 2. Cat, 2·8 kgm pressure responses to vagus pretreated, 8 mgm./kgm. for two days. Blood- oradrenaline (*NOR*), acetylcholine (*ACH*), left *S.*) and amphetamine (*AMPH*)

Discussion

A lowering of body-temperature slows the rate of all physiological processes, but some are more affected than others. For example, for a given fall in temperature the decrease in rate of metabolic and rhythmic processes is two to three times as great as

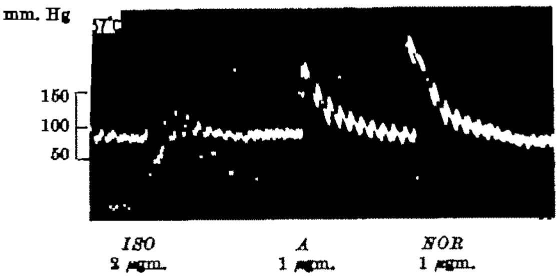


Fig. 3. Cat, 4·6 kgm. Reserpine pretreated, 50 μgm./kgm. for three days. Blood-pressure responses to adrenaline (*A*), noradrenaline (*NOR*) and isoprenaline (*ISO*)

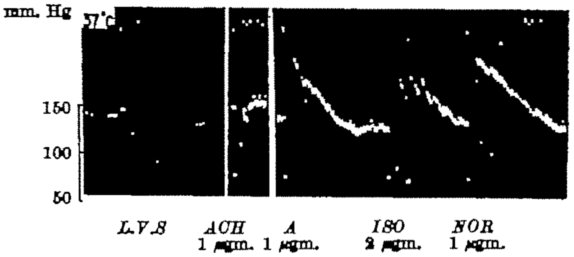


Fig. 4. Cat, 2 9 kgm. Reserpine pretreated, 5 μgm./kgm. for five days. Blood-pressure responses to left vagus stimulation (*L.V.S.*), acetylcholine (*ACH*), adrenaline (*A*), isoprenaline (*ISO*) and noradrenaline (*NOR*)

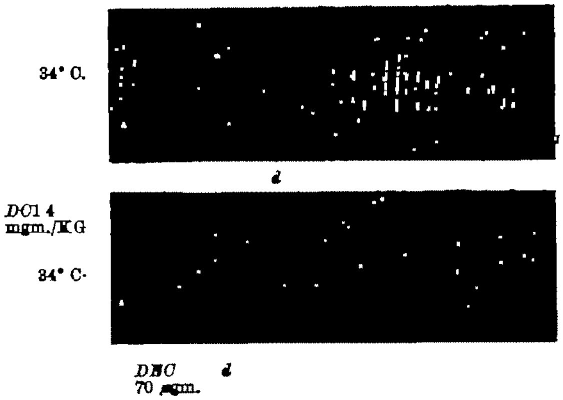


Fig. 5. Cat, 2·8 kgm. Effect of decamethonium before and 1 hr. after the intravenous administration of 4 mgm./kgm. dichloroisoprenaline; *d* = direct stimulation

the decrease in rate of diffusion of metabolites[5]. The same is apparently true for the action of various drugs. Some drugs become more effective at lower temperatures, whereas the action of others is reduced. On this basis, Johnson, Eyring and Polissar[6] have classified drugs into two types. Among the first type are those drugs which produce their action by competitively inhibiting enzyme systems. The second type includes a large number of narcotics. There are also drugs exhibiting both types of effect. According to this classification, the drugs used in the present work must belong to the first type, since all become more effective at lower temperatures. Fig. 6 illustrates this point. In two different animals, one at 38° C. and the other at 34° C., the same dose/kgm. of amphetamine was administered. The action produced by the drug was both more pronounced and more prolonged in the cooled animal.

The striking resemblance between the changes produced by cooling alone and those produced by the drugs under consideration, together with the fact that the effects of these drugs are increased at lower temperatures, suggested the possibility of a common basis for their mechanism of action. By far the most obvious change produced either by cooling or by any of the drugs studied is a prolongation of responses elicited by various means; obviously the rate of recovery of the effector cells after activation is slowed. This appears to be independent of either the type of activation (stimulation or inhibition) or the type of nervous control (adrenergic or cholinergic; autonomic or motor). It is therefore very tempting to suggest that the action of these drugs, so far as this phenomenon of prolongation is concerned, is brought about by inhibition of the metabolic processes underlying 'recovery' of a cell after activation.

There is greater uniformity in the changes produced at cholinergic than at adrenergic sites. At cholinergic sites each of the drugs in this group gave rise to the same type of change though to varying extent, whether administered chronically or acutely. On the other hand, at the adrenergic sites there were distinct differences, possibly because by virtue of their chemical structure these substances are presented here with a greater variety of enzymic processes to act upon—processes concerned with the synthesis, storage, release and destruction of the catecholamines all along the adrenergic pathway. The resultant effects, therefore, will depend (*a*) on the direct 'mimicking' ability of the compound (as in the case of tyramine, amphetamine, ephedrine), (*b*) on the ease with which they penetrate cell membranes, and finally (*c*) on their action as inhibitors of various enzymic processes. The wide spectrum of effects which these drugs produce on adrenergic systems could thus be explained.

But what can be the general mechanism by which these drugs interfere with the recovery of a cell after excitation, an effect seen at both cholinergic and adrenergic sites? Possibly by competitively inhibiting enzyme systems concerned with the restoration of a cell after activation. These various molecules look chemically very different, but we cannot really see how they come to be competitive. But take the following

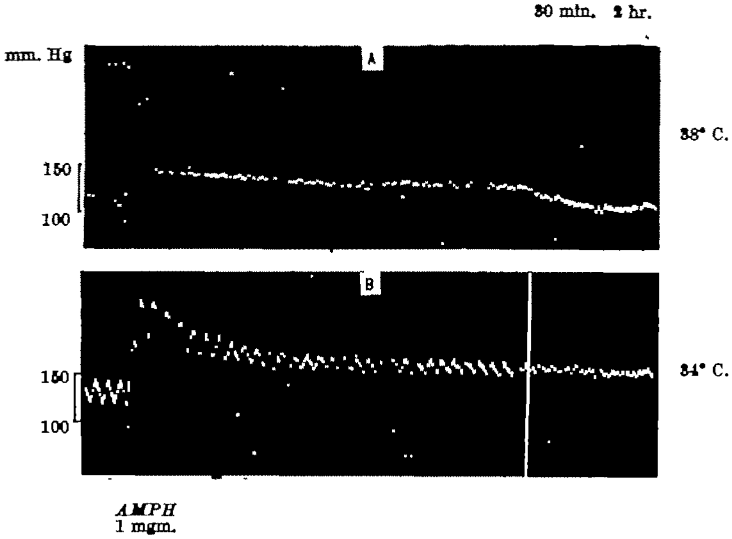


Fig. 6. Effect of 0 8 mgm./kgm. of amphetamine sulphate on the blood pressure of a cat (*A*) at 38° C. and (*B*) another cat at 34° C.

points into consi
is liberated close
is released mainl
the blood stream,
every single cell
gives rise to mark
cooling and the d
fluence the respon
than those to nora
make it very tem
itself may be dir
process of a cell a
produced by re
tyramine, amphet
prenaline on the
explained as due
from its points of

My thanks are
Co., Ltd., for the
Laboratories, Ltd.

while noradrenaline
or cells, adrenaline
renal medulla into
it into contact with
(b) only adrenaline
anges ; and (c) both
ghout this work in-
e a great deal more
se facts put together
late that adrenaline
d in the 'recovery'
. Then the changes
thidine, bretylium,
ine and dichloroiso-
echanism could be
ment' of adrenaline

ghs, Wellcome and
retylium'; to Ciba
idine ; and to Eli
Lilly and Co., for the dichloroisoprenaline. This investigation was supported by a grant from the Palissade Foundation, Inc., of New York.

Summary

It has been found that reserpine, guanethidine, bretylium, tyramine, amphetamine, ephedrine and dichloroisoprenaline produce changes closely analogous to those observed in animals the body temperature of which has been lowered. The metabolic basis of these changes is discussed.

---

[1] Bigland, B., and Zaimis, E., *J. Physiol.*, 141, 420 (1958).

[2] Bigland, B., Goetzee, B., Maclagan, J., and Zaimis, E., *J. Physiol.*, 141, 425 (1958).

[3] Cannard, T. H., and Zaimis, E., *J. Physiol.*, 149, 112 (1959).

[4] Powell, C. E., and Slater, I. H., *J. Pharmacol.*, 122, 480 (1958).

[5] Brown, D. E. S., "The Physiology of Induced Hypothermia" (National Academy of Sciences—National Research Council, Washington, D.C., 1956).

[6] Johnson, F. H., Eyring, H., and Polissar, M. J., "The Kinetic Basis of Molecular Biology" (Wiley, New York, 1954).

CA

Gates and Crellin

LABELLED HYBRIDS OF HÆMOGLOBIN

ROME VINOGRAD and WILLIAM D. HUTCHINSON

vision of Chemistry and Chemical Engineering, California Institute of Technology,
Pasadena, California

Preparation of ^{14}
Adult and

HUMAN adult
mutant sick
consist of two pai
of known *N*-termi
globin differs from
tion of a valyl resi
β chains[3]. Both
molecules of appr
in acid and in a
recombine to form
tion[4–6]. Singer and
of sickle-cell hæmo
sociated together a-
ization with an exc

In studies of su
hæmoglobins we h
for the preparation
highly radioactive
type of sub-unit
inactive. Such s
globins are of use i
nature of sub-units

The preparatio
hæmoglobin mole
adult, sickle-cell h
hybrid hæmoglobi
bination after dis
hæmoglobins in ei

Formation and
of Adult a

Equimolar mixt
sickle-cell carbon
labelled with carb
24 hr. at 3° C.
(0·033 *M* disodiu

belled Hybrids of
emoglobins

HbA) and its allelic
lobin (HbS) each
de chains, α and β,
. Sickle-cell hæmo-
bin in the substitu-
amyl residue[2] in the
dissociate into two
l molecular weight
ons ; the products
les in neutral solu-
ported that mixtures
lt hæmoglobin, dis-
mbine upon neutral-
molecular sub-units[7].
mations of various
l a general method
of useful amounts of
ybrids in which one
while the other is
lled *hybrid* hæmo-
tion of the chemical
ariant hæmoglobins.
14 labelled hybrid
ated here with the
em. The carbon-14
ormed upon recom-
ixtures of the two
aline solutions.

arbon-14 Hybrids
Hæmoglobin

n adult normal and
obin, one uniformly
e, were dialysed for
a phosphate buffer
hosphate, 0·0167 *M*
sodium phosphate, 0·15 *M* sodium chloride) of *p*H 11·0 or an acetate buffer (0·1 *M* sodium acetate, 0·15 *M* sodium chloride, 0·042 *M* acetic acid) of *p*H 5·0. This dialysis was followed by a dialysis to a *p*H of 7·22 against the buffer specified as chromatographic developer No. 1 by Allen, Schroeder and Balog[8]. 20–50 mgm. of the mixtures were separated on an '*IRC*-50' column in equilibrium with developer No. 1 at 6° C. The adult hæmoglobin was eluted at this temperature, after which the sickle-cell hæmoglobin was eluted at 28° C. The concentrations of the chromatographic fractions were determined spectrophotometrically at the absorption maxima of carbonmonoxyhæmoglobin at 541 or 415 mμ ; or, in cases where the hæmoglobins were believed to be contaminated with methæmoglobin cyanide, at the isobestic wave-length 522 mμ.

The specific activities of the hæmoglobin samples were measured using a Nuclear-Chicago gas-flow Geiger counter, model *D*-47, equipped with a 'micromil' window. At the high level of specific activities of these hæmoglobins, less than 0·5 mgm. was required per planchette. No corrections for self-absorption were necessary with these amounts of hæmoglobin. A fixed volume of solution, 0·5 or 1·0 ml., was plated.

In experiments with radioactive human sickle-cell hæmoglobin it was necessary to free the material of the fast-moving minor hæmoglobin components in sickle-cell hæmoglobin. This was accomplished by chromatography of 50–100 mgm. of sickle-cell hæmoglobin with developer No. 2 (ref. 8). The major sickle-cell hæmoglobin component was recovered by warming the column to 28° C. The hæmoglobin solutions were concentrated by centrifuging for 18 hr. at 40,000 r.p.m. in the No. 40 rotor of a 'Spinco' preparative ultracentrifuge at 5° C. Concentrated solutions, usually containing 8–15 per cent hæmoglobin, were withdrawn from the bottom of the centrifuge tubes with a hypodermic syringe fitted with a 4-in. 22-gauge needle.

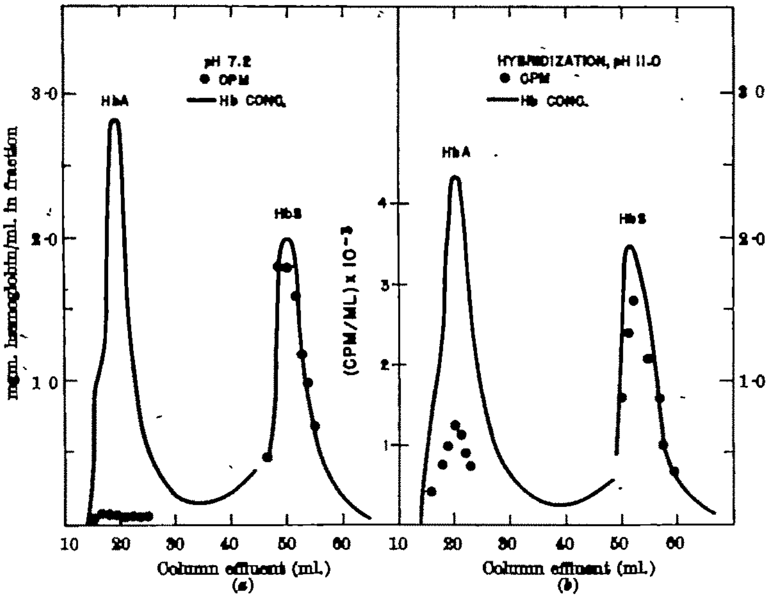


Fig. 1. Transfer of radioactive α sub-units in a mixture of human adult hæmoglobin and carbon-14-L-leucine labelled sickle-cell hæmoglobin dialysed to pH 11 and afterwards dialysed to pH 7·2. (*a*) Experiment 6, (*b*) experiment 4, Table 1.

Preparation of Radioactive Hæmoglobins

The unlabelled hæmoglobins were prepared from freshly drawn blood samples from either normal or sickle-cell anæmic individuals by the procedure of Drabkin[9]. The hæmoglobin was not crystallized[9].

It was desired that the radioactive hæmoglobins used in the hybridization experiments be uniformly labelled in the α and the β chains. L-leucine was chosen because of the abundance of this amino-acid in the molecule and the presence of leucine in both α and β N-terminal peptides. It has recently been shown that there are close to an equal number of leucine residues in both chains[10]. Uniform labelling, therefore, should lead to equal specific activities in the α and β chains.

The radioactive hæmoglobins were prepared from the red blood cells of anæmic donors. Blood samples containing 15–40 per cent reticulocytes were used within 2 hr. after the blood was drawn. Following four washings with cold isotonic saline solution, the red cell suspensions were incubated by a modification of the procedure devised for rabbit reticulocytes by Borsook *et al.*[11].

The complete incubation mixture was prepared using the following stock solutions:

(*a*) 0·13 *M* sodium chloride, 0·005 *M* potassium chloride, 0·0075 *M* magnesium chloride, in redistilled water.
(*b*) 0·22 *M* glucose in solution (*a*), prepared fresh for each incubation.
(*c*) 0·01 *M* ferrous ammonium sulphate in solution (*a*), prepared fresh.
(*d*) 0·27 *M* sodium bicarbonate in redistilled water, prepared fresh.
(*e*) 0·01 *M* glutamine in solution (*a*), stored frozen.
(*f*) Amino-acid mixture: *l*-alanine 180, *l*-arginine 100, *l*-aspartic acid 330, *l*-cysteine 50, glycine 400, *l*-histidine hydrochloride 500, *l*-isoleucine 52 (*l*-leucine 52), *l*-lysine hydrochloride 330, *l*-methionine 50, *l*-phenyl alanine 260, *l*-proline 160, *l*-serine 175, *l*-threonine 200, *l*-tryptophan 60, *l*-tyrosine 150, *l*-valine 370, *l*-hydroxyproline 150 (amounts of amino-acids expressed as mgm. per 1,000 ml. of solution *a*). After boiling to dissolve all amino-acids, the pH was adjusted to 7·0 with 5 *N* sodium hydroxide. This stock solution was stored frozen in small lots which were thawed out as needed.

The following amounts of the above solutions were added, in the order given, to 10 ml. of packed red blood cells: 5·85 ml. of amino-acid mixture, 0·60 ml. glucose solution, 1·2 ml. glutamine solution, 1·8 ml. of sodium bicarbonate solution, 11·7 ml. ferrous ammonium sulphate solution. Seven micromoles, 50 µc., of Nuclear-Chicago uniformly labelled radioactive L-leucine, dissolved in 0·5 ml. solution *a*, was then added to the mixture. In these incubations the cold L-leucine was omitted.

The cells were incubated for 4 hr., washed four times and lysed with distilled water and toluene. After removal of cell debris by low- and high-speed centrifugation, the resulting hæmoglobin solutions were dialysed against several changes of distilled water to remove unincorporated carbon-14 labelled L-leucine. The specific activities of the hæmoglobins in several preparations were between 3,000 and 7,000 c.p.m./mgm.

Results of Hybridization Experiments

The results of a typical hybridization experiment and the chromatographic separation of the two hæmoglobins are shown in Fig. 1*b*. In Fig. 1*a* the results of a chromatographic separation of the same materials mixed at pH 7, but not dissociated at pH 11, show that there is little contamination of human adult normal hæmoglobin by the radioactive sickle-cell hæmoglobin. Inspection of the curves in Fig. 1 shows that no new chromatographic species have appeared as a result of the dissociation of the mixture at pH 11 and that transfer of activity from the sickle-cell hæmoglobin to the adult hæmoglobin occurs. The specific activity of the adult hæmoglobin after dissociation and recombination is approximately one-third that remaining in the sickle hæmoglobin. In Table 1, experiments 1–9 summarize the results of several similar experiments in which the hæmoglobins were dissociated in acid and alkaline solutions. The specific activities given in Table 1, together with standard deviations, are average values of the specific activities of all chromatographic fractions containing more than 0·2 mgm./ml. of hæmoglobin. This usually accounted for more than 80 per cent of the recovered

Table 1

Exp. No.	pH	Specific activities of reactants		Specific activities of products		Percentage hybridization*
		HbA	HbS	HbA	HbS	
1	11·0	3,500	0	2,600 ± 200	860 ± 50	99 ± 10
2†	11·0	3,500	0	2,700	800	80
3	7·2	3,500	0	3,200 ± 300	64 ± 15	6 ± 2
4	11·0	0	1,900	480 ± 30	1,400 ± 200	108 ± 16
5	11·0	0	1,900	370 ± 50	1,570 ± 100	71 ± 10
6	7·2	0	1,900	90 ± 40	1,650 ± 200	16 ± 8
7	5·0	700	0	500 ± 60	130 ± 20	80 ± 16
8	5·0	2,000	0	1,600 ± 150	270 ± 20	31 ± 3
9	7·2	600	0	550 ± 50	12 ± 4	9 ± 0
10	11·0	6,500	0	5,800 ± 500	220 ± 100	11 ± 6
11	11·0	0	1,900	160 ± 70	1,750 ± 160	27 ± 12

* The percentage of hybridization was calculated assuming a ratio of specific activities of the products of three to one for 100 per cent hybridization.

† The specific activities in this experiment were determined on single aliquots from the fractions of adult and sickle-cell hæmoglobin of highest concentration.

sample. It is see
ments at pH 11 t
in the initially ina
third of that rema
Singer and Itano
of one-quarter of
inactive hæmoglob
identity of one-h
hæmoglobin mole
shown the forma-
guishable hybrids
and adult carbon
cluded that the hæ
non-identical halv

(a

Both sickle-cell
to be in the form
We have found th
when equal amoun
globins are brough
to pH 11, mixed a
then quickly ne
buffer, pH 6·8. T
shown in Table 1,
from these results
line conditions m
and further dissoc

(b) α

The fraction of m
must be less than
results of ultracen
cell hæmoglobin
shown to be half
bination by neut
to the same ratio o
(A balanced equa-
transfer of α chain

$2\alpha_2^{**}\beta_2^{**} \rightarrow 2$

$2\alpha_2\beta_2^{s} \rightarrow 2$

For mechanism (b)

$4\alpha_2^{**}\beta_2^{**} \rightarrow 4\alpha^*\beta^*$ 4

$\rightleftarrows$

$4\alpha_2\beta_2^{s} \rightarrow 4\alpha\beta^{s}$ 4

By both mechani
activities in the pr

hybridization experi-
ecific activity found
obin is roughly one-
ther hæmoglobin.
out that the transfer
ity into the initially
tive evidence of the
ckle-cell and adult
investigators have
ophoretically distin-
cell ferrihæmoglobin
lobin, and have con-
cule dissociates into
tion :

$+ \beta_2$

moglobin are known
les at pH 11 (ref. 5).
hybridization occurs
ell and adult hæmo-
y dialysis for 24 hr.
I 11 for 10 sec., and
2·8 *M* phosphate
hese experiments are
) and 11. It appears
oglobins under alka-
nto identical halves
ers :

$2\alpha + 2\beta$

arter molecule state
accordance with the
s in which normal
l hæmoglobin were
pH 11. On recom-
h mechanisms lead
ities in the products.
anism (a), assuming

$^{**}\beta_2^{**} + \alpha_2\beta_2^{**}\}$

$\alpha_2\beta_2^{s} + \alpha_2^{**}\beta_2^{s}\}$

s :

$^{**} + 2\alpha\alpha^*\beta_2^{**} + \alpha_2\beta_2^{**}\}$

$_2^{s} + 2\alpha\alpha^*\beta_2^{s} + \alpha_2\beta_2^{s}\}$

rtionment of radio-
to be such that the

ratio of specific activities is three to one.) This proposed mechanism for sub-unit transfer implies that β and β^s do not combine, and similarly, $\alpha\beta$ does not combine with $\alpha\beta^s$.

Significance of Hæmoglobin Hybrid Formation

The hybrids labelled with carbon-14 described here are useful materials in two general areas of hæmoglobin studies. First, any peptide fragment isolated from digests of the whole molecule may be identified with respect to the sub-unit of origin. An example of this was the first identification of the aberrant or non-transferring sub-unit in the normal hæmoglobin/sickle-cell hæmoglobin system with the β *N*-terminal peptide[2]. In the second kind of study, a sub-unit transferring between two hæmoglobins may be readily followed as in the case of reactions between hæmoglobins A and F (ref. 12), S and H (ref. 13), and more recently in interspecies systems between adult hæmoglobin and rabbit hæmoglobin. In the latter case, through the use of $\alpha_2^*\beta_2$, the compositions of the two interspecies hybrids were readily recognized (unpublished work from this Laboratory).

This investigation was supported in part by a grant (*H*-3394) from the National Institutes of Health, United States Public Health Service. We wish to thank Drs. R. T. Jones and W. A. Schroeder for their advice in connexion with the chromatographic procedures, also Dr. P. A. Sturgeon, Children's Hospital, Los Angeles, for supplying us with the blood samples and the hæmotological data.

[1] Rhinesmith, H. S., Schroeder, W. A., and Martin, N., *J. Amer. Chem. Soc.*, **80**, 3358 (1958).

[2] Ingram, V. M., *Nature*, **178**, 792 (1956).

[3] Vinograd, J., Hutchinson, W. D., and Schroeder, W. A., *J. Amer. Chem. Soc.*, **81**, 3168 (1959).

[4] Field, E. O., and O'Brien, J. R. P., *Biochem. J.*, **60**, 656 (1955).

[5] Hasserodt, U., and Vinograd, J., *Proc. U.S. Nat. Acad. Sci.*, **45**, 12 (1959). Hutchinson, W. D., M.S. thesis, California Institute of Technology (1957); and unpublished results for the dissociation of sickle-cell carbonmonoxyhæmoglobin at pH 11 0.

[6] Itano, H., and Singer, S. J., *Proc. U.S. Nat. Acad. Sci.*, **44**, 522 (1958).

[7] Singer, S. J., and Itano, H., *Proc. U.S. Nat. Acad. Sci.*, **45**, 174 (1959).

[8] Allen, D. W., Schroeder, W. A., and Balog, J., *J. Amer. Chem. Soc.*, **80**, 1628 (1958).

[9] Drabkin, D. L., *J. Biol. Chem.*, **164**, 703 (1946); *Arch. Biochem. Biophys.*, **21**, 224 (1949).

[10] Hill, R. J., and Craig, L. C., *J. Amer. Chem. Soc.*, **81**, 2272 (1959).

[11] Borsook, H., Deasy, C. L., Haagen-Smit, A. J., Keighley, G., and Lowy, P. H., *J. Biol. Chem.*, **196**, 669 (1952). Also Borsook, H., private communication.

[12] Jones, R. T., Schroeder, W. A., and Vinograd, J., *J. Amer. Chem. Soc.*, **81**, 4749 (1959).

[13] Jones, R. T., Schroeder, W. A., Balog, J., and Vinograd, J., *J. Amer. Chem. Soc.*, **81**, 3161 (1959).

EFFECTS O
ID THE NATURE OF THE PRIMARY SPECIES IN DIOLYSIS OF AQUEOUS SOLUTIONS

By J. T. ALLAN and Dr. G. SCHOLES

Dep
istry, King's College, University of Durham, Newcastle upon Tyne, 1

IT has been kno
observed in th
aqueous solutions
in pH (ref. 1). In
for example dece
acid or of methan
of hydrogen and

time that the yields
nising radiations on
nfluenced by changes
e systems examined,
solutions of formic
erved that the yields
on products from the

solute dropped sharply on going from acid to neutral conditions. Somewhat similar pH effects have since been noted in various other aqueous systems[2]. As yet, however, no satisfactory explanation has been offered for these results.

In the course of an investigation of the effect of cobalt-60 γ-rays on aqueous solutions of various simple

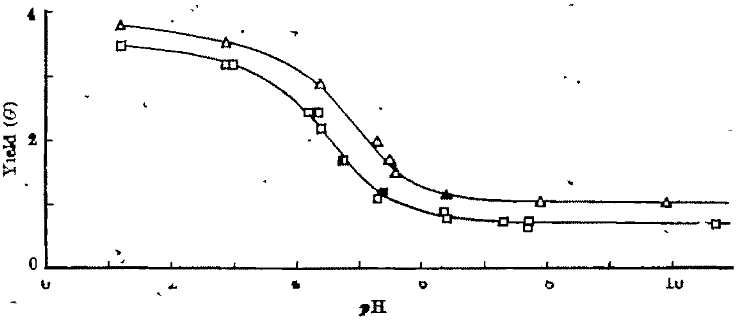


Fig. 1. Dependence on *p*H of the yields of acetone and hydrogen from aqueous solutions of *iso*propanol (10^{-3} *M*) irradiated with cobalt-60 γ-rays *in vacuo*. □, acetone; △, hydrogen

aliphatic alcohols, carried out in this laboratory, particular attention has been directed to the study of *p*H effects *in vacuo*.

In this communication we present some results obtained from *iso*propanol solutions. The main product was found to be acetone. The yields of acetone and of hydrogen from *iso*propanol solutions (10^{-3} *M*) were studied as a function of *p*H over the range *p*H ~ 1 to ~ 10. In the more strongly acid solutions (*p*H < 3) and in solutions at *p*H > 7, the yields were linear with dose, up to the highest doses used (4×10^{18} eV./ml.). In the range *p*H ~ 3 to ~ 6, however, the yield–dose plots were non-linear, falling off with increasing dose. Detailed examination down to the lowest practical doses showed that initially there was a high yield, but this could not be accurately determined. Above about 3×10^{17} eV./ml., the deviation of the plots from non-linearity was not quite so pronounced. *G*-values (molecules/100 eV.) for the yields of hydrogen and acetone in this particular *p*H range were, therefore, computed from results obtained using doses ranging from 3×10^{17} to $1{\cdot}2 \times 10^{18}$ eV./ml. Fig. 1 shows the *p*H-dependence of the radiation-yields obtained in this manner.

It was apparent from these results that some back reactions were taking place in solutions irradiated at *p*H > 3. Experiments were therefore carried out in which acetone was added to *iso*propanol solutions (10^{-3} *M*) prior to irradiation. Some results are shown in Table 1. In the *p*H range 3–6, such additions lead to notable decreases in the yields of hydrogen. It would appear, therefore, that the *p*H-dependence in *iso*propanol solutions is largely associated with back reactions involving the acetone produced by radiation. Essentially similar results have been observed with solutions of methanol (Lyons, Scholes and Smith, unpublished results) and of ethanol (Nixon and Scholes, unpublished results), where it has been found that the corresponding aldehydes enter into the back reactions.

Table 1. EFFECT OF ACETONE ON THE YIELDS OF HYDROGEN FROM *ISO*PROPANOL SOLUTIONS IRRADIATED WITH COBALT-60 γ-RAYS *in vacuo*

Solution	Yield of hydrogen (*G*)*				
	*p*H = 1·20	*p*H = 3·45	*p*H = 4·20	*p*H = 4·50	*p*H = 7·90
*Iso*propanol (10^{-3} *M*)	3·80	3·37	3·00	2·75	1·05
*Iso*propanol (10^{-3} *M*)–acetone (2×10^{-4} *M*)	3·80	3·10†	2·00	1·70	1·05

* Values for *iso*propanol solutions are taken from Fig. 1. The yields in *iso*propanol–acetone solutions are initial yields.

† 10^{-3} *M* *iso*propanol–10^{-4} *M* acetone.

Chemical reactions induced by ionizing radiations in dilute aqueous systems are due to the free radicals, denoted as H and OH, produced by the action of the radiation on the water[3]. In addition, there is some primary formation of 'molecular' hydrogen and hydrogen peroxide[4]. The overall radiolysis of water is conventionally represented as:

$$H_2O \rightsquigarrow H, OH, H_2, H_2O_2 \qquad (1)$$

Radical formation is the result of the excitation and ionization processes which occur as a consequence of the absorption of the ionizing radiations[5]. There is some controversy, however, about the fate of the electrons formed from the ionization process. Lea and Gray[6], Weiss[6] and Platzmann[7] have considered that the ejected electron is captured by a water molecule at some distance from the parent positive ion and exists, possibly attached to a water molecule, until interaction with the aqueous medium allows formation of a hydrogen atom according to the process:

$$H_2O^- \rightarrow H + OH^- \qquad (2)$$

Weiss[8] has discussed questions regarding the stability of the positive and negative ions from water, pointing out that they may have a life-time long enough to enable them to undergo chemical reactions with the solute present. Deaerated solutions of monochloroacetic acid were found to be systems in which the results could best be explained in terms of reactions of the negative ion, H_2O^- (the electron in water or 'polaron')[9].

The results reported above can only be explained if we assume the presence in irradiated neutral and alkaline solutions of *iso*propanol of two forms of the 'hydrogen atom' (cf. ref. 10). One of these dehydrogenates *iso*propanol, but the other cannot and reacts with acetone and probably also to some extent with the hydrogen peroxide produced according to reaction (1). Since it seems highly unlikely that H_2^+ and H could be the two forms under these conditions of *p*H, we must conclude that the species are H and the electron (polaron). Furthermore, they are both produced in the act of radiolysis, and the results indicate that, under these conditions, $G_{\mathrm{H}} = 0{\cdot}6$ and $G_{\mathrm{H_2O^-}} = 2{\cdot}3$. These hydrogen atoms could very well arise from excitation processes of the type[6]:

$$H_2O^* \rightarrow H + OH \qquad (3)$$

The effects of *p*H which, as described above, are essentially due to a back reaction involving acetone could then be ascribed to the competition:

$$H_2O^- + H_2O^- \rightarrow 2H_2O + H \qquad (4)$$

$$H_2O^- + CH_3.CO.CH_3 \rightarrow H_2O + [CH_3.CO.CH_3]^- \qquad (5)$$

In the *p*H range 3–6, addition of acetone depresses the yield of hydrogen by influencing the competition in favour of reaction (5), and for the same reason one would expect non-linearity of the yield–dose plots. From the experiments in the presence of acetone the ratio of the rate constants of reactions (4) and (5) can be calculated as $k_4/k_5 = 2{\cdot}3$. It should be pointed out that H_2^+, which is formed in acid solutions[11], could still be a reacting species at low *p*H.

The above mec
which have been
systems. It has
ethanol solutions i
drops markedly a
relatively unchan
shown that ethyl
irradiation of ox
(Nixon and Scho
case of ethanol so
is :

$H_2O^- + O$

leading to the co
Hydrogen pero
also compete wi
according to the

$H_2O^- + H$

When the total a
be scavenged by
under certain con
which is often pr
special precaution
carbon dioxide ca

$CO_2 +$

In formic acid
radiation product
dioxide ; the dep
carbon dioxide an
nected with rea
reaction (7)), co
presence of oxalic
acid which have b
established (Simic
results) and is pr
the CO_2^- (CO_2H)
reaction (8).

Fricke and H
yields of hydroge
propionaldehyde
first increasing an
centration is incr
has also been ob

ccount for pH effects
nany other aqueous
[12] that in deaerated
X-rays, G (aldehyde)
but that G (glycol) is
cently, it has been
in fact, formed on
ions of acetaldehyde
ed results). In the
re, the back reaction

$+ CH_2CHO^-$ (6)

ehyde to glycol.
in reaction (1) will
n for the polaron,

$OH + OH^-$ (7)

r of polarons cannot
products they may,
with carbon dioxide,
ated systems unless
The reaction with
ed by the equation :

$^- + H_2O$ (8)

low pH, the only
is, in fact, carbon
H of the yields of
could thus be con-
sibly together with
reaction (4). The
l solutions of formic
with γ-rays has been
Weiss, unpublished
by dimerization of
uced according to

that the radiation
ons of acetone and
with concentration,
ng as the solute con-
mum hydrogen yield
irradiation of mono-

chloroacetic acid solutions at pH 1·20 (ref. 9). We have confirmed that there is a maximum in acetone solutions ; at pH 1·2 this occurs at a concentration of 10^{-2} molar. These are examples where the solute itself can react both with the hydrogen atom (or H_2^+ in acid solution) and with the polaron. At low concentrations of solute in acid media, reaction (4) is predominant and dehydrogenation processes occur. As the concentration is increased, however, increased scavenging is offset by reactions of the polaron with the solute, for example, reactions (6) and (7). Hence, the hydrogen yield goes through a maximum.

In a study of the exchange reactions induced by radiation in D_2–H_2O, Gordon and Hart[13] observed that above pH ~ 7 the yields of HD fell off very rapidly, and this was attributed to ionization of the OH radical. However, these particular results could be accounted for by the decrease in the extent of reaction (4) in this pH region. Above pH ~ 8 these authors noted a significant increase in the yields of hydrogen gas, an observation which would suggest that the life-time of the polaron can be sufficiently long to allow recombination to form molecular hydrogen. Such considerations, together with the large ratio of (G_{H_2O}) (G_H), would tend to support the suggestion[8] that the polarons contribute towards the molecular hydrogen yield.

We thank Prof. J. Weiss for valuable discussions and for his encouragement of this work.

[1] Fricke, H., and Hart, E. J., *J. Chem. Phys.*, 6, 229 (1938).
[2] For review, see Lefort, M., in "Actions Chimiques et Biologiques des Radiations" (Masson et Cie, Paris, 1955).
[3] Weiss, J., *Nature*, 153, 748 (1944); *Brit. J. Radiol.*, Supp. 1, 56 (1947).
[4] Allen, A. O., "Ann. Rev. Phys. Chem.", 3, 57 (1952).
[5] Lea, D. E., "Actions of Radiation on Living Cells" (Camb. Univ. Press, London, 1946).
[6] Weiss, J., "Ann. Rev. Phys. Chem.", 4, 143 (1953).
[7] Platzmann, R. L., *Radiation Res.*, 2, 1 (1955).
[8] Weiss, J., *Nature*, 174, 78 (1954); *Experientia*, 12, 7, 280 (1956).
[9] Hayon, E., and Weiss, J., Second Int. Conf. Peaceful Uses of Atomic Energy (1958).
[10] Barr, N. F., and Allen, A. O., *J. Phys. Chem.*, 63, 928 (1959). Baxendale, J. H., and Hughes, G., *Z. Phys. Chem.*, 14, 323 (1958).
[11] Weiss, J., *Nature*, 165, 728 (1950).
[12] Jayson, G. G., Scholes, G., and Weiss, J., *J. Chem. Soc.*, 1858 (1957).
[13] Gordon, S., and Hart, E. J., *J. Amer. Chem. Soc.*, 77, 3981 (1955).

MAGNE N OF SEDIMENT CORES FROM THE EASTERN ATLANTIC OCEAN

By M. J. KEEN

Department of Geodesy and Geophysics, Cambridge

THE remanen
the continen
but only a few st
from the oceans[1,]
of experiments w
number of cores
The investigation
where. They wer
sediments acquire
these are related
thereby informat
magnetic field or
oceanic cores mig
of the magnetic m
A number of c
of R.R.S. *Discov*

n of sediments from
studied extensively ;
n made on sediments
describes the results
n made on two of a
ern Atlantic Ocean.
ribed in detail else-
find out how oceanic
c properties and how
physical properties ;
story of the Earth's
nethod of correlating
Further, the study
e of intrinsic interest.
ted during the cruise
lay until July 1958[3].

The first core described, 3738, was taken on the lower slopes of a group of abyssal hills on the western edge of the Iberian abyssal plain[4] (Station 3738, 41° 00′ N., 15° 08′ W., corrected depth 5,267 m.). The second core, 3780, was taken at the bottom of a bank about 3 m. above the abyssal plain (Station 3780, 41° 26′ N., 14° 43′ W., corrected depth 5,333 m.). They were obtained with a piston corer, and were not oriented with respect to the direction of the Earth's present magnetic field. The core 3738 is about 4 m. long ; results on only the top 3 m. are presented here. Core 3780 is 6 m. long.

Core 3738 consists of brown clay and foraminiferal ooze, and of mixtures of these two types of sediment ; evidence of burrowing occurs at intervals throughout the length of the core. A summary of the lithology

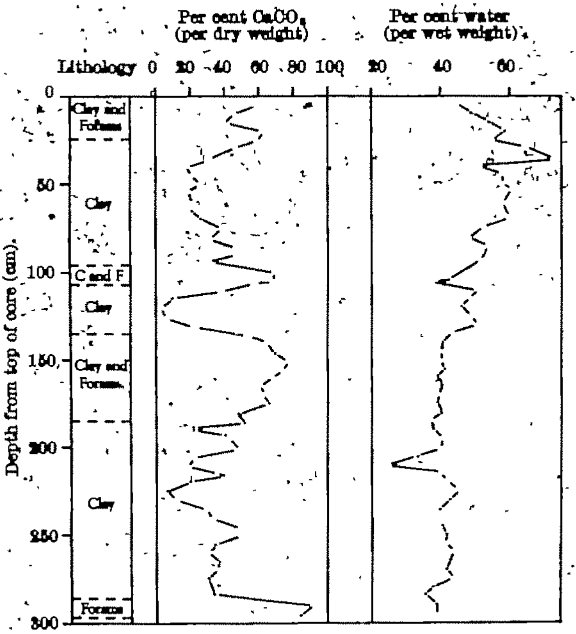


Fig. 1. Core 3738: lithology, percentage CO₂—(calculated as calcium carbonate) and percentage water plotted against depth of the core

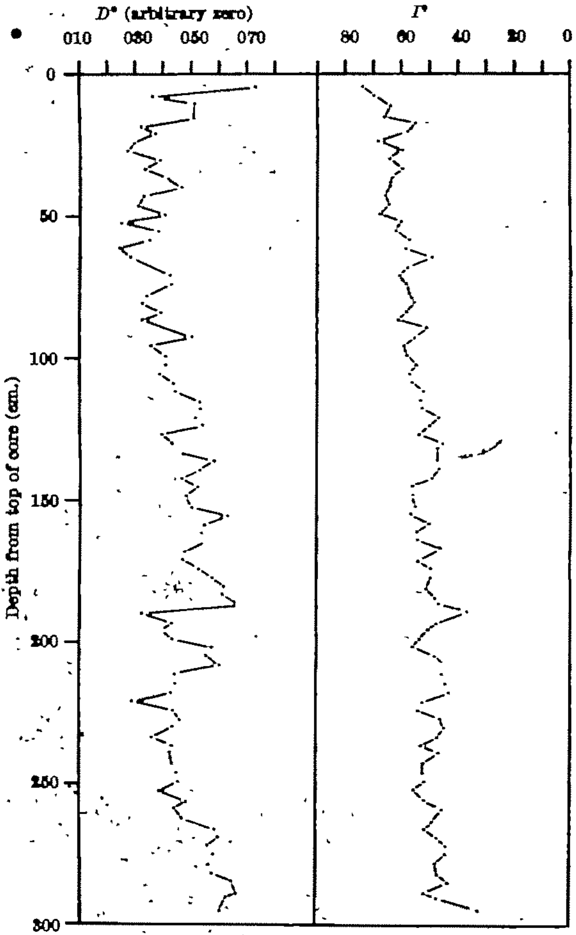


Fig. 2. Core 3738: values of $D°$ and $I°$ plotted against depth of core

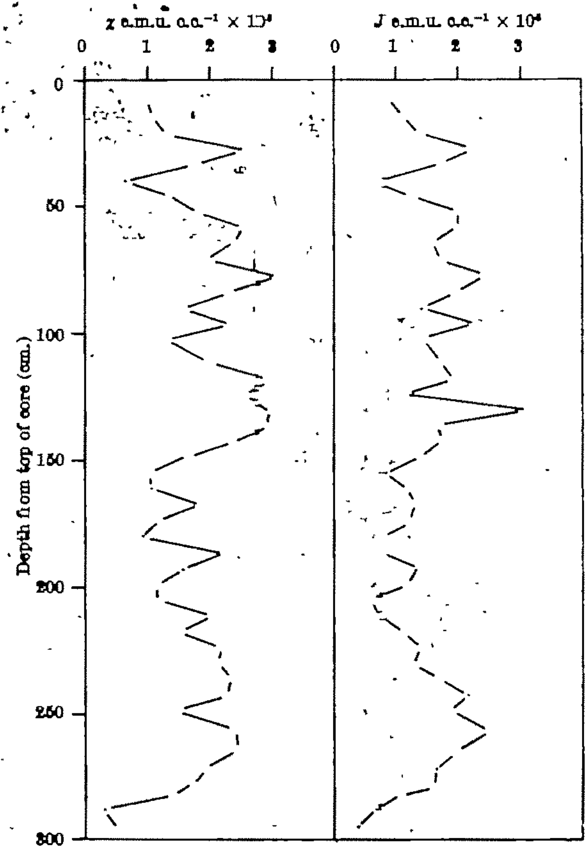


Fig. 3. Core 3738: values of χ and J plotted against depth of core

is given in Fig. 1, with the percentage of total carbonates and the water content. The carbonate content is given as a percentage of the dry weight and the water content as a percentage of the wet weight. The samples taken for the investigation of the remanent magnetization were in the form of cylinders 2·7 cm. in length and in diameter, and were taken immediately after the core had been opened and before it had dried out significantly; sampling was continuous down the core. All the samples were oriented in the same way relative to the core as a whole; the direction of the length of the core can be expected to be the vertical. The direction and intensity of the remanent magnetization of each sample was measured on an astatic magnetometer similar to that described by Collinson *et al.*[5]. The susceptibility was measured with an a.c. bridge by comparing the samples with standards.

The magnetic data are shown in Figs. 2, 3 and 4. Fig. 2 shows the variation in the values of declination, D (azimuth), and the inclination, I (dip), down the core. The values of D are plotted with an arbitrary zero and the values of I with the direction of increased depth down the length of the core as 90°. The present value of I in the area from which the core was taken is about 58° (ref. 6). Fig. 3 shows the variation in intensity of remanent magnetization, J, and the variation in magnetic susceptibility, χ, down the core: the values are given in e.m.u. c.c.$^{-1}$ of wet sediment. Fig. 4 shows histograms of the values of D and I of all the specimens measured.

The minerals which cause the magnetization have been investigated only by thermo-magnetic analysis and two sets of experiments were carried out. In

one set the char
of the whole s
ceptibility brid
separations wer
balance similar
Chevallier[7]. T
per cent of t
magnetite.

The work whi
reproduced the
samples embrac
histogram of th
variation over
that of the kno
of the values c
known historica
This may be ex
has been found
core and the va
that there may
amounts up to a
and 2). Evid
animals is comm
part of the sedi
direction of re
acquired until s
deposited and
further by comp
direction have b
correlation betw
of one another

Core 3780 con
turbidity curre
cm. thick may b
core the change

ility with temperature
asured using the sus-
second set magnetic
n a thermo-magnetic
to that described by
gest that at least 90
moment is caused by

e so far could not have
r variation since the
e time-interval. The
Fig. 4) show, however,
is about the same as
ndon. The histogram
eater range than that
ed towards low values.
correspondence which
water content down a
ination, which suggests
in the inclination by
gh compaction (Figs. 1
rbance by burrowing
ll rework the uppermost
s possible that the final
tization has not been
the sediment has been
tion has been altered
versals in the remanent
hese cores, and no cross-
n within a mile or two
onspicuous.
f material deposited by
ent of the order of 100
any one time. In this
are much greater than

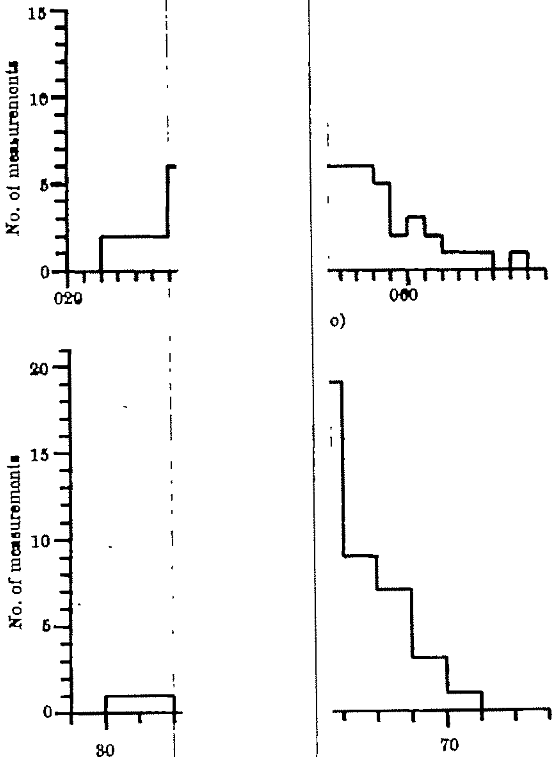


Fig. 4. Core 3738 : values of D° and I° for all easured

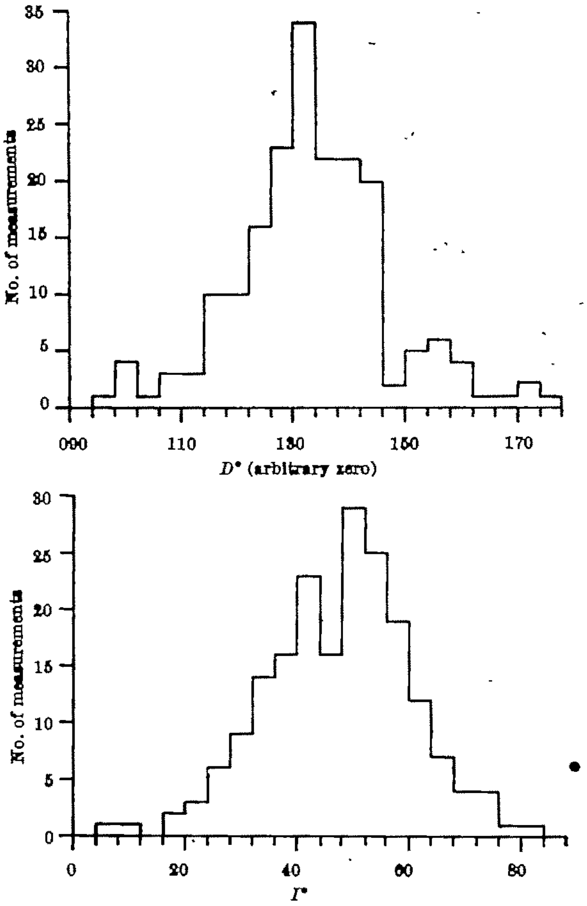


Fig. 5. Core 3780 : histograms of the values of D° and I° for all the specimens measured

in the type of core described above, and this can be seen in the histograms (Fig. 5).

The cores have been stored horizontally since collection before being measured and in some cases for as long as eighteen months ; there are no results which suggest instability over this length of time. Stability is also suggested by the correspondence between changes in inclination and compaction.

The results suggest that the magnetization of the sediments of the type found in core 3738 is due to the Earth's magnetic field during deposition or soon after deposition while the core is still wet and is being reworked by burrowing animals. Studies are being made of longer cores and of cores taken within 200 m. of each other to see whether reversals of polarity of the sediments occur and whether correlation can be found between adjacent cores.

I should like to thank members of the Department of Geodesy and Geophysics and the National Institute of Oceanography for their help and advice and the Royal-Dutch Shell Group for a scholarship.

---

[1] McNish, A. G., and Johnson, E. A., *Terr. Magn. Atmos. Elect.*, **43**, 401 (1938).

[2] Johnson, E. A., Murphy, T., and Torreson, O. W., *Terr. Magn. Atmos. Elect.*, **53**, 349 (1948).

[3] Reported in *Geophys. J.*, **2**, 168 (1959).

[4] Heezen, B. C., Tharp, M., and Ewing, M., Spec. Pap. Geol. Soc. Amer., **65**, 80 (1959).

[5] Collinson, D. W., Creer, K. M., Irving, E., and Runcorn, S. K., *Phil. Trans. Roy. Soc.*, A, **250**, 71 (1957).

[6] "Curves of Magnetic Dip" (Admiralty, London, 1955).

[7] Chevallier, R., and Pierre, J., *Ann. Phys., Paris*, X° Ser., **18**, 38 (1932).

LETTERS TO THE EDITORS

ASTROPHYSICS

Gravitational Red Shift of Hydrogen 21-cm. Radiation as a Method to measure Galactic Gravitational Potential

THE 21-cm. hyperfine emission from the neutral hydrogen atom has an exceedingly narrow natural width, corresponding to a transition probability of $2 \cdot 84 \times 10^{-15}$ sec.$^{-1}$. Consequently, in principle, small variations in its frequency resulting from gravitational effects offer a method to measure gravitational potential in our Galaxy, provided that they are not too small compared with the temperature broadening. The galactic disk is well known to emit 21-cm. radiation, and from its observed Doppler shifts the radial dependence of its rotational velocity has been deduced. Because the true Doppler shifts of galactic rotational motion are large, it may be difficult to detect the expected gravitational shift, which also looks like a Doppler shift. But, in principle, the two effects may be separated because the true Doppler shifts have opposite signs at the same radius on opposite sides of the galactic centre, whereas the gravitational frequency shift has the same sign.

Added to the true Doppler shift, and the gravitational frequency shift, there is the temperature broadening of the 21-cm. line. For radiation emitted near the centre of the galaxy ($R \leq 1$ kpc) which propagates out to the Earth ($R = 8 \cdot 2$ kpc) the true Doppler shift has an average value of about 25 km./sec., and the temperature broadening is about 1·0 km./sec. corresponding to a temperature of 150° K. for neutral hydrogen.

Assuming the numerical values[1] at present accepted for the galactic gravitational potential, we compute the gravitational frequency shift for this radiation to be $\sim 0 \cdot 7$ km./sec. Using the usual gravitational shift formula[2]:

$$\frac{\Delta \nu}{\nu} = \frac{\varphi_2 - \varphi_1}{c^2}$$

where φ_2 and φ_1 are the potentials at the point of emission and absorption respectively.

This frequency shift is equivalent to a Doppler shift resulting from a relative velocity v:

$$\frac{\Delta \nu}{\nu} = \frac{v}{c}$$

Consequently, the apparent Doppler shift velocity equivalent to the gravitational frequency shift is given by:

$$v \simeq \frac{1}{c}(\varphi_2 - \varphi_1)$$

and is positive (shift to bluer frequency) or negative (shift to redder frequency) accordingly as the photon comes to the Earth from a region of higher or lower gravitational potential. From the hypothesis that the galactic gravitational potential increases with increasing radius it follows that photons coming to us from near the centre of the Galaxy are red shifted whereas those coming from radii larger than 8·3 kpc are blue shifted.

Now let the potentials[1] be taken as $|\varphi_1| = 2 \cdot 9 \times 10^{15} \frac{\text{cm.}^2}{\text{sec.}^2}$ at $R_1 = 0$ kpc and $|\varphi_2| = 0 \cdot 82 \times 10^{15} \frac{\text{cm.}^2}{\text{sec.}^2}$ at $R_2 = 8 \cdot 2$ kpc, where we have multiplied by a factor (Schmidt, Martin, private communication) of 2 to account for a revised value of the total galactic mass. Then the equivalent velocity is:

$$|v| = \frac{1}{3} \times 10^{-10}[2 \cdot 9 - 0 \cdot 82] \times 10^{15} \frac{\text{cm.}}{\text{sec.}} = 0 \cdot 7 \text{ km./sec.}$$

If the galactic mass or galactic diameter should be different from the presently accepted values (ref. 1 and Schmidt, Martin, private communication) the equivalent velocity measured would differ from the value computed here.

A determination of the equivalent velocity for some region of the Galaxy measures the difference in gravitational potential between the point of emission and the Earth, and so gives independent information on the mass of the Galaxy. However, the effect is small, and will require to be detected against a background of large rotational Doppler shifts. In principle, this may be done in the following way, assuming the matter of the disk to be distributed symmetrically with respect to the galactic centre. Suppose one integrates all observed Doppler shifts, weighted by observed relative intensity, over an angular interval symmetric with respect to the galactic centre, $\vartheta \leq \theta \leq -\vartheta$, where θ is the angle between the direction of observation and the direction of the galactic centre. Then the sum of terms coming from all true Doppler shifts should add to zero, because these are positive and negative accordingly as θ is positive and negative, whereas the terms arising from gravitational shifts have always the same sign, and consequently add. The resultant sum when divided by the integral of total amount of neutral hydrogen present in that region is equal to the average gravitational shift in that region. If the effect is too small to measure one may nevertheless be able to determine an upper limit for the galactic mass.

There are, of course, various other effects which can distort the above simple approach and which may have to be taken into account such as the motion of the Sun, and possible errors in the determination of the Galactic centre.

The first might be treated in the following way. Assume the distribution of mass as symmetrical with respect to the line between Earth and galactic centre. Let the integral I over the given angular interval 2ϑ, symmetrical with respect to the galactic centre, be plotted versus ϑ for various heights of observation above, in and below the galactic plane, both in the direction of the galactic centre and in the opposite direction. In principle, these sets of data are sufficient to allow determination of the velocity of the solar system in the galactic plane with respect to the galactic centre, because resulting linear effects change sign for the two sets of data.

If the centre of the galaxy x_0 has been incorrectly identified, its effect may be minimized as follows. Compute $I(2\vartheta)$ for various assumed positions of the centre, on both sides of x_0; then integrate $I(2\vartheta)$ over x. The resultant depends on the gravitational red shift, and the error caused by wrong choice of

centre is ~(Δλ x measures the region of
integration an es the error in locating
the centre.

We are grat sions with F. D. Drake,
J. W. Findlay er, D. S. Heeschen, M.
Schmidt, O. St sternack.

This work w t under the auspices of
the U.S. Atom mmission.

L. F. Landovitz
L. Marshall

Brookhaven oratory,
Upton

---

[1] Schmidt, Martin, . Vederlands, 466, 15 (1956).

[2] Landau, L., and Lif Theory of Fields", 277 (Addison-
Wesley, Cambr s, 1951).

Measure gnetic Fields in
C ic Flares

Spectra of r mospheric flares taken
by the flare s at Ondřejov[1] show an
evident splittin emission line of Na I
which is attrib gnetic field existing in
that part of t ere where the sodium
lines are forme nation is supported by
the following f

(1) Only the t into two components,
while no effect for the D_2 line (Fig. 1).
Were the effect er physical reason inde-
pendent of the such as self-absorption,
it would have b both lines of the sodium
doublet.

(2) For one c ultra-violet part of the
spectrum was aphed, and the same
effect can be f λ3706 line of the third
doublet of Ca n pattern of which is
identical with D_1 line. Values of the
magnetic inten d from the Na I and
Ca II lines, re in a good agreement
(Table 1).

Apart from t lets our plates contain
one more line h the Zeeman splitting
might be found polarization equipment,
namely, that c ublet of Al I, λ3944.
The emission in ever, is less intense and
consequently th uld not be recognized
in this case.

(3) Both the photographed above a
sunspot with magnetic field. No

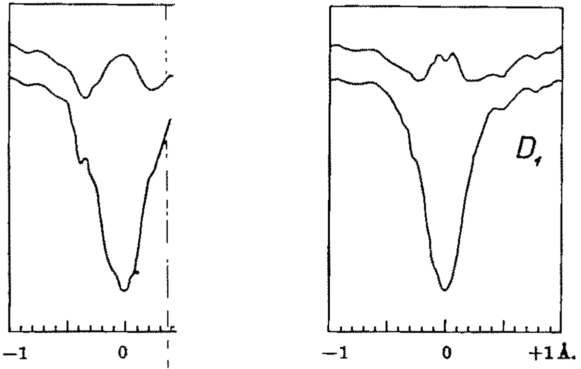


Fig. 1. Photometr D_1 and D_2 lines of sodium
in the flare above ve) and in the photosphere
close to the flare (D_1 emission is split by the
magnetic field; the tly absorbed on its red wing
by the λl r (March 29, 1959)

Table 1. Resulting Intensity of Magnetic Fields on March 29 (Spectra taken at 7 hr. 53 min and 56 min.) and on August 18 (Spectra taken at 10 hr. 34 min., 39 min. and 41 min.)

Line	Method	Splitting	Intensity $g = 4/3$ gauss	Intensity $g = 1$ gauss
March 29				
D_1	tracing	0·110 Å.	2,500	3,400
D_1	visual	0 117 Å.	2,700	3,600
August 18				
D_1	tracing	0·121 Å.	2,800	3,700
D_1	visual	0·134 Å.	3,100	4,100
λ3706	visual	0 054 Å.	3,200	4,200

effect of this type has been found for flares outside the spots.

The flares considered are: the first one on March 29, 1959, 7h. 46m.–9h. 30m., maximum phase at 7h. 43m., importance 2, position 17 N., 36 E., maximum H_α line width 4·0 Å., maximum H_α central intensity ~ 125 per cent of the continuum[2]. Its part was projected on a spot, the maximum magnetic intensity of which was ascertained to 2,500 gauss on March 30, and 2,400 gauss on March 31 (ref. 3). No magnetic measurement was at our disposal on the day of the flare appearance. The second flare was observed on August 18, 1959, 10h. 13m.–12h. 35m., maximum phase between 10h. 25m. and 10h. 31m., importance 3, position 12 N., 32 W., maximum H_α line-width $\gtrsim$ 5·6 Å. Measured maximum magnetic intensity of the spot associated was ascertained to 2,500 gauss on the day of the flare appearance and 3,100 gauss on August 19 (ref. 3). Spectra of both the flares were photographed by Miss Růžičková.

Fig. 1 presents profiles of the sodium D_1 and D_2 lines in the spectrum of the flare of August 18, traced by a Khol recording microphotometer. The linear dispersion was 1 Å./mm. and the resolving power 10^5. In the ultra-violet region the dispersion was 0·67 Å./mm.

The splitting was measured by two methods: from the tracings recorded, and visually from a projection of the negatives enlarged twenty times. The resulting values are given in the third column of Table 1. The splitting of the Ca II line was too small to be distinguished by a microphotometer tracing.

Due to the fact that the σ and π components are not separated, the determination of the magnetic intensity is rather uncertain. As both the flares appeared not far from the centre of the solar disk and directly over sunspots, the path of the radiation can be assumed as parallel with the magnetic lines of force. In such a case we may consider the σ components only, and we obtain the values of intensity given in the fourth column of Table 1. As, however, metallic emission lines of flares seem to be formed rather high in the chromosphere[4], we cannot be sure about the course of lines of force in the emitting area and weaker π components can also be present. Therefore, we add as the upper limit the case of $g = 1$ in the last column of Table 1.

Although the precision of our measurements, made without any polarization equipment, is not very high, one can be sure that during these flares strong magnetic fields—approximately of the same order as in the photospheric part of the sunspots—existed rather high in the chromosphere. This supports former conclusions[5] that the gradient of the magnetic intensity above sunspots is extremely low. As always, the most intensive regions of flares were photographed by the Ondřejov spectrograph; our result also shows that even very bright parts of chromospheric flares can exist directly in those parts of the solar atmosphere where very strong magnetic fields are present.

M. BLAHA
M. KOPECKÝ
Z. ŠVESTKA

Astronomical Institute,
Czechoslovak Academy of Sciences,
Ondřejov.
April 19.

---

[1] Valníček, B., Letfus, V., Blaha, M., Švestka, Z., and Seidl, Z., *Bull. Astro. Inst. Czech.*, 10, 149 (1959).

[2] "Compilations of Solar–Geophysical Data, Boulder" (March and August 1959).

[3] "Solar Data, Moscow–Leningrad" (March and August 1959).

[4] Švestka, Z., *Bull. Astro. Inst. Czech.* (in the press).

[5] Severny, A. B., and Bumba, V., *The Observatory*, 78, 33 (1958).

GEOPHYSICS

Stress-Dependent Magnetization in Some Quartz-Dolerites

WHEN non-axially magnetized cylindrical specimens of a quartz-dolerite have been axially compressed in an axial magnetic field of the order of the Earth's, their natural remanent magnetism vectors have changed towards the ambient field direction.

The empirical functions:

$$K = \frac{P_\varphi - P_{\varphi 0}}{\tan 90 - \varphi} \pm 7 \text{ per cent} \qquad (1)$$

and:

$$I_T = \frac{I_A}{\tan 90 - \varphi} \pm 10 \text{ per cent} \qquad (2)$$

fit the measured changes where P_φ is the pressure applied to produce a vector making an angle φ with the field and compression direction, K is a parameter dependent upon the magnetic minerals and the ambient field-strength, and I_A and I_T are the axial and transverse components of the natural remanent magnetism intensity.

An example for specimen number 18*H* is given in Table 1.

Table 1

P_φ (kgm./cm.^{2})	$90 - \varphi$ (°)	Tan $90 - \varphi$	I_A (arbitrary	I_T units)	Field oersteds
0·0	−59	−1·68	−17·0	10·0	1·8
127·2	−49	−1·15	−13·8	12·0	1·8
254·2	−31	−0·61	− 6·1	10·0	1·8
381·6	−14	−0·25	− 2·9	11·5	1·8
508·8	+21	+0·38	+ 4·2	10·8	1·8
636·0	+55	+1·43	+13·0	9·0	1·8

Putting $\tan 90 - \varphi = y$, $P_\varphi = x$ and $K = 1/b$, then the least squares solution for the straight line $y = bx + c$ leads to:

$$K_{1 \cdot 8} = 217 \pm 13$$

similarly:

$$I_T = 10 \cdot 5 \pm 1 \cdot 0$$

The error in K is equivalent to an error of 4°–5° in φ, about twice the repeatability of a measurement, a difference attributed to magnetic inhomogeneities accentuated by the stress treatment. Results for several specimens from the same dyke locality in fields up to 2·4 oersteds and pressures up to 636 kgm./cm.^{2} (that is, 30–50 per cent of that to produce fracture) are given in Table 2.

Stereograms of natural remanent magnetism vectors for a number of cores from specimens 15 and 18 (Fig. 1) are examples of an unstable and a stable type respectively. Their K-parameters are a measure of their stabilities under conditions of geological significance. Specimen 18 has retained its magnetization in the original Permian thermal remanent magnetism direction[1]. The present field makes angles, measured almost in the meridian, of 90° and 115° with the natural remanent magnetism of specimen 18*H* and the Permian field respectively. This indicates the maximum geological compression (P_{90}) on the core in the present field direction since:

Table 2

Specimen	Core	Field	K
15	*H*	0·6	295 ± 20
15	*C*	1·2	98 ± 3
15	*C*	1·8	55 ± 5
15	*G*	2·4	63 ± 6
18	*H*	0·6	590 ± 90
18	*H*	1·2	270 ± 10
18	*H*	1·8	217 ± 13
18	*B*	1·2	590 ± 25
18	*B*	2·4	344 ± 11
20	*I*	0·6	575 ± 30
21	*B*	1·8	147 ± 15

$$P_{115} - P_{90} = 600 \tan (90\text{–}115)$$

so

$$P_{90} = 300 \text{ kgm. cm.}^2\text{, where } P_{115} = 0$$

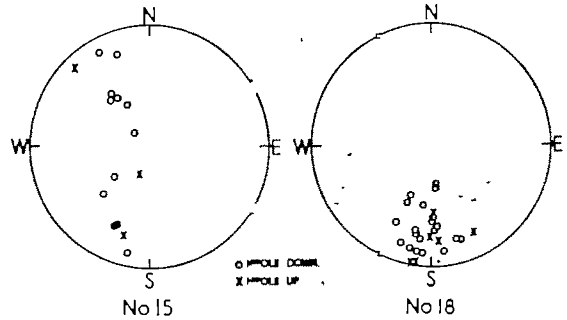


Fig. 1

An experiment on one specimen shows that the K_{TRM} is three or four times greater than its K_{NRM} in the Earth's field. This suggests that the stress dependence is due to unmixing of higher temperature magnetic phases[2]. One specimen showed a decrease of K_{NRM} after repeated stress treatment. It is hoped to continue these measurements over a wider range of field and stress and rock-types and to examine the magnetic minerals optically.

D. W. POWELL

Department of Geology,
University of Glasgow.
June 1.

---

[1] Creer, K. M., Irving, E., and Nairn, A. E. M., *Geophys. J.*, 2, 319 (1959).

[2] Graham, J. W., Buddington, A. F., and Balsley, J. R., *Nature*, 183, 1318 (1959).

Atmospherics on 20 kc./s. at the Time of Local Aurora

A CONTINUOUS registration of atmospherics on 20 kc./s. has been in action, during the night hours, at our Geophysical Observatory since July 1959, with some interruptions during December 1959–February 20, 1960.

Every time (30 cases to date) that a strong aurora was seen, the 20-kc./s. registration showed distinct intermittent and violent bursts, some of which saturated the receiver and sent the recording pen

off scale for
greater than 6
At other tim
bursts of atmo
but whether th
no catalogue
obtained. As
to have an ob
sub-zero tempe
tinuously radia
owing to regu
Administration
Nevertheless,
comings we h
sufficiently str
earthward stre
lower stratosph
ionized stripes o
the intensity of
in distant regio
visible with its
colouring. Th
last longer tha
protons. The
auroræ have no
seconds, some
atmospherics.
transient ioniza-
intense bursts
lated in time.

Geophysical
College
Montre
June

s. The intensity was
0 ohms.
corded similar sporadic
the skies were overcast;
ora we cannot say since
ible auroræ could be
ution we cannot afford
in the open and with
e year round. A con-
lso out of the question
e Telecommunications

ding all these short-
ession that auroræ of
can, at times, beam
s or electrons into the
r troposphere. These
nosphere could enhance
mospherics, originating
ed where the aurora is
sions of brightness and
oduced, if any, should
d injections of auroral
es of intensity of the
ation. Some last a few
s, as do the bursts of
nomena, namely, the
er troposphere and the
erics, seem to be corre-

E. GHERZI

S

Ferromag
Behaviour I

A PSEUDO-P
per cent each o
in palladium h
strongly depen
temperatures
temperature t
pendent of the
than that of
A graph of m
Fig. 1, and Fig
ture of the app
derived from th
tion curves, wh
It seems sign
the temperatur
pure palladium
a specimen of
bility independ
susceptibility i
observed that it
value down to
shows a marke
higher value at
associated with
thus seems to p
ter, as discuss
when alloying t
of electrons is
are little chan

ntiferromagnetic
Transition Group

y containing 1 atomic
silver in solid solution
to have a susceptibility
magnetic field at low
hysteresis. At room
ty is accurately inde-
out 5 per cent greater
n.
against field is given in
dependence on tempera-
eous magnetization (σ_s)
rtions of the magnetiza-
χH.
falls to a low value in
e the susceptibility of
num[1]. We have found
dium to show suscepti-
the magnitude of this
n Fig. 2, and it will be
dily from the maximum
e a less-pure specimen
low about 20° K., the
specimen is presumably
impurities.) Palladium
tiferromagnetic charac-
, and we suggest that
which the mean number
, the basic interactions
nt imperfections in the

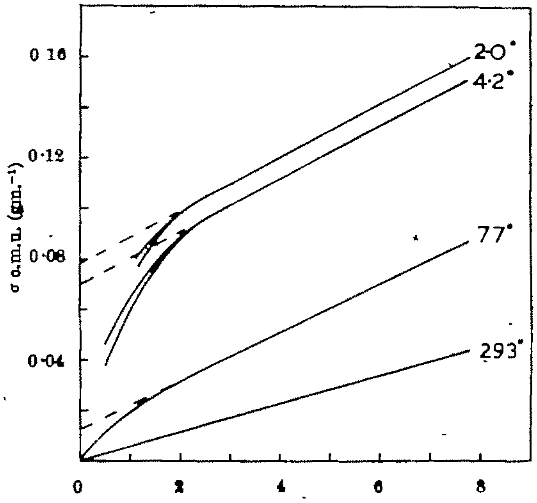


Fig. 1. Magnetization (σ) against magnetic field (H) for a palladium 1 per cent silver 1 per cent rhodium alloy

antiferromagnetic order give rise to a ferromagneti
moment. An explanation of this type has been pu
forward for the weak ferromagnetism of α Fe_2O
(ref. 3). More direct evidence of antiferromagnetism
is being sought by neutron diffraction. The electrica
resistance of the pseudo-palladium alloy shows n
marked anomaly in the temperature-range concerned
but a negative magneto-resistance is found in lo
fields at 4·2° K.

The co-existence of ferromagnetism and anti
ferromagnetism might lead one to expect exchang
anisotropy effects like those in the Co–CoO system
(ref. 4), or in the perhaps more analogous disordere
Ni_3Mn alloy (ref. 5), but we have not found the
palladium alloy to be appreciably affected by coolin
in a magnetic field.

In an alloy containing 5 per cent each of rhodium
and silver, the dependence of the susceptibility o
the field appears at lower temperatures, but is wel
established at 4·2° K.; although the susceptibilit
of a binary alloy of palladium with 5 per cent rhodium
which has a very enhanced susceptibility at 20° K

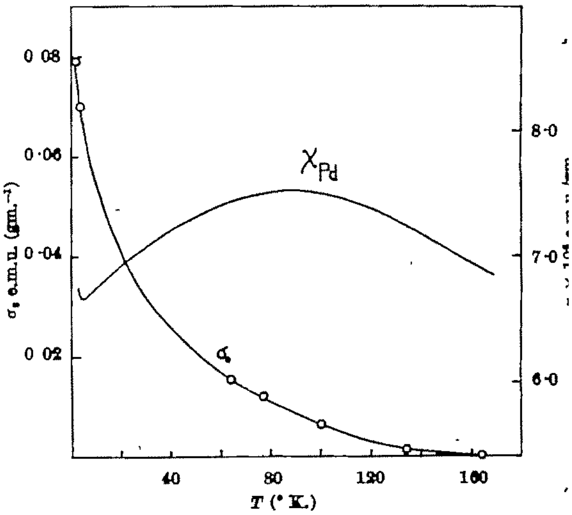


Fig. 2. Spontaneous magnetization (σ_s) against temperature for a palladium 1 per cent silver 1 per cent rhodium alloy and magnetic susceptibility (χ_{Pd}) of pure palladium

(ref. 6), has been found by us to show only an extremely small dependence upon field at helium temperatures. This would suggest that rhodium alone depresses the susceptibility maximum of pure palladium, thereby raising the low-temperature susceptibility but preventing the appearance of local ferromagnetism. A palladium 1·6 per cent silver alloy also shows no anomalous behaviour at 4·2°.

This investigation is being extended to related alloys, and a fuller account will be published elsewhere. We thank the Mond Nickel Co. (Precious Metals Division) for the provision of the alloys, the Royal Society and the Atomic Energy Research Establishment, Harwell, for financial support, and Mr. R. V. Bellau for assistance with the electrical measurements.

B. R. Coles
D. Griffiths

Department of Physics,
Imperial College, London, S.W.7.

[1] Hoare, F. E., and Matthews, J. C., *Proc. Roy. Soc.*, A, 212, 137 (1952).
[2] Lidiard, A. B., *Proc. Roy. Soc.*, A, 224, 161 (1954).
[3] Néel, L., "Adv. in Phys.", 4, 202 (1955).
[4] Meiklejohn, W. H., and Bean, C. P., *Phys. Rev.*, 102, 1413 (1956).
[5] Kouvel, J. S., and Graham, C. D., jun., *J. Phys. Chem. Solids*, 11, 220 (1959).
[6] Hoare, F. E., and Preston, J., *Nature*, 180, 334 (1957).

Direct Observation of Surface Contamination formed in Demountable Vacuum Systems

The visible contamination of specimens examined in the electron microscope is the result of a reaction between the electron beam and matter adsorbed on the irradiated surface. This adsorbed material is known to consist of hydrocarbon molecules[1], though it may also contain some water molecules; it exists on surfaces in all demountable vacuum systems. The layer is troublesome in many experiments and processes involving such systems, but evidence of its presence is only indirect and little is known about its thickness or composition. It is particularly noticeable in high-resolution shadow-casting for the electron microscope (unpublished work), since it limits the resolution by causing a fine background structure. In the course of an investigation of this structure, a method was found for studying the adsorbed layer directly, and also for estimating its thickness. It was found that the layer was visible in the electron microscope when viewed end-on and sandwiched between two carbon films (see Fig. 1). The procedure is carried out as follows.

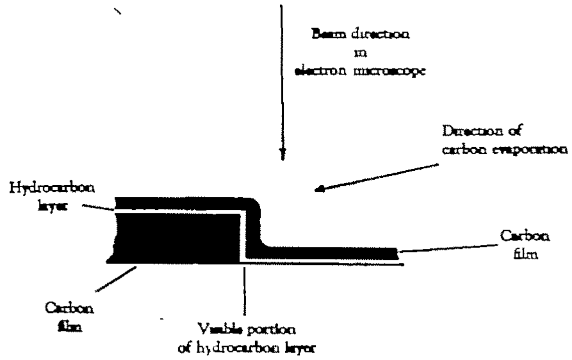


Fig. 1. Diagram showing the manner in which a contaminant layer, deposited from a vacuum system, can be viewed directly in the electron microscope

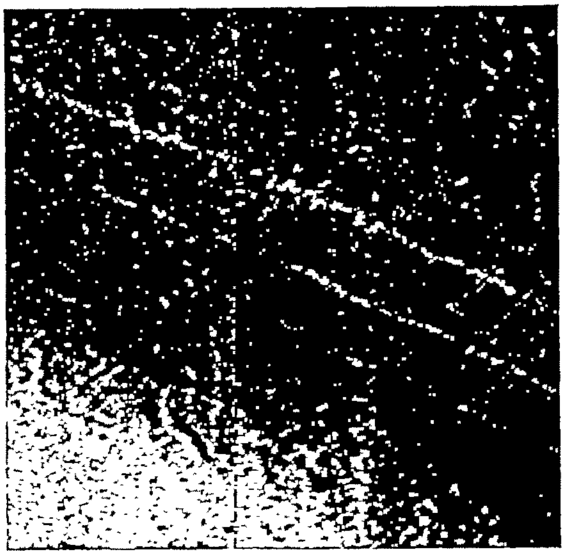


Fig. 2. A contaminant layer deposited from a vacuum system viewed end-on in the electron microscope; each white line represents a different layer (see text). (× 400,000)

A carbon film about 300 Å. thick is deposited on a glass slide and floated on to a water surface. A second carbon film about 100 Å. thick is deposited on a freshly cleaved mica surface. A drop of water is placed on the coated mica, and a few small pieces of the floating carbon film transferred to the drop with a very fine glass rod. The excess water is removed with filter paper and the thick carbon film allowed to dry on to the thinner The second film provides vertical steps A further carbon film is now evaporated against one of the steps at an angle of 26½° to the horizontal as shown in Fig. 1, the direction of deposition being perpendicular to the line of the step. The combined films are floated on to water, and the portion containing the step mounted on a grid. The step edge is located in the electron microscope, and a thin line transparent to electrons and separating the final carbon deposit from the step face can be clearly seen. If the orientation of the specimen is such that the direction of the incident electron beam is not parallel to the step face, then the line disappears, as might be expected.

A simple experiment shows that the thickness of this line depends upon the time for which the step face is exposed to the atmosphere in the pumping plant. This is carried out by depositing several secondary carbon layers, in a series of short bursts spaced by varying intervals of time. In this way the change in thickness can be studied in a single electron micrograph, such as that shown in Fig. 2. Here, the material in the line marked *A* was deposited while the plant was pumped down from atmospheric pressure and then evacuated with the diffusion pump for 30 min. The line *B*, only just visible, was formed in an interval of 1 sec. between two depositions of carbon, the line *C* was formed in 20 min. and *D* in 10 min. During these intervals, the system (pumped by a 'Metrovac' 03*B* diffusion pump, with no cold trap, using 'Apiezon *B*' oil was at a pressure of about 10^{-4} mm. mercury. It can be seen from the electron micrograph that the width of the line depends on the time of exposure to the atmosphere in the system. This indicates that the line transparent to electrons represents an end-on view of a layer of material

which originat
that the layer
than a simila
contains a high
power less tha
case if the lay
The thickne
layer *B* about
monomolecular
would be abou
thus form in t
a dynamic eq
when a layer
deposited.
The direct
this way could
of a vacuum
hydrocarbon v
It has been
above can be
thickness of
degree of accur
the lines, whi
reference mark
carbon deposit
lines *C* and *D*
representing a
equal the thick
placed horizon
of evaporation
lowering the
horizontal to
metrically so
vertical step
With a suitabl
about three tim
on the step fr
in the electron
would give a t
A prelimin
measurements
using an optica
a reasonable c

Optical m
223
140
121

The optical
ferometer micr
the convention
It has been
method is sa
platinum/carb
shown promis
I thank Miss
tive measurem
of the Labora
communication

Associated Ele
Resear
Alderm
Alc
B

[1] Bunce, A. H., *Br*
[2] Dyson, J., *J. Opt*
[3] Tolansky, S., "M
Oxford, 1948)
[4] Bradley, D. E., *B*

mping plant. The fact
transparent to electrons
carbon shows that it
atoms with a scattering
on, which would be the
hydrocarbon molecules.
about 25 Å. and that of
suggests that layer *B* is
bable that the molecules
meter; a monolayer can
sec., but it appears that
reached within 20 min.
molecules thick has been

f contaminant layers in
etermining the efficiency
egard to the amount of

he technique described
thod for measuring the
orated films to a high
be seen from Fig. 2 that
sharp, can be used as
ng the thickness of the
e, the distance between
ick on the micrograph,
s of 175 Å. This will
deposited on a substrate
he step, since the angle
as 45° (see Fig. 1). By
ition, the ratio of the
ess will be altered geo-
thickness exists on the
the horizontal target.
kness 'magnification' of
tained without difficulty
measurement of 60 Å.
o an accuracy of 9 Å.
of 20 Å. to within 3 Å.
on between thickness
n the same carbon film
hat described here gives

n microscope method
206 Å.
110 Å.
118 Å.

loyed a shearing inter-
is at least as accurate as
e technique[5].
he electron microscope
silicon monoxide and
minium films have also

rrying out the compara-
T. E. Allibone, director
mission to publish this

D. E. BRADLEY

ies, Ltd.,

1, 101 (1953).
37 (1957) (see pp. 561–62).
rferometry" (Clarendon Press,
10, 198 (1959).

Rare Modes in the Spontaneous Fission of Californium-252

CALIFORNIUM-252, a man-made trans-uranic element, having an α-particle half-life of 2·2 yr., undergoes spontaneous fission. Approximately one fission occurs per 38 α-particles, and the material is therefore well suited to an investigation of the possibility of rare modes of spontaneous fission.

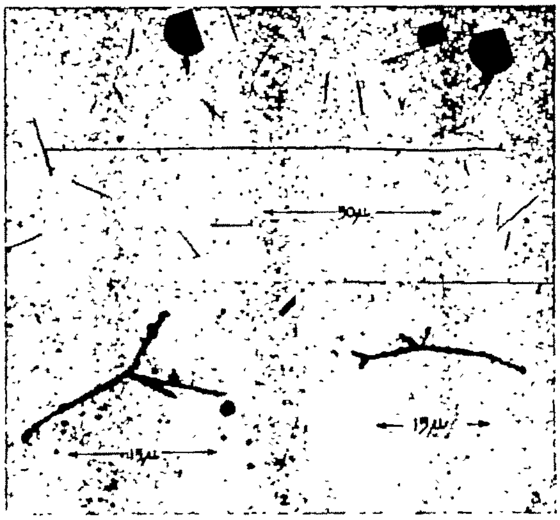
In slow-neutron fission[1,2], fast-neutron fission[3] and photofission[4,5], two rare fission modes have been established. In one the emitted particle is long-range and uniquely an α-particle; in the other, short-range particles, apparently light elements, appear to be emitted in the process. There is also, in slow-neutron fission, some evidence for fission into three particles of approximately equal mass and kinetic energy, but this is not unambiguous[6].

Observation of the quaternary fission of uranium-235 was claimed in 1946 by a French group[7], but later work in this laboratory[8] showed that, if it occurred, the frequency was much less than that estimated from the French investigation.

In the present experiment, where minute traces of californium-252 were incorporated into Ilford K_5 and E_1 emulsions, the conditions of observation were more favourable than in any of the earlier nuclear emulsion studies. Since the plates required no irradiation, they contained only the californium-252 fission and α-tracks plus the usual slight background from inevitable radioactive inclusions. Random association of tracks yielding 'spurious' events was therefore greatly reduced and could be virtually eliminated by measurement of a range of distributions of tracks in the emulsion.

In a study of 50,000 binary events in these emulsions the following types of event have been recorded:

(1) 179 cases have been observed of ternary fission into two heavy fragments and a long-range α-particle; the frequency is 1 per 280 (± 25) spontaneous binary fissions. The mode appears to be significantly more frequent than in the case of slow-neutron fission of uranium-235, uranium-233 or plutonium-239 (ref. 8). An example is shown in Fig. 1.

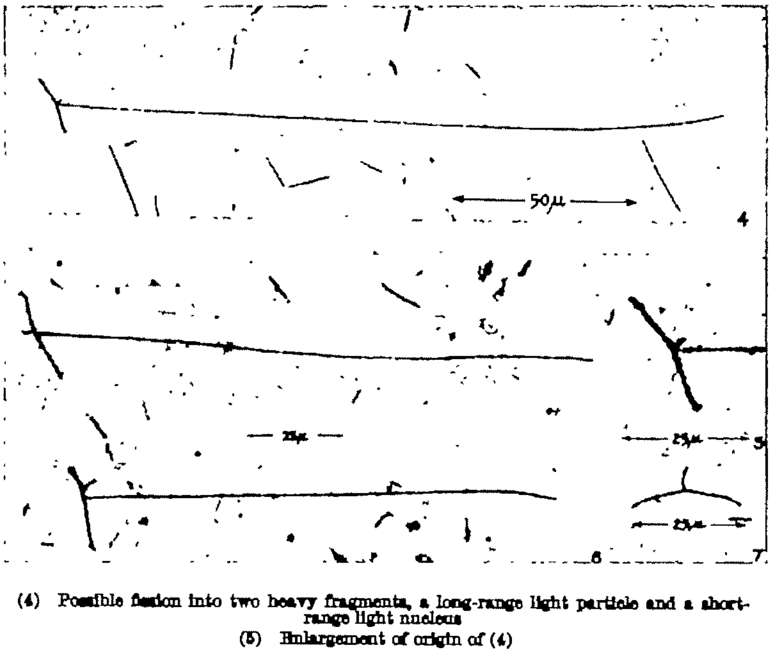


(1) Ternary fission of californium-252
(2) Probable quaternary fission of californium-252
(3) Projection of recoils in emulsion shortly after fission giving appearance similar to a quaternary fission

(2) Eight good examples and four additional possible cases of fission into four heavy fragments (Fig. 2) have been observed. Apart from quaternary fission, the only other possible explanation for these events is that they arise from recoils projected in the emulsion by the pair of fission fragments within $\frac{1}{2}\mu$ of the origin. Two experimental results oppose such an explanation. Although events of this general type do occur (as is indicated by Fig. 3 but where the 1μ spacing between the forks clearly eliminates the event as quaternary), their observed frequency is too low to explain the four-particle events. Moreover, if scattering accounted for such events, then in the earlier study of 600,000 uranium-235 binary fissions[4], some 100 such events should have been observed; in fact only 2 were recorded. We therefore believe the events to be true spontaneous quaternary fission, the frequency being roughly 1 per 5,000 binary fissions.

(3) Three events of the type Fig. 4 (and see enlargement of origin, Fig. 5) have been observed. Again these might be explained as an event of type 1 with a recoil occurring near the origin, and such spurious cases do occur as indicated in Fig. 6. However, during our earlier work where more than 10^6 binary fissions were examined, only one other example of such an event was observed. These events may, therefore, represent a mode of spontaneous quaternary fission involving emission of a long-range α-particle and a short-range light nucleus in addition to the two fission fragments.

(4) As in previous experiments, a considerable number of events are observed which could be interpreted as ternary fission, the third fragment being a short-range light nucleus. The frequency of occurrence of such tracks at the origin appears to be greater than would be expected from Rutherford scattering. In addition to these events, which occur at a rate of 1 per 80 (± 20) binary fissions, others have been observed which could be ternary fission into three roughly equal parts. Analysis of the type employed by Catala *et al.*[6] indicates that many of these arise through fission fragments colliding with silver or bromine nuclei in the emulsion. However, it does not exclude all and it could be that this mode of fission exists in californium-252.



(4) Possible fission into two heavy fragments, a long-range light particle and a short-range light nucleus

(5) Enlargement of origin of (4)

(6) Examples of a ternary event of type (1) with a recoil track close to origin, easily distinguishable from (4)

(7) Case of possible ternary fission into three roughly equal fragments

The experiments are continuing, and will be reported in detail later. We wish to thank Prof. E. M. McMillan and Dr. S. G. Thompson, of the University of California, who provided the californium for these experiments.

E. W. TITTERTON
T. A. BRINKLEY

Research School of Physical Sciences,
Australian National University,
Canberra.
June 8.

---

[1] Titterton, E. W., *Nature*, 168, 590 (1951). Demers, P., "Ionographie, Les Emulsions Nucléaires", 253 (Montreal University Press, 1958).

[2] Fulmer, C. B., and Cohen, B. L., *Phys. Rev.*, 108, 370 (1957).

[3] Titterton, E. W., *Phys. Rev.*, 83, 673 (1951).

[4] Titterton, E. W., and Brinkley, T. A., *Phil. Mag.*, 41, 500 (1950).

[5] Titterton, E. W., and Goward, F. K., *Phys. Rev.*, 76, 142 (1949).

[6] Catala, J., Casanova, J., and Domingo, V., *Nature*, 184, 1057 (1959).

[7] Tsien, S. T., Ho, Z. W., Chastel, R., and Vigneron, J., *J. Phys. Rad.*, 8, 165 and 200 (1947).

[8] Allen, K. W., and Dewan, J. T., *Phys. Rev.*, 80, 181 (1950).

[9] Titterton, E. W., *Nature*, 170, 794 (1952).

The Second Virial Coefficient of Methane at Low Temperature

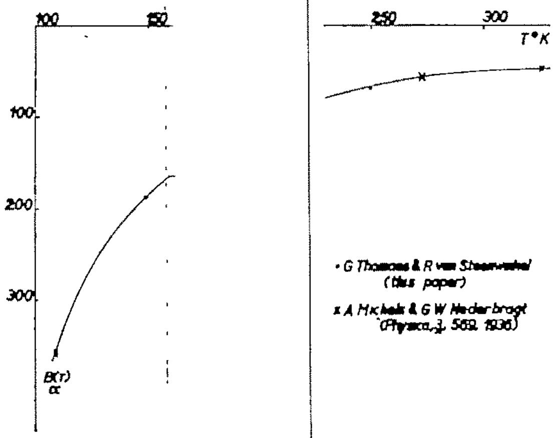
THE second virial coefficient of methane has been determined over a range of temperatures from 108° to 350° K. by means of an apparatus which is described elsewhere[1].

The principle of the experiments consists in measuring the difference in the expansion of volume of the gas under study and a reference gas. In our experiments we chose hydrogen as reference substance. The working pressure is less than one atmosphere; this allows us to neglect coefficients of higher order than the second in the expansion of the compressibility factor pV/nRT, where p is pressure V, is volume, R is the gas constant, T is absolute temperature and n is number of moles.

Methane was obtained by distillation at low temperature of commercial 'pure grade' gas. The melting of the solidified sample we used took place over a range of less than 1×10^{-3} °K. The vapour pressure at the triple point was 87·58 mm. mercury. The value of 87·60 ± 0·10 mm. mercury was found at the National Bureau of Standards of Washington by Armstrong, Brickwedde and Scott[2] with a carefully purified sample. The purity estimated from the range of freezing point was better than 99·8 per cent (ref. 3). The hydrogen used was 'research grade' gas of 99·99 per cent purity.

Values obtained for methane are listed in Table 1. In Fig. 1 these values are reproduced for compari-

Temperatures (° K.)	Measur betwe viria of n hydrog	cond virial oefficients hydrogen c.c./mole)	Deduced values for the second virial coefficient of methane (c.c./mole)
108·45	– –	+ 0·280	− 364·99 − 361·54
125·2	– –	+ 3·025	− 267·97 − 268·92
149·1	– –	+ 6·923	− 188·04 − 187·64
186·4	– –	+ 10·15	− 126·10 − 126·20
223·6		+ 12·099	− 82·62 − 82·69
249·3		+ 13·033	− 68·53 − 68·28



son with those
Nederbragt[4] at h
between the two

Michels and G. W.
ures. The agreement
ellent.

Thomaes
Van Steenwinkel*

Faculty of S
Free University,
Avenue F.-D. Ro
Brussel

---

* Chercheur à l'Ins
(Brussels–Belgium).

[1] Thomaes, G., and Ste
[2] Armstrong, G. T., B
Bur. Stand., 55,
[3] "Temperature. Its
Industry" (Reinh
[4] Michels, A., and Ned
(1936).

taire des Sciences Nucléaires

Rev. Sci. Instr. (in the press).
nd Scott, R. B., *J. Res. Nat.*

nd Control in Science and
r York, 1941).
ysica, 3, 1000 (1935); 3, 569

ING

Depende ent-Aggregate
Bond-Stre e of Aggregate

In a recent stu
Portland cement
was found to be
In some instance
of the flexural s
smooth aggregat

gth of the bond between
wn aggregate surfaces
t of the paste matrix.
r example in the case
in concrete containing
egate bond is likely to

be the factor controlling strength. Although several aspects of the mode of failure of concrete could be explained by this concept, it was soon clear that a number of others which should also have been explained were, in fact, anomalous. The form of the departures from expected behaviour suggested that cement-aggregate bond-strength might depend on aggregate size, and the following experiments were therefore performed to check this possibility.

Cubes of water-saturated basalt-aggregate, with edge-lengths ranging from 0·5 to 3·0 in., were bonded to a paste of ordinary commercial Portland cement, cured for 24 hr. in the moulds at 70° F., and afterwards stored under water at 70° F. for six days. Cement paste, with a water/cement ratio of 0·35 by weight, was bonded to the aggregate cube face to be tested, while the opposite face, previously grooved with a diamond saw, was bonded to paste with a water/cement ratio of 0·31. These conditions ensured preferential failure at the interface between aggregate and the 0·35 water/cement ratio paste when the composite beam was subjected to mid-point loading as shown in Fig. 1. The beam was immersed in water during testing[2], and the number of replications ranged from 20 for the ½-in. cubes, down to 10 for the 3-in. cubes. The mean coefficient of variation was 15 per cent.

The results (Fig. 2) show that with the square aggregate surfaces used here, bond-strength decreases with increasing size of aggregate, and that there is a linear relationship between cement-aggregate bond-strength and the logarithm of the reciprocal of the area bonded.

Although coarse aggregate and mortar are frequently considered to be the two phases of which concrete is composed it has also been argued that if the bond between cement paste and coarse aggregate is likely to fail, then the bond to fine aggregate would also fail, and that the two phases to be considered are cement paste and all aggregate, regardless of size. These alternative hypotheses have been debated in discussions[3,4] on the mode of failure of concrete and, in this connexion, it might be thought that extrapolation of the present results back to the point where bond-strength equals paste-strength (in the present case 2,000 lb./in.[2]) would decide between these two points of view. Such an extrapolation leads to the conclusion that bond failure ceases to be the most likely cause of tensile failure of concrete when the aggregate size falls below 14 B.S.S. mesh. However, the results of additional experiments suggest that the rate at which bond-strength increases with decreasing aggregate size is not maintained below ½-in. aggregate, although experimental difficulties in this region have so far prevented an accurate assessment of the situation.

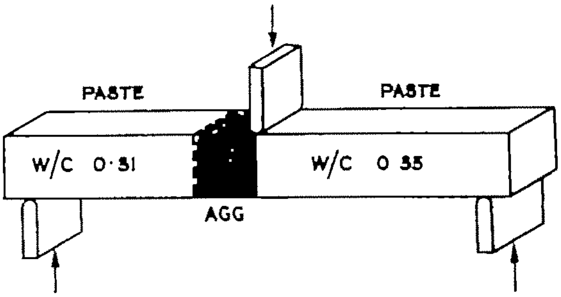


Fig. 1

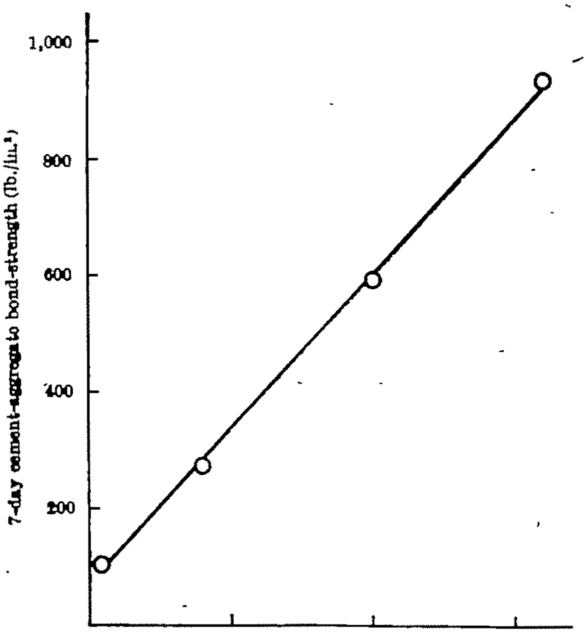


Fig. 2

Thus, instead of favouring the view that the transition size between coarse and fine aggregate has special significance in the phenomenon of failure in concrete, or the alternative view that bond is equally likely to fail at the surface of either coarse or fine aggregate, the present results indicate that there are likely to be specific zones of weakness in concrete, and that these zones are located at the junction between the paste matrix and the largest aggregate pebbles present. With this hypothesis as a basis, explanations can be advanced for a number of experimental observations concerning the strength of concrete, for example:

(1) The flexural strength of concrete is less than the flexural strength of the corresponding mortar[4]. This result would be expected because, in the transition from concrete to mortar, the weakest bonds have been eliminated by exclusion of the largest aggregate pebbles.

(2) In an investigation[5] on the strengths of concretes containing coarse aggregate with maximum sizes ranging from ⅜ to 2½ in. it was found that in spite of the progressive reduction in mixing water requirement as maximum size of coarse aggregate increased, increasing the maximum size of aggregate above ¾ in. did not necessarily increase either flexural or compressive strength. Lowest strengths were in fact obtained with concrete containing 2½ in. maximum size aggregate. These effects are apparently caused by introducing areas of exceptionally weak cement-aggregate bond, as a consequence of increasing the maximum size of aggregate in the mix.

(3) In the investigation[5] mentioned in (2) the reproducibility of strength tests was found to be poorest for concrete containing the largest maximum size of aggregate. The dependence of cement-aggregate bond-strength on aggregate size could explain this behaviour as follows. Taking an extreme case, such as that of specimens used for flexural strength tests on mixes containing the largest pebbles, it is apparent, first, that these large pebbles, which develop the weakest cement-aggregate bond, will be relatively few in number, and secondly, that whether or not a cement-aggregate interface on one of the large pebbles is suitably orientated and in that part of the beam which is in maximum tension, could have an appreciable effect on the strength of the specimen, and could be the cause of the poor reproducibility of these particular tests.

A possible reason for the bond-strength size effect is that in cement paste the process of hardening may be accompanied by dimensional changes which are large enough to give rise to considerable internal stress in the paste film in contact with the aggregate surface, when this tendency of the paste to move is opposed by the aggregate. The larger the surface bonded, the greater the internal stress and the smaller the apparent bond-strength. A rather similar situation applies in the case of the restraint which different sizes of aggregate exert on Portland cement paste during drying shrinkage[6].

For a number of reasons it is considered that the bond-strength size effect in concrete will probably not be as marked as that shown by isolated cement-aggregate interfaces such as those studied here. For example, near the region where maximum tensile stress exists in a beam tested in flexure the orientation of the largest aggregate surfaces may be such that these comparatively weak areas of cement-aggregate bond are subjected only to low tensile stress. Also, the largest aggregate pebbles are not embedded in neat cement paste, but in a matrix the dimensional changes of which are likely to be reduced by the stabilizing influence of the smaller pebbles and sand grains which it contains.

K. M. ALEXANDER
J. WARDLAW

Cement and Ceramics Section,
Chemical Research Laboratories,
Commonwealth Scientific and
Industrial Research Organization,
G.P.O. Box 4331.
Melbourne, C.1.

[1] Alexander, K. M., *J. Amer. Concrete Inst.*, 31 (5), 377 (1959).

[2] Alexander, K. M., *Nature*, 183, 885 (1959).

[3] Blakey, F. A., *Mag. Concrete Res.*, 10 (28), 39 (1958).

[4] Jones, R., and Kaplan, M. F., *Mag. Concrete Res.*, 9 (26), 89 (1957).

[5] Walker, S., Bloem, D. L., and Gaynor, R. D., *Proc. Highway Research Board*, 38, 367 (1959).

[6] Alexander, K. M., and Wardlaw, J., *J. Amer. Concrete Inst.*, 30 (12), 1303 (1959).

A Historical Note on the Reciprocal Theorem and Theory of Statically Indeterminate Frameworks

OPINIONS seem to vary concerning the origin of the reciprocal theorem. Thus, in his book "Mathematical Theory of Elasticity" (4th edit. 1927), A. E. H. Love attributed the theorem to E. Betti (*Il nuovo Cimento*, ser. 2, 1872), but stated that it is a special case of a more general theorem due to Lord Rayleigh (*London Math. Soc. Proc.*, 4, 1873). In his book "Theory of Sound" (Vol. 1, 2nd edit. 1894), however, Rayleigh also acknowledged the reciprocal theorem as due to Betti. Neither Love nor Rayleigh connected Maxwell's name with the theorem although it is widely known as "Maxwell's Reciprocal Theorem". In fact, Maxwell did include a statement of a form of the reciprocal theorem in his paper "On the Calculation of the Equilibrium and Stiffness of

Frames" (*Phil. I*). It is, no doubt, due
to this work, whi efore the relevant work
of Betti and Ray well is nowadays given
credit for the the interesting to note the
neglect of Maxw Rayleigh and Love.

Another autho rk, in retrospect, had
some bearing u iprocal theorem was
A. Clebsch (18 , although Clebsch's
book "Theorie d fester Korper" (Leip-
zig, 1862) (whic ted into French and
annotated by Se d Flamant and pub-
lished in Paris widely quoted by
elasticians, incluc and Love, the chapter
which is relevant ocal theorem seems to
have escaped the This is Chapter 8, the
final chapter, whi with systems of bars,
that is, framewo r, there seems to be
no reference to th bsequent publications
of engineering sci axwell is regarded as
the pioneer of stat ninate frame analysis.
It seems likely, t in common to some
extent with Max *loc. cit.*), this aspect
of Clebsch's work l to the mathemati-
cians but forbidc gineers of his time.
Thus, in Art. 90, C s book, Clebsch dealt
generally with t f pin-jointed space
frameworks with y, and showed that
the equations of f the joints can be
expressed in term lacements and coeffi-
cients of elasticit being the stiffness
coefficients. Clebs dentity of the cross-
coefficients, that which expresses the
reciprocal propert ems, though he does
not seem to hav reciprocal theorem
verbally. Navier, 'Résumé des Leçons
données a l'Ecole Chaussées sur l'Appli-
cation de la Me l'Etablissement des
Constructions et d 1826), gave the same
basic method of cally indeterminate
elastic frameworks velop it to the same
extent as did Cleb

In recent years n has been given to
the systematic an ar elastic statically
indeterminate fram tion to the program-
ming of digital com uctural analysis. It
is therefore interest at for the majority
of structural syste ach using stiffness
coefficients, identic l by Clebsch nearly
a hundred years ag as the most suitable
for this purpose.

T. M. CHARLTON

Sidney Sussex Colle

M iY

A Possible xo-Electron Emission in Pl formed Metals

THE blackening c ographic emulsions
by freshly fracture surfaces was first
studied in detail by 97[1]. This phenom-
enon, the Russell v known to be a
consequence of the hydrogen peroxide
on the freshly ex surfaces[2]. More
recent work by Gr ted that the form-
ation of hydrogen initiated, in the
presence of water va en, by the emission
of low-energy exo-e s emission received
considerable attenti ber of Continental
workers[3], and it is epted that in the
case of metals the electrons are emitted from crystal imperfections in the freshly formed or distorted oxide layer.

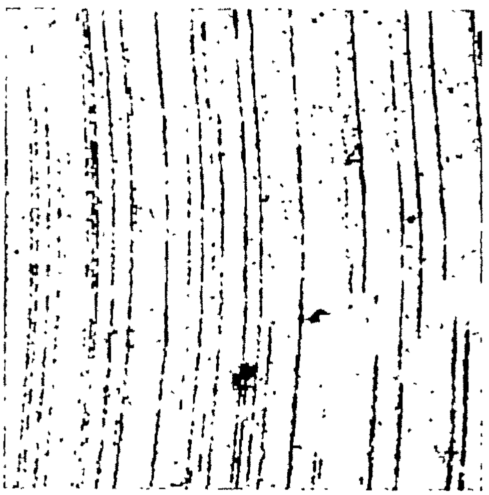


Fig. 1. The appearance of exposed emulsion at low magnification. Lines correspond to slip lines on the crystal surface. (× 140)

So far, only the macroscopic or integrated aspects of both the Russell effect and exo-electrons have been studied. We have observed, by the use of an autoradiographic stripping emulsion of high resolution, certain microscopic features of the Russell effect which may be useful in revealing the origin of both phenomena. The improved image resolution obtained by this technique was made possible by placing the emulsion in intimate contact with the metal surface.

High-purity zinc single crystal rods were electropolished, thoroughly cleaned, statically strained and the emulsion (Kodak *AR*10 stripping emulsion) then applied to the surface. Exposure times of 1 hr. were generally found adequate, provided the exposure was commenced within a few minutes of straining. On examination of the emulsion with an optical microscope, black lines were observed which corresponded exactly to slip-lines on the crystal surface. An example is shown in Fig. 1. Since the slip displacement varied around the circumference of the crystal, it was possible to deduce that the continuous black

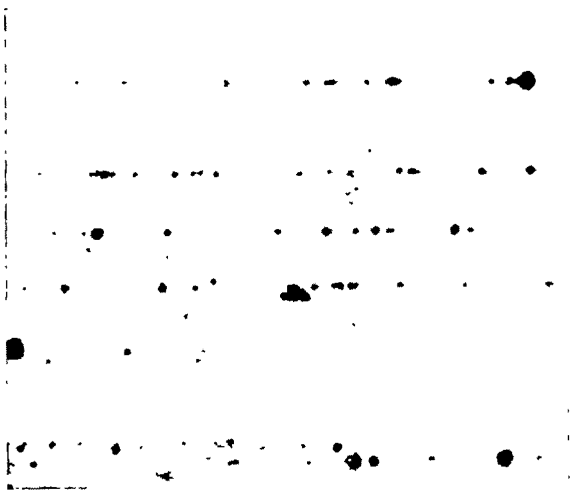


Fig. 2. Pattern obtained from slip lines of small displacement. Maximum useful magnification of emulsion. (× 940)

lines were associated with relatively large slip displacement. With decreasing slip displacement the lines first became discontinuous and then resolvable into rows of individual spots (Fig. 2). This latter configuration resembles the dislocation etch pits observed by one of us[6] along the slip lines of zinc single crystals.

The foregoing evidence shows that the Russell effect, and probably exo-electron emission, in plastically deformed metals originate from slip bands on the surface. The similarity between the patterns observed here and dislocation etch pits configurations further suggests that the centres of emission are the points where dislocations terminate at the surface of the crystal. It is possible that at such points the oxide film is highly distorted by the emergence of the dislocation, thus producing the imperfections necessary for exo-electron emission. This hypothesis is further supported by recent work reported by Young[7], who has shown that oxide nuclei are formed at dislocations.

The hypothesis is in agreement with previous observations that both the rate of exo-electron emission and the intensity of the Russell effect increase with increasing deformation[8]. It would be interesting to make a comparison of the rate of emission from two crystals of widely differing dislocation concentrations.

A. H. MELEKA
W. BARR

British Iron and
Steel Research Association,
140 Battersea Park Road,
London, S.W.11.

[1] Russell, W. J., *Proc. Roy. Soc.*, 61, 424 (1897).
[2] Grunberg, L., and Wright, K. H. R., *Nature*, 170, 456 (1952).
[3] Grunberg, L., *Proc. Phys. Soc.*, B, 66, 153 (1953).
[4] Kramer, J., "Der Metallische Zustand" (Gottingen, 1950).
[5] Lohff, J., and Raether, H., *Z. Phys.*, 142, 310 (1955).
[6] Meleka, A. H., *Phil. Mag.*, 1, 803 (1956).
[7] Young, F. W., *Acta Metallurgica*, 8, 117 (1960).
[8] Grunberg, L., and Wright, K. H. R., *Acta Physica Austriaca*, 10, 375 (1957).

Correlation of the Alternating Stresses required to initiate and propagate a Fatigue Crack in Mild Steel

EXPERIMENTAL results obtained from mild steel plates containing small edge cracks subjected to reversed direct stress loading (that is, zero mean load) have suggested that whether or not a crack grows is governed by the parameter $\sigma^3 l$ (σ = nominal alternating stress, tons/sq. in., l = length of edge crack, inches)[1]. If the value of $\sigma^3 l$ is greater than 5·5, a crack will grow; if less, it will remain dormant. It has been shown[1–4] that with certain notched specimens, non-propagating cracks may be present at the root of the notch of those tested at stresses equal to and below the conventional notched fatigue limit (that is, for specimens either remaining unbroken or being completely broken). When the geometry of the specimens is such that non-propagating cracks are present, the conventional notched fatigue limit is independent of the radius of the notch root and is equal to the alternating stress required to propagate the crack. This depends on the depth of the notch, for it has been shown[1] that the relationship $\sigma^3 l = 5\cdot5$ is applicable if l is taken as the depth of notch plus the length of non-propagating crack formed.

It is generally accepted that at zero mean load the fatigue strength of a notched specimen is greater than that given by the plain fatigue limit of the material divided by the geometric elastic stress concentration factor for the notch. Many attempts, usually related to the existence of the stress gradient at the root of the notch, have been made to account for this discrepancy; however, ignorance of the possibility of non-propagating cracks has led to much confusion. Isibasi and Uryu[4], however, differentiated between crack initiation and propagation; they found that for mild steel notched specimens, cracks formed at the root of the notch when the distribution of stress was such that over a distance of 0·002 in. in from the root of the notch the stresses were equal to or greater than the plain fatigue limit.

For zero mean load the material at the root of a notch is subjected to similar stress distributions on the tension and compression halves of the loading cycle; the material ahead of a crack, however, is subjected to stress concentration effects only on the tension half of the cycle. Thus when considering the intrinsic fatigue strength of the material ahead of a crack, the zero to tension value is appropriate. For the mild steel under consideration, this value is about 0–22 tons/sq. in. The yield stress of the material is about 19 tons/sq. in., and thus measurement of the plastic zone ahead of the crack in a plate specimen will give an approximate estimate of the length of material subjected to stresses greater than the plain fatigue limit. Frost and Dugdale[5] made such measurements on annealed (furnace-cooled from 800° C.) mild steel sheet specimens and found for the initial period of growth that the length of the plastic zone (l_p) was directly proportional to the current length of crack (l), that is, $l_p = Cl$; l_p and l were measured from the centre line of the specimen. I have shown[1] that C could be empirically related to the nominal stresses by the equation:

$$C = 1 + 0\cdot0013\sigma^3$$

where σ was the maximum tensile stress in the loading cycle. For the mild steel plate specimens used to determine the $\sigma^3 l = 5\cdot5$ relationship, it appears reasonable to assume a similar type of relationship, namely:

$$C = 1 + K\sigma^3$$

Estimates have been made of the length of the plastic zone developed ahead of a fatigue crack by applying a static tensile load to cracked fatigue specimens; high nominal stresses were imposed, so that measurable plastic zones resulted. An example is shown on Fig. 1. Taking measurements from the outside edge of the plate, that is, including the depth of the notch, $l_p = 0\cdot50$ in. and $l = 0\cdot28$ in.; thus $C = 1\cdot8$. The nominal stress applied was 13 tons/sq. in., giving $K = 0\cdot00036$. If λ is the length of plastic zone measured from the tip of the crack, then:

$$\lambda = l_p - l = 0\cdot00036\sigma^3 l$$

and substituting $\sigma^3 l = 5\cdot5$ will give the value of λ which must be subjected to stresses equal to or greater than the plain fatigue limit before the crack will grow; hence $\lambda = 5\cdot5 \times 0\cdot00036 = 0\cdot002$ in. This agrees with the value obtained by Isibasi and Uryu[4] from notched specimens.

Fatigue cracks in plain specimens are known to start on the surface, and metallographic examination

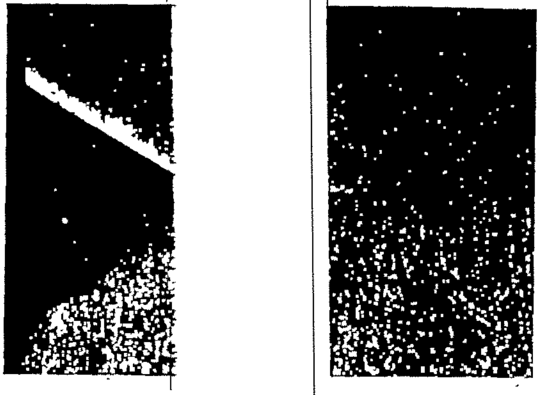


Fig. 1. Plastic zone
2¼ in. wide, opposit
under cyclic stress
steel plate, ¼ in. thick by
in. deep. Crack grown
d statically. (× 3·9)

of the surface of
has shown that
micro-cracks after
these will not gro
opposed to spread
micro-cracks have
a critical minimum
$\sigma^3 l = 5 \cdot 5$ applies
smallest crack-len
then putting σ eq
plain fatigue limit
crack-length 0·00
entity, for it is im
be propagated at

Thus, for mild
required to initia
and that required
can be correlated
is accepted that a
is formed at the pl

This communica
the Director of the

Properties and Me
National En
E

in fatigue specimens
occur from which
It is suggested that
y of the specimen (as
rface) until sufficient
er to form a crack of
ming the relationship
ll crack-lengths (the
ested was 0·004 in.),
just greater than the
. in.), gives a value of
ust be formed as an
horter crack will not

he alternating stress
a notched specimen
crack of given length
n fatigue limit, if it
mum depth 0·002 in.
it.

ied by permission of
ineering Laboratory.

N. E. Frost

erials Division,
oratory,

---

[1] Frost, N. E., *Proc. In*-
[2] Frost, N. E., *Aeronau*
[3] Frost, N. E., and Du
(1957).
[4] Inbasi, T., and Uryu,
Mech., Kyushu Uni
[5] Frost, N. E., and Dugd

l, No. 35 (1959).
57).
Mech. Phys. Solids, 5, 182
Research Inst. for Applied
956).
. *Phys. Solids*, 6, 92 (1958).

Y

Interaction o
Hyd

d with Sodium
Water

In a previous
360-mμ band of p
shift to the red b
concentrated solut
action of picric aci
has, therefore, bee
the absorption spe
various concentrat
results are shown i

The absorption I
the region 300–45

is reported that a
water was found to
μ by addition of a
hydroxide. Inter-
hydroxide in water
by measurement of
ric acid solutions at
m hydroxide. The

icric acid solution in
absence of sodium

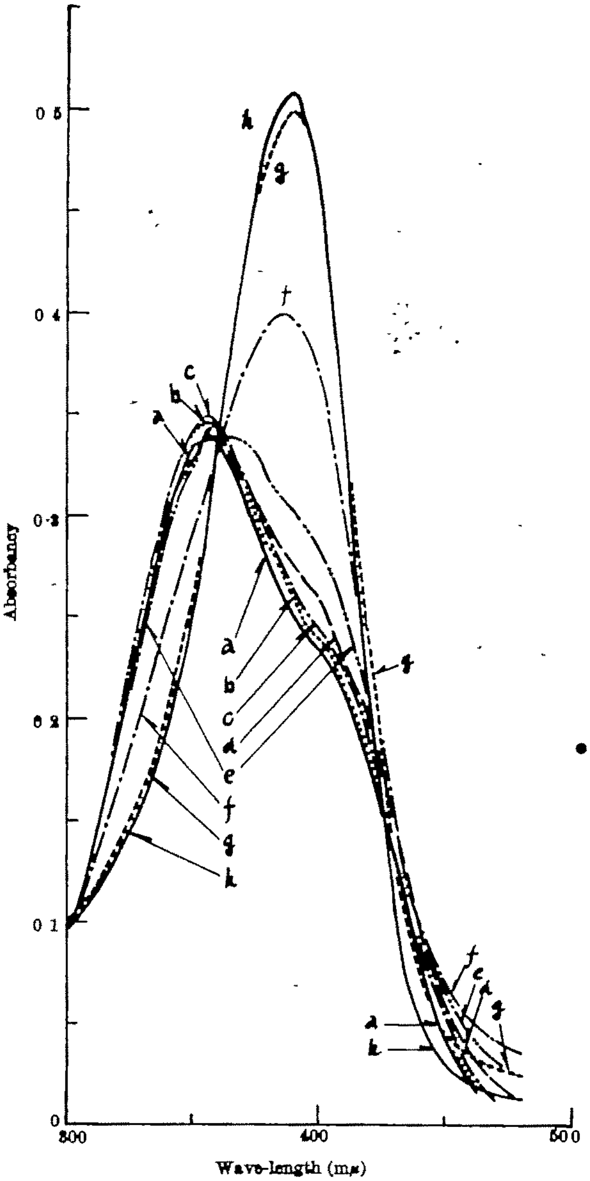
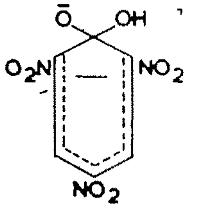


Fig. 1. Absorption spectra of aqueous solutions of picric acid ($2 \cdot 42 \times 10^{-5}$ *M*) at various concentrations of sodium hydroxide at 20° C. (path-length of cells, 1 cm.). Concentrations of sodium hydroxide: *a*, 0; *b*, 0·206 *N*; *c*, 0·411 *N*; *d*, 1·03 *N*; *e*, 1·44 *N*; *f*, 2·06 *N*; *g*, 3·09 *N*; *h*, 4·11 *N*

hydroxide is due mainly to picrate anion. The absorbancy of the 360-mμ band of picric acid slightly increases at low concentrations of sodium hydroxide up to 0·411 *N* and then decreases at concentrations of sodium hydroxide higher than 0·411 *N*. The increase in the absorbancy at 360 mμ can be interpreted as being due to nearly complete dissociation of picric acid, caused by sodium hydroxide. On the other hand, absorbancy at about 390 mμ increases with the increasing concentration of sodium hydroxide. The absorption curves of the solutions at the higher concentrations of sodium hydroxide over 2·06 *N*, showing the sharp and intense bands at about 390 mμ, are greatly different from those of the solutions with the low concentrations of sodium hydroxide. Accordingly, the intense 390-mμ band, the absorbancy of which decreases slowly when the solution is stood at room temperature for long days, cannot be ascribed to picrate anion.

When 1,3,5-trinitrobenzene and its derivatives in water are treated with sodium hydroxide, red solutions are immediately formed.' These red colours have been ascribed to complexes such as [trinitrobenzene·OH]⁻ (refs. 1 and 2). It has been reported by Kimura[3] that picric acid in a mixture of acetone and ethanol gives an intense 410-mμ band and a weak 485 mμ one when a drop of sodium hydroxide solution is added, owing to formation of [picric acid.CH_2-$COCH_3$]⁻. The intense 390 mμ band of picric acid in aqueous concentrated solution of sodium hydroxide may be expected to be due to a complex of [picrate anion·OH]⁻, which seems possibly to be the ion (I) of Meisenheimer's type[4].



(I)

The spectra were measured with a Hitachi *EPU*-2 spectrophotometer.

I wish to thank Prof. Y. Nomura for helpful discussions.

TAKEHIRO ABE

Department of Chemistry,
Defence Academy,
Yokosuka, Japan.

---

[1] Abe, T., *Bull. Chem. Soc. Japan*, 32, 339 (1959).

[2] Abe, T., *Bull. Chem. Soc. Japan*, 33, 41 (1960).

[3] Kimura, M., *Pharm. Bull.* (Japan), 3, 75 (1955).

[4] Meisenheimer, J., *Ann. der Chemie*, 323, 205, 214, 241 (1902).

Generation of Aerosols by Vapour-Phase Polymerization of Methyl Acrylate

THIS particle generator made by us is the outgrowth of work by Melville[1], in which he studied the photopolymerization of methyl acrylate and methyl methacrylate vapour at low pressures in a closed chamber in which no other gas was present. On irradiation with ultra-violet light in the 2500-Å. region, a fairly dense cloud of particles is formed in the chamber. The ultra-violet light activates the monomer and small nuclei are formed, that is, a few molecules of polymer on which the remaining monomer gas can react. Once the reaction is initiated, it will continue without further irradiation.

We have found that this process can also be carried out in a flow system (Fig. 1) at atmospheric pressure so long as oxygen is excluded. Ordinary cylinder nitrogen gas was passed over freshly distilled monomer and mixed with a larger volume of nitrogen gas. It then entered a quartz tube of 3 cm. internal diameter where a beam of ultra-violet light was focused on it from a Hanovia type *A*, 500-W. high-pressure mercury arc lamp. The gas flowed past the light source at 0·1–0·5 cm./sec. Visible aerosols that exhibited higher-order Tyndall spectra were produced, indicating a fair degree of monodispersity. The methyl acrylate gave solid particles, while the methyl methacrylate produced liquid particles. Neither materials seemed to be stable in the electron microscope, but dark-field microscopy showed uniform particles ranging from 0·1 to 2·0μ, depending on the concentration of vapour and rate of flow.

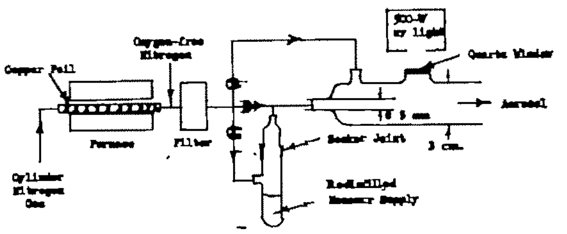


Fig. 1. Methyl acrylate particle generator

The most difficult problem was the formation of polymer on the walls of the quartz tube, which prevented the short-wave radiation from reaching the monomer vapours. Some work was done with a vapour-free gas sheath to keep the polymer off the wall. However, due to the low rate of production of particles and the other problems mentioned above, the work was discontinued in favour of other devices for the production of homogeneous aerosols of sub-micron dimensions.

The work is presented here in the hope that it may stimulate others, who are not confronted by immediate practical needs, to follow up on this rather interesting variation on aerosol generators.

We acknowledge the guidance of Dr. S. Katz, who suggested this approach to the problem. The work was supported by the Air Force Cambridge Research Center, Bedford, Massachusetts (Contract No. *AF* 19(604)-2411), as part of a programme on electrostatic size classification of sub-micron aerosols.

R. PEARSON*
G. LANGER

Armour Research Foundation,
Chicago, Illinois.

---

* Present address: Illinois Institute of Technology, Chicago, Illinois.

[1] Melville, A. W., *Proc. Roy. Soc.*, A, 167, 99 (1938); A, 163, 511 (1937).

Determination of Nonanol Residues in Potatoes

A NEW method for the destruction of potato sprouts in the course of potato storage is ventilating with air containing nonanol in the amount of 0·1 mgm. per litre[1]. By applying this British method in our country we were very interested in the determination of nonanol in the ventilation air as well as in the potatoes after being treated in this way. The nonanol used is the branched isomer 3,5,5′-trimethylhexanol-1, produced by Imperial Chemical Industries, Ltd.

For the determination we use Feigl's spot test for the alcoholic hydroxyl group using the reagent vanadium oxinate[2] quantitatively, as has also been discussed by others[3–5]. We are applying this reaction using solid vanadium oxinate as reagent in a toluenic solution of nonanol.

The reagent vanadium oxinate is prepared by mixing a solution of 15 gm. 8-hydroxyquinoline in 600 ml. acetic acid (6 per cent) and a solution of 2·3 gm. sodium meta-vanadate ($NaVO_3.4H_2O$) in 600 ml. water. After 1 hr. the precipitate is filtered

by suction (*S.*
then with a li
is dried *in vac*
Standard sol
and contains 0
solution. For
7 ml. of such
solid vanadium
(diam. 16 mm.
for 1 hr. in a b
period the tube
water. The
filtered through
then washed
reaction solutio
up to exactly 1
treating 7 ml. p
to the reaction
reaction solutio
Beckman *B* spec

A straight sta
ing that 3 mgm.
gives $E_{375} = 0$
content in the
5 l. is taken.
filling 5 flasks of
cell. Always us
air in the flasks
the toluenic non
same way as desc
to make a deter
without nonano
potatoes produc
For determinin
potatoes a samp
peels are treated
by mixing ('*M.*
2·5 l. The su
Quickfit 5-l. react
a steam inlet,
The steam distil
toluene, the tolu
up to exactly 5
solution, 7 ml. is
heretofore. By
realized that the
fraction that also
the determinatio
that is not treate
same way as the
the alcoholic con
sample that is tr
treated sample
seeking for.

The recovery
a known amount
the mixer amount

Institute of Stora
Agricultura
Bornsesteeg 59
The Neth

[1] Burton, W. G., *Eur.*
[2] Feigl, F., "Spot Tests
[3] Buscaróns, U. S., *Anal*
[4] Buscaróns, C. S., *Anal*
[5] Kudo, J., and Aoki,
Abst., 48, 80).

rst washed with water,
The vanadium oxinate

pared in. pure toluene
nanol per 7 ml. toluenic
standardization curve,
about 30 mgm. of the
mixed in a test tube
marble and immersed
ath. After this heating
) min. in cold streaming
l reaction solution is
of wadding, which is
l. pure toluene. The
quid together are made
n blank is prepared by
he same way. Relative
inction of the coloured
l, in our case, with a
t at 375 mμ.

urve is obtained, show-
e end volume of 10 ml.
rmining the nonanol
an air sample of about
y this can be done by
h the air in the storage
0 ml. pure toluene the
active shaking. From
7 ml. is treated in the
re. It is also desirable
omparable storage cell
r it is possible that
ohols that also react.
l residues in treated
s peeled. Tubers and
d both are suspended
in a total volume of
steam-distilled in a
splash head containing
listillate is collected.
wice with 25 ml. pure
e collected and made
the toluenic nonanol
ame way as described
method it has to be
contains an alcoholic
reaction. Therefore,
e made with a sample
l but is stored in the
he difference between
d as nonanol) of the
content of the non-
anol residue we are

ation measured with
led to the potatoes in
per cent.

W. F. VAN VLIET
W. H. SCHRIEMER

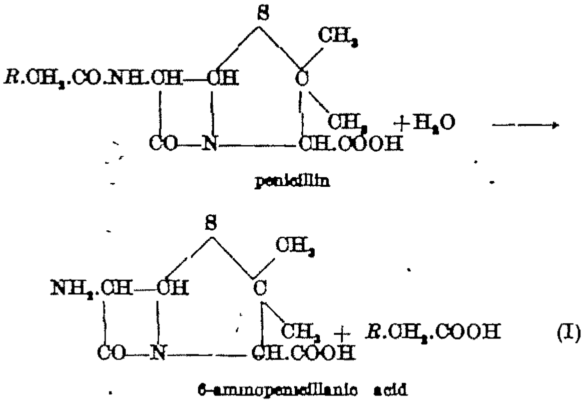
e of

158).
s", 172 (Elsevier, 1956).
0 (1949).
y Quim., 49, B, 367 (1953).
tu, 6, 791 (1957); (*Chem.*

BIOCHEMISTRY

Formation of 6-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis

WE have found that enzymatic activity which brings about reaction (1) is fairly widespread among micro-organisms:



Sakaguchi and Murao[1], and later Murao[2], originally reported this type of enzyme activity to occur in *Penicillium chrysogenum* with penicillin *G* as substrate. Although we have been unable to confirm such activity in *P. chrysogenum* with penicillin *G* as substrate, with certain other penicillins, including penicillin *K*, such activity can be demonstrated.

Among the micro-organisms at least two distinct types of enzyme activity are encountered which bring about reaction (1). These differ primarily in the type of penicillins serving as substrate. One type is widely distributed among the actinomycetes and filamentous fungi and is also present in certain yeasts. With this type of enzyme, penicillin *K* and dihydro-*F* and also penicillin *V* are readily hydrolysed, but penicillin *G* is split only very slowly. Compared with penicillin *V*, penicillin *G* is only hydrolysed at about 1 per cent of the rate. Studies on this enzyme produced by a strain of *Streptomyces lavendulae* show that the activity is almost entirely extracellular with a *p*H optimum in the region of 9·0 and a temperature optimum of about 50° C. The enzyme can be precipitated with ammonium sulphate and dried as an acetone powder with little loss of activity. Enzyme formation does not appear to be induced by growing in the presence of the substrate.

The other type of activity has only been detected among the bacteria and appears to be largely confined to the genera *Escherichia* and *Alcaligenes*, but activity has also been detected in certain other genera. With any given species there is a high degree of strain specificity with regard to enzyme formation. With this type of enzyme, penicillin *G* is hydrolysed very readily, whereas penicillin *V* is only split at about 20 per cent of this rate. When penicillin *G* is used as substrate with cells of a strain of *Escherichia coli* which have been centrifuged and then resuspended at twice their original density, a concentration of 2 per cent penicillin *G* can be converted to 6-aminopenicillanic acid to 95 per cent of completion in 4 hr. Studies with a strain of *E. coli* show the *p*H optimum for this enzyme to be 7·5–8·5 with a temperature optimum of about 40° C. With the species of *Escherichia* the enzyme activity is usually associated with the cells but with other bacteria considerable activity may occur extracellularly. As with the enzyme produced by the actinomycetes and moulds there is no evidence of induced enzyme formation.

In addition to the hydrolysis of penicillin to give 6-aminopenicillanic acid, this enzyme also facilitates the reaction in the opposite direction so as to bring about the synthesis of penicillin from 6-aminopenicillanic acid and a suitable side-chain. Using a strain of *E. coli* the optimum *p*H for penicillin *G* synthesis from 6-aminopenicillanic acid and phenylacetic acid is about 5·5, in contrast to an optimum of about 8·0 for hydrolysis. The synthetic reaction is also favoured, as might be expected, by increased concentration of 6-aminopenicillanic acid. Reaction in the direction of synthesis shows a similar specificity with regard to the type of penicillin as does the hydrolytic reaction.

We acknowledge our appreciation of valuable discussions with Dr. J. Farquharson, director of research, and to the Board of Beecham Research Laboratories, Ltd., for permission to publish.

G. N. Rolinson
F. R. Batchelor
D. Butterworth
J. Cameron-Wood
M. Cole
G. C. Eustace
Marian V. Hart
M. Richards
E. B. Chain

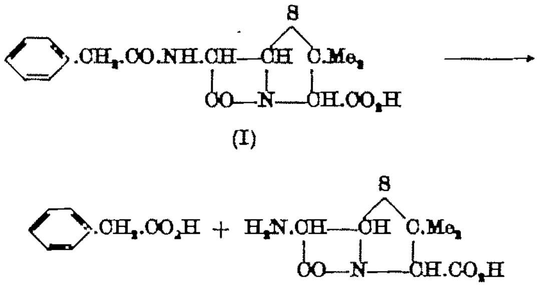
Beecham Research Laboratories, Ltd.,
Brookham Park,
Betchworth,
Surrey.
June 20.

[1] Sakaguchi, K., and Murao, S., *J. Agric. Chem. Soc.* (Japan), **23**, 411 (1950).

[2] Murao, S., *J. Agric. Chem. Soc.* (Japan), **29**, 400, 404 (1955).

Bacterial Penicillin Amidase

Sakaguchi and Murao[1] reported on the presence of an enzyme in the mycelium of *Penicillium chrysogenum* and *Aspergillus oryzae* which would split penicillin *G* (I) into phenylacetic acid (II) and 'penicin' (III):



(I)

(II) (III)

Although they offered no rigorous proof of structure, they postulated that 'penicin' was the compound formed. In the nomenclature of Sheehan *et al.*[2], 'penicin' is termed 6-aminopenicillanic acid. We have attempted to reproduce the work, but have not been able to detect even small amounts of (III). Batchelor *et al.*[3] demonstrated the presence of (III) in penicillin fermentations which were carried out in the absence of added side-chain precursor. (III) was detected by activation of the fermentation liquor with phenylacetyl chloride after removal of the natural penicillins by solvent extraction at low *p*H. This resulted in the formation of (I), which could be measured by standard bacterial inhibition assays.

We wish to report upon the formation of (III) from (I) through the action of a penicillin amidase prepared from cells of *Alcaligenes faecalis*. A preliminary survey was first made of cultures in an attempt to demonstrate the presence of this amidase. Under the conditions used, traces of (III) were produced from (I) by cells of *Aerobacter cloacae*, *Bacillus subtilis* var. *niger*, *Micrococcus lysodeikticus*, and *Mycobacterium phlei*. Much greater amounts were detected when *A. faecalis* was used, and further work was concentrated upon this organism.

The standard amidase assay used consisted of growing the cells for 18 hr. at 27° C. on a rotary shaker, collecting cells by centrifuging 20·0 ml. of broth, and adding 0·5 ml. of an 80 mgm. per ml. solution of the potassium salt of (I) in 0·1 *M* *p*H 7·5 potassium phosphate buffer plus sufficient of the same buffer to bring the volume to 2·0 ml. The reaction mixture was incubated in a 37° C. water-bath with intermittent shaking for 4 hr. The supernatant was then assayed for (III) by treatment with phenylacetyl chloride[3] and bioassaying the (I) formed by a plate diffusion assay.

That (III) was the product formed was proved by its isolation in crystalline form from a large-scale reaction mixture. (III) was identified by comparison with the authentic compound using chemical and infra-red analyses.

The specificity of the enzyme was tested by comparison of activity using penicillins *G*, *K* and *V* and α-phenoxyethyl penicillin as substrates. The production of (III) was greatest from (I). To ensure that permeability barriers did not account for the specificity, a cell-free enzyme preparation was made and its specificity again tested. Cells of *A. faecalis* grown in Difco heart infusion broth were exposed for 30 min. in a 10 kc./s. Raytheon sonic oscillator. The debris was removed by centrifugation in the cold at 12,000*g* for 30 min. The activity of this cell-free extract was tested for production of (III) from the various penicillins (Table 1). It can be seen that the same order of activity is obtained with both preparations. The soluble preparation was not tested on α-phenoxyethyl penicillin.

The ability of the enzyme to catalyse the reverse reactions was tested by adding to a mixture of cells and (III), sodium phenylacetate, sodium phenoxyacetate, and sodium caproate. Measurable amounts of (I) and penicillin *K* but not of penicillin *V* were formed under the conditions of the experiment (Table 2). A similar experiment with α-phenoxypropionic acid and (III) failed to reveal any synthesis of α-phenoxyethyl penicillin. The specificity of the synthesis approximates that of the reverse reaction, indicating that the same enzyme is involved.

Almost complete conversion of (I) to (III) could be obtained at lower levels of (I) and longer incubation

Table 1. Specificity of *A. faecalis* Amidase for Different Substrates

Source of enzyme	Substrate			
	Penicillin *G*	Penicillin *V*	Penicillin *K*	α-Phenoxyethyl penicillin
Whole cells	5,740	1,015	3,045	294
Sonic extract	5,740	805	2,170	•

Results expressed in μgm./ml. 6-aminopenicillanic acid.

Table 2. Specific

of Different Penicillins by
idase

Substra	Whole cells	Sonic extract
(III) + Sodium p	444	91
(III) + Sodium p	<10	<10
(III) + Sodium c	265	80

Substrate concent
in terms of (I).

Results expressed in units/ml.

Table 3. Penicilli

ivity in Re-used A. faecalis

Consecutive run N	(hr.)	mgm./ml. (III)
1		2,675
2		4,050
3		3,230
4		lost
5		3,825

times than used
per ml. final conc
time).

The enzyme ac
was extremely
much as five tim
incubation with
in (III) productio
A more detaile
be published else

l assay system (5 mgm.
) for a 6-hr. incubation

whole cell preparations
have been re-used as
rifugation and further
was no apparent loss

hese experiments will

C. A. Claridge
A. Gourevitch
J. Lein

Research Divi
Bristol Labora
Syracuse, New
June 20.

[1] Sakaguchi, K., and
(1950).

[2] Sheehan, J. C., Hene
Chem. Soc., 78,

[3] Batchelor, F. B., Doy
Nature, 183, 257

Chem. Soc. (Japan), 23, 411

nd Johnson, D. A., J. Amer.

H. C., and Rolinson, G. N.,

Production of L
Strain of Clavic
in S

Derivatives by a
Stevens and Hall
ulture

A strain of C.
isolated from th
found growing on
was found, after
grown on agar[1], t
acid derivatives in

The culture med
position: mannit
cinate, 3 per cent
0·1 per cent; M
per cent; tap
Experiments were
500-ml. shake fl
100 ml. of culture
on a rotary shake
stirred fermenters
in capacity. The
rivatives were al
released into the
Their production,
metrically by mea
Urk reaction[2], beg
day and increased

li Stevens and Hall
palum distichum L.
ghbourhood of Rome
on a rye embryo
of producing lysergic
ilture.

l the following com-
; ammonium suc-
hydrogen phosphate,
03
2).
in
ng
ed
in
es
le-
ly
n.
ri-
en
nd
th

day, when concentrations up to 2 mgm. per ml. (calculated as lysergic acid) were reached. An excess of oxygen in the culture fluid was essential for production of alkaloid.

The bases were extracted from the filtered culture media at pH 7·2–7·4 with organic solvents and transferred to water (by extraction with diluted acids). The alkaloids were then concentrated by repeating this procedure several times, and finally recovered from the organic solvent phase as the free bases or the maleates.

Four main substances were obtained which were recognized as two pairs of isomers, deriving from lysergic and *iso*lysergic acid respectively.

The members of the first pair of isomers were both obtained in the crystalline state and identified as lysergic acid amide (*iso*ergine[3]) and *iso*lysergic acid amide (ergine[4]); their decomposition points, crystal form, chromatographic behaviour and infra-red spectra were identical with the corresponding properties of authentic specimens. On hydrolysis with N sodium hydroxide, lysergic acid amide gave ammonia and lysergic acid in good yield; the lysergic acid thus obtained was identical in all respects with an authentic specimen derived from natural ergot. The mixture of both pairs of alkaloids on hydrolysis with N sodium hydroxide gave ammonia and lysergic and *iso*lysergic acid, which were identified chromatographically. On treatment with anhydrous hydrazine or hydrazine hydrate[5], lysergic acid amide as well as *iso*lysergic acid amide gave racemic *iso*lysergic acid hydrazide in good yield; the latter was identified by its infra-red spectrum.

The members of the second pair of alkaloids yielded readily one molecule of acetaldehyde and one molecule of ammonia on treatment with diluted mineral acids in the boiling water-bath. The lysergic acid derivative was easily transformed into lysergic acid amide, with concomitant evolution of acetaldehyde, at pH 8 and 50°. The latter reaction occurs slowly even on standing at room temperature. The isomer derived from lysergic acid was obtained in the crystalline state as the free base from chloroform and as the acid maleate from methanol–ether. The free base was obtained in long solvent-free prisms which started to decompose at 135° C. (Kofler) and showed $[\alpha]_D^{20°}$ + 29° ± 2° (C = 1 in dimethylformamide) and no appreciable rotation in pyridine. Its ultra-violet spectrum was identical with that of other amide-substituted derivatives of lysergic acid (maxima at 242 and 312 mμ). The infra-red spectrum is shown in Fig. 1.

Analysis (free base): calculated for $C_{18}H_{21}N_3O_2$ (311·37). C, 69·43; H, 6·80; N, 13·50. Found: C, 69·23; 69·30; H, 6·94–7·04; N, 13·69.

Analysis (maleate): calculated for $C_{18}H_{21}N_3O_2.C_4H_4O_4$ (427·44): C, 61·81; H, 5·90; N, 9·83. Found: C, 61·80; H, 6·33; N, 9·87.

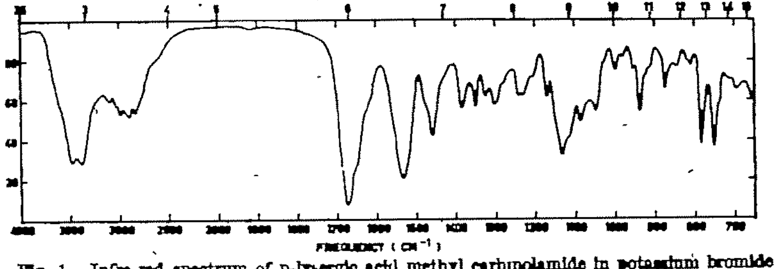
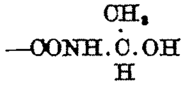


Fig. 1. Infra-red spectrum of D-lysergic acid methyl carbinolamide in potassium bromide (C = 0·3 per cent)

The second member of the pair of isomers, derived from *iso*lysergic acid, was not obtained in the crystalline form; but by isomerization with diluted acetic acid, it was readily transformed into the isomer obtained from lysergic acid described above.

The two lysergic acid derivatives yielding acetaldehyde are thought to have the acetaldehyde moiety linked to the lysergic acid moiety in the form of the carbinolamido linkage:



$$\begin{array}{c} \mathrm{CH_3} \\ \text{—CONH.}\overset{|}{\mathrm{C}}\mathrm{.OH} \\ \mathrm{H} \end{array}$$

Neither the two isomers of lysergic acid amide nor those of lysergic acid methyl carbinolamide have previously been reported to occur in Nature.

Full details of this work will be published elsewhere.

F. ARCAMONE P. PENNELLA
C. BONINO A. TONOLO
E. B. CHAIN LIDIA VERO
A. FERRETTI

International Centre of Chemical Microbiology,
Istituto Superiore di Sanità,
Rome.

---

[1] Tonolo, A., Selected Sci. Papers from the Istituto Superiore di Sanità, Rome, 2, 373 (1959).

[2] Voigt, R., *Microchim. Acta*, 619 (1959).

[3] Smith, S., and Timmis, G. M., *J. Chem. Soc.*, 1440 (1936).

[4] Smith, S., and Timmis, G. M., *J. Chem. Soc.*, 763, 1543 (1932); 1166 (1936).

[5] Stoll, A., and Hofmann, A., *Helv. Chim. Acta*, 26, 922 (1943).

Microbial Synthesis of Protein in Relation to the Biogenesis of Nucleic Acids with *Azotobacter vinelandii* as the Test Organism

Caspersson[1] and Brachet[2] first directed attention to the possible role of ribonucleic acid in protein synthesis. This role has been re-evaluated by Brachet and Six[3]. Ribonucleic acid is supposed to serve as a template for protein synthesis. Evidence in favour of and against this hypothesis has been documented by Chantrenne[4], Meister[5], Simkin[6] and Hartman and Buchanan[7].

One of the most useful tools in demonstrating the relationship between protein and nucleic acid syntheses is to use antibiotics and antimetabolites which interfere with either one or both the processes[1–6]. The mechanism of incorporation of radioactive amino-acids into protein of particulate preparations of *Azotobacter vinelandii* is being investigated in detail in this laboratory. As a prelude to that work, the effect of some antibiotics and antimetabolites on the synthesis of nucleic acid and of protein in whole cells of *A. vinelandii* has been studied. Similar effects have been observed in cell-free preparations as well.

Disodium hydrogen phosphate (^{32}P) and sodium sulphate (^{35}S) were found to be rapidly incorporated into the growing cells of *A. vinelandii*. The fraction soluble in trichloroacetic acid attained saturation with either tracer, phosphorus-32 or sulphur-35, within about an hour, whereas incorporation into the fractions insoluble in trichloroacetic acid maintained a steady rate of incorporation in parallel with the growth of the cells. The resting cells of *A. vinelandii* similarly incorporated phosphorus-32 and sulphur-35 at a comparatively good rate. As in the case of growing cells, a source of energy, for example sucrose, was needed for the incorporation of both the tracers into the resting cells. Analyses of the fractions insoluble in trichloracetic acid showed that 90 per cent. of the phosphorus-32 was incorporated into nucleic acids, whereas 97 per cent of the sulphur-35 was incorporated into protein. Thus the incorporation of phosphorus-32 and sulphur-35 into the fractions insoluble in trichloracetic acid of the resting cells can be looked upon as reflecting protein and nucleic acid syntheses respectively.

The results of inhibition studies of the incorporations of phosphorus-32 and sulphur-35 into resting cells of *A. vinelandii* in the presence of antibiotics and antimetabolites are presented in Table 1. The detailed kinetic results will be presented elsewhere. The concentrations of the inhibitors chosen are three times those required for inhibition of growth.

Table 1. EFFECT OF ANTIBIOTICS AND ANTIMETABOLITES ON THE INCORPORATION OF PHOSPHORUS-32 AND SULPHUR-35 INTO THE NUCLEIC ACIDS AND PROTEIN OF THE RESTING CELLS OF *A. vinelandii*

Antibiotic or antimetabolite used	Inhibition of incorporation (per cent)*	
	Phosphorus-32	Sulphur-35
Chloramphenicol (600 μgm./ml.)	5	90
Streptomycin (400 μgm./ml.)	45	90
Penicillin (114 μgm./ml.)	15	54
p-Fluorophenylalanine (720 μgm./ml.)	17	36
8-Azaguanine (600 μgm./ml.)	13	71

* Percentage inhibitions have been calculated with reference to the incorporation of the tracers into the fractions of the control insoluble in trichloracetic acid containing no antibiotic or antimetabolite, which was 400 counts/min. in the case of phosphorus-32 and 375 counts/min. in the case of sulphur-35.

In experiments on the incorporation of phosphorus-32, incubation was at 30° C. for 2 hr. with constant shaking in a total volume of 10 ml. containing 610 μmoles of sucrose, 42 μmoles of radioactive potassium phosphate, *p*H 7·0 (2·4 × 10^6 counts/min.), 150 mgm. (on dry weight basis) of cells of *A. vinelandii* and a suitable amount of growth inhibitor or antimetabolite (see Table 1). For the incorporation of sulphur-35, conditions were exactly the same with the exception that 23 μmoles of radioactive sodium sulphate (2 × 10^6 counts/min.) were added instead of phosphate. Non-radioactive phosphate buffer (42 μmoles) was, however, included. Control incubations without any antibiotic or antimetabolite were always run. Incorporation was stopped by quick centrifugation at 20,000*g* followed by washings; the cells were washed four times, each time with 10 ml. of 0·05 *M* phosphate or 0·05 *M* sulphate respectively. Washed cells were treated with 1 ml. of cold 10 per cent trichloracetic acid for 30 min. The precipitate collected by centrifugation was re-treated with [illegible] ml. of cold 5 per cent trichloracetic acid. Finally, the precipitate was washed twice in each case with 10 ml. of 0·05 *M* phosphate (or sulphate) and suspended in 10 ml. of water. Aliquots were plated, dried and counted in a thin-window Geiger counter (Nuclear Chicago Co.). Since the plating was done at infinite thinness, no self-absorption correction was needed.

Incorporation of phosphorus-32 into nucleic acids is affected only to a small extent in the presence of chloramphenicol. Protein synthesis as reflected by incorporation of sulphur-35 is, however, inhibited to a great extent as expected. Streptomycin similarly interferes with incorporation of sulphur-35. Incorporation of phosphorus-32 is also inhibited to a considerable extent. Penicillin, which is known to

stop bacterial
thesis of cell w
nucleic acid v
sulphur-35 is inh
amino-acid anal
synthesis of pr
extents. In the
guanine, incorp
inhibited, altho
with the synthe
nucleic acid p
azaguanine, as i
may indicate fa
synthesis of nor

Similarly, the
mate into protei
of *A. vinelandii*
presence of som
bolites (Table 2).
ing between 2,0
fractional centri
A. vinelandii, ma
The preparation
phate buffer.

erfering with the syn-
affect the synthesis of
reas incorporation of
siderable extent. The
henylalanine, inhibits
nucleic acid to small
urine analogue, 8-aza-
hur-35 is considerably
nly slight interference
acid. The abnormal
he incorporation of
her micro-organisms[8],
le a template for the

oration of ^{14}C-*l*-gluta-
rticulate preparations
o be affected in the
iotics and antimeta-
ate fraction sediment-
0*g* was prepared by
cell-free extracts of
ical cell disintegrator.
y washed with phos-

Table 2. Effect of
Antimetabolites on the
Incorporation of ^{14}C
Protein in Particulate
Prepa
landii

Antibiotic or antimet added	e incorpor- mole)/(mgm. n in 2 hr.)	Inhibition (per cent)
None	7 5	—
Chloramphenicol (600 ml.)	7	90
Penicillin (160 µgm./m	7 6	none
Streptomycin (400 µg	3 8	68
8-Azaguanine (305 µg	7 5	none
p-Fluorophenylalanin (365 µgm./ml.)	3 2	17

The control inc
biotic or antimeta
of 2·14 ml. of 10
buffer, *p*H 7·0;
10 µmoles of a
of hexose diphos
(3·40 × 10^5 count
paration equivale
was at 34° C. for 2
the addition of 10
precipitated prote
trichloracetic acid,
finally suspended i
sion was plated,
counter. Protein
only a few count
treatment.

Chloramphenicol
l-glutamic acid to
penicillin does not
L-amino-acid is pr
cell-wall peptide[9].
similar circumstan
inhibition in the
partial incorporati
tion in the presenc
able. As 8-azagua
tion of amino-acid
is no synthesis
formation of abnor
preparations, in sh
made with the inta

re without any anti-
ed in a total volume
otassium phosphate
magnesium chloride;
sphate; 10 µmoles
noles of *l*-glutamate
and particulate pre-
protein. Incubation
tion was stopped by
loracetic acid. The
tedly washed with
acid and water and
liquot of the suspen-
ted in the gas-flow
minute control gave
round after similar

incorporation of
0 per cent, whereas
indicating that the
orporated into the
^{14}C-*dl*-glutamate in
about 27 per cent
nicillin, indicating
l material. Inhibi-
in is also consider-
ffect the incorpora-
assumed that there
d and subsequent
ids[8] in the cell-free
o the observations
inhibition observed

with the amino-acid analogue may reflect its competitive inhibition with the ^{14}C-amino-acid during incorporation into protein, as a mixture of seventeen natural amino-acids has been found to inhibit the incorporation of glutamate to a considerable extent.

My thanks are due to Dr. D. P. Burma for his advice and suggestions during the progress of the work, which was carried out under a project sponsored by the Council of Scientific and Industrial Research, India.

MAHARANI CHAKRAVORTY

Bose Research Institute,
Calcutta-9.

[1] Caspersson, T., *Naturwiss.*, 29, 33 (1941).
[2] Brachet, J., *Arch. Biol.* (Liège), 53, 207 (1942).
[3] Brachet, J., and Six, N., *Biochim. Biophys. Acta*, 35, 580 (1959).
[4] Chantrenne, H., "Ann. Rev. Biochem.", 27, 35 (1958).
[5] Meister, A., *Rev. Mod. Phys.*, 31, 210 (1959).
[6] Simkin, J. L., "Ann. Rev. Biochem.", 28, 145 (1959).
[7] Hartman, S. C., and Buchanan, J. M., "Ann. Rev. Biochem.", 28, 365 (1959).
[8] Lasnitzki, I., Matthews, R. E. F., and Smith, J. D., *Nature*, 173, 346 (1954). Matthews, R. E. F., and Smith, J. D., *ibid.*, 177, 271 (1956). Mandel, H. G., Sugarman, G. L., and Apter, R. A., *J. Biol. Chem.*, 225, 151 (1957).
[9] Mandelstam, J., and Rogers, H. J., *Nature*, 181, 956 (1958). Hancock, R., and Park, J. T., *ibid.*, 181, 1050 (1958). Gale, E. F., Shepherd, C. J., and Folkes, J. P., *ibid.*, 182, 592 (1958).

Flavonoid Pigments of *Lathyrus odoratus*

ALTHOUGH the genetics and chemistry of flower colour variation in the garden sweet pea, *Lathyrus odoratus*, have been much investigated[1], none of the pigments present has yet been fully characterized. As part of a general study of flavonoid production in garden plants[2–4], these pigments have now been analysed by means of paper chromatography and absorption spectrophotometry. Since the sweet pea varieties used by earlier investigators were not available, comparable colour forms were chosen from the wide range of present-day varieties. Examination by chromatography divided them into three main classes, depending on whether their anthocyanins were derived from the orange pelargonidin, the magenta cyanidin or the mauve delphinidin. Three deeply pigmented varieties, 'Air Warden', 'Harrow' and 'Jupiter', representing respectively each of these colour classes, were chosen for detailed examination since they contained the greatest number of pigments.

Table 1. OCCURRENCE OF FLAVONOIDS IN SWEET PEA COLOUR VARIETIES

Variety	Anthocyanins	Flavonol glycosides
'Air Warden' scarlet cerise (also other varieties: orange and salmon shades)	pelargonidin 3-rhamnoside 5-glucoside-3-rhamnoside* 3-glucoside 3-xylosylglucoside 3 · 5-diglucoside	kampferol 3-rhamnoside*
'Harrow' deep carmine (also other varieties pink and rose shades)	cyanidin and peonidin 3-rhamnoside 5-glucoside-3-rhamnoside* 3-glucoside 3-xylosylglucoside peonidin 3 : 5-diglucoside	kampferol and quercetin 3-rhamnoside*
'Jupiter' deep purple (also other varieties lilac, mauve and blue shades)	delphinidin and petunidin 3-rhamnoside delphinidin, petunidin and malvidin 5-glucoside-3-rhamnoside*	kampferol, quercetin and myricetin 3-rhamnoside*

* Major glycosides; minor flavonol glycosides not shown.

Nineteen anthocyanins and three flavonol glycosides were isolated and identified by means of methods already described[2]. Their distribution is indicated in Table 1. Paler-coloured varieties generally contained the same pigments as the intensely coloured types though in less amount, except that the anthocyanidin 3-rhamnosides were completely lacking. Five white varieties which were examined contained the same flavonol glycosides as either 'Air Warden' or 'Harrow'; a myricetin-containing white form equivalent to 'Jupiter' was not found. Besides the three flavonol 3-rhamnosides shown in Table 1, several other flavonol glycosides were present in small amounts in most varieties. Three (that occurred with kampferol 3-rhamnoside in the white variety 'Valerie') were kampferol derivatives which had two or more sugar residues, of which one, at least, in each case was rhamnose. 'Valerie' also contained the cinnamic acid related to kampferol, namely, *p*-coumaric acid. It was present esterified both with glucose and with a rhamnosylglucose (probably rutinose). The glucose ester is the same compound that has recently been identified in potato berries[5] and flowers of *Primula obconica* (Corner, J. J., and Harborne, J. B., unpublished work); the other ester has not yet been described.

The presence in *Lathyrus* of two new series of anthocyanidin glycosides (that is, the 3-rhamnosides and 5-glucoside-3-rhamnosides) is noteworthy since the 3-substituted sugar, in almost all the known anthocyanins, is glucose. The new pigments have much higher R_F values than the corresponding glucosides in all the usual solvent systems. Furthermore, they are much more resistant than 3-glucosides and 3 : 5-diglucosides to hydrolysis by fungal anthocyanase (see ref. 6); the 5-glucoside-3-rhamnosides, for example, gave good yields of the corresponding 3-rhamnosides after incubation for 2 hr. with excess enzyme at 37° C. and *p*H 3·9.

Glycosides of all six common anthocyanidins are, with one exception, represented in both the new series: the exception is malvidin 3-rhamnoside which has, however, been provisionally identified on the basis of R_F values in wild *Lathyrus sativus*, following the observation (Pecket, R. C., private communication) that an unusual malvidin derivative was present in that species. Pecket found that other species of *Lathyrus* (including a wild *L. odoratus*) contained only 3-glucosides. The present discovery of as many as five different kinds of glycoside in the sweet-pea shows that domestication has had a very marked effect on pigment synthesis in this species. The only other plant known to contain anthocyanin mixtures as complex as these is *Streptocarpus* (which is of hybrid origin[4,7]).

In disagreement with an earlier report[1], related anthocyanidins and flavonols occur together in all the varieties examined. This agrees with findings in *Solanum phureja*[3] and a number of other plants[3,4]. The genes *E* and *Sm*, which control hydroxylation of the anthocyanidins in *Lathyrus*, evidently also determine the flavonol hydroxylation pattern. Since flavonols and anthocyanidins are both present as 3-rhamnosides, it is likely that the same enzyme controls the addition of this sugar to both kinds of pigment. The addition of the other sugar residues must, however, be controlled by enzymes which exhibit a greater degree of substrate specificity. These results thus provide additional evidence of the close biosynthetic relationship that exists between flavonols and the anthocyanidins and of the great complexity of pigment glycosidation that occurs in highly evolved garden plants.

J. B. Harborne

John Innes Horticultural Institution,
Bayfordbury, Hertford,
Herts.

[1] Beale, G. H., Robinson, G. M., Robinson, R., and Scott Moncrieff, R., *J. Genet.*, 37, 375 (1939).

[2] Harborne, J. B., *Biochem. J.*, 74, 262 (1960).

[3] Harborne, J. B., and Sherratt, H. S. A., *Nature*, 181, 25 (1958).

[4] Harborne, J. B., in "Plant Phenolics in Health and Disease" (in the press).

[5] Corner, J. J., and Harborne, J. B., *Chem. and Indust.*, 76 (1960).

[6] Harborne, J. B., and Sherratt, H. S. A., *Biochem. J.*, 65, 24 P (1957).

[7] Lawrence, W. J. C., and Sturgess, V. C., *Heredity*, 11, 303 (1957).

Ferricyanide Reduction Method for Reducing Sugars

THE ferricyanide reduction method and its modifications[1-3] for the determination of reducing sugars are among the more commonly used techniques for this purpose. They depend on the spectrophotometric measurement of the amount of prussian blue formed when excess ferric iron is added to the reactant mixture.

As prussian blue forms an unstable, hydrophobic colloidal sol, protective agents, generally hydrophilic colloids, are added to keep it from flocculating. Gum ghatti[1,3], gum arabic[2], or 'Duponol'[3] is generally used. When added in excess they adsorb on the hydrophobic prussian blue, reversing the charge and stabilizing the sol.

However, the above-mentioned protective agents have several defects. The gums contain reducing materials which must first be oxidized with potassium permanganate; in addition, if the amount of glucose or other reducing sugar present in the aliquot is greater than 150–200 μgm., the resultant prussian blue frequently flocculates in spite of the protective agents, preventing accurate measurement. 'Duponol' thickens the reactant mixture, and great care must be taken to avoid the introduction of small air bubbles which tend to remain suspended.

Although oxalic acid has long been known to peptise prussian blue sols[4,5], its use does not seem to have been attempted in connexion with the ferricyanide method for reducing sugars. Its use is described in this communication.

The method followed was that of Folin and Malmros[1] as modified by Umbreit, Burris and Stauffer[3]. However, gum ghatti was omitted from the ferric iron solution. After heating the glucose–ferricyanide mixture in a boiling water bath for 15 min. and cooling, 5 ml. of ferric iron solution and then 1 ml. 0·8 per cent aqueous oxalic acid solution were added rapidly. The volume was made up to 25 ml. with distilled water, and after standing 15 min. the optical density at 520 mμ was measured with a Beckman *DU* spectrophotometer. A reagent blank was prepared and all determinations were in duplicate.

Fig. 1 indicates that Beer's law is obeyed up to 300 μgm. of glucose. The reactant solution appeared perfectly clear when observed with the unaided eye or a microscope, even after standing for 1–2 hr. When gum ghatti or gum arabic was used as a stabilizer, microscopic aggregates could be seen after 10–15 min., and frequently flocculation occurred rapidly. The use of one-fifth as much oxalic acid also resulted in flocculation after 15 min., while if more than 1 ml.

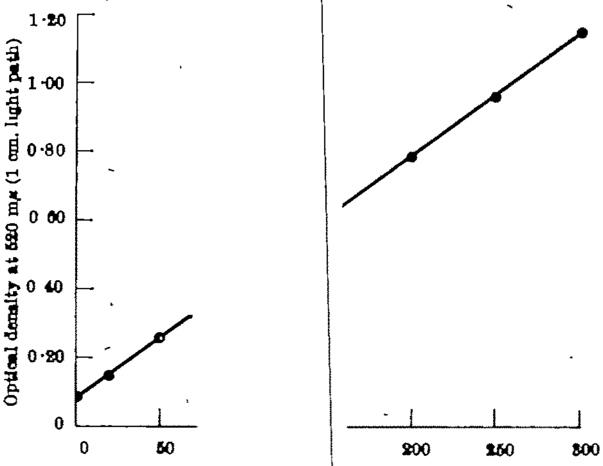


Fig. 1. Plot of op
glucose in aliquot.

0 mμ versus micrograms of
iplicate determinations are

was used, the s
rather than a bl
acid itself is a r
described its rea
blank adequately
of ferricyanide.

and a greenish-yellow
lted. Although oxalic
, under the conditions
slow, and the reagent
for any slight reduction

HARD I. MATHLES*

Laboratorium vo
Technische
Delft.

ie,

* Post-doctoral Fell
Infectious Diseases, U

al Institute of Allergy and
lic Health Service.

[1] Folin, O., and Malm
[2] Park, J. T., and Jol
[3] Umbreit, W. W., Bu
Techniques", 238
Minn., 1957).
[4] Jirgensons, B., "Org
pany, Amsterdam
[5] Selmi, *Nuov. Ann. S*
in ref. 6.
[6] Bolam, T. R., and Ta

hem., 83, 115 (1929).
hol. Chem., 181, 149 (1949).
Stauffer, J. F., "Manometric
ing Company, Minneapolis,
) (Elsevier Publishing Com-
logna, 8, 401 (1874), quoted
arad. Soc., 35, 268 (1939).

GY

Urinary Ami
Diets of V

tern of Cats on
tein Content

QUALITATIVE c
pattern of four ac
investigated, whil
diets of progressi
order to estimat
necessary to main
Six diets were p
provided by white
proportion of fish t
(on a dry-weight b
19 and 13 per cent
six consecutive f
first of these each
received the diet c
tion of protein;
greatest, and so on
cat on the last da
two-dimensional a
the solvents being
collidine/2.6 lutidin

urinary amino-acid
ales, 2 females) were
n a series of mixed
g protein content in
um dietary protein
equilibrium[1].
hich the protein was
, and by varying the
rotein concentrations
eved: 46, 39, 32, 26,
ent was divided into
riods: during the
as caged separately,
greatest concentra-
ond period the next
collected from each
od and analysed by
er chromatography,
r (4:1) and 2.4.6
: 1). Analysis was

carried out on 15 μl. urine; a similar volume of an oxidized specimen was run at the same time. Papers were developed with ninhydrin and spots identified by the position to which they ran and their colour reaction with ninhydrin[2], and by running pure samples of amino-acids with the urine specimens in some instances.

Some 6–9 spots were usually detected, the three strongest and most consistent being methyl-histidine, taurine and felinine. Glycine and alanine were variably present; the other spots were unidentified. Methyl-histidine was present in each cat's urine on each diet. It has been suggested that it derives from ingested anserine[3] and has been identified in large quantities in the urine of several carnivores, including that of domestic cats[3]. Taurine disappeared from the urine of both male cats on the two lowest protein diets, when all the animals were in negative nitrogen balance[1], and from the urine of both females collected at the end of the period on the 13 per cent protein diet. After this period all the cats were placed on high-protein diets and taurine reappeared in all urine specimens. Felinine (cystein-S-isopentanol)[4] was almost always present in the unoxidized specimens, often producing the strongest spot. It was never present after oxidation: if this was carried out by hydrogen peroxide in the presence of ammonium molybdate[3] a spot in the position normally occupied by cysteic acid invariably occurred; if by hydrogen peroxide alone a brownish spot appeared close to methyl-histidine (with an R_F value slightly less in phenol, slightly greater in collidine/lutidine). Datta and Harris[3] in no case found both felinine ('cat spot') and taurine occurring in quantity in the same urine, and suggested on the results of dietary experiments that felinine is synthesized in the body from cysteine which would otherwise be further metabolized to taurine, this synthesis being encouraged by some component of cod-liver oil. However, it is shown in the experiment reported here that both taurine and felinine may be excreted in considerable quantity at the same time, but that on diets providing less than the minimum concentration of protein necessary to maintain nitrogen equilibrium (21 per cent dry weight in this experiment[1]) felinine may be excreted preferentially to taurine. It has been suggested[5] that felinine may be formed in the cat kidney (where it may exist in a bound form) and be excreted directly; only traces were detected in plasma and bladder tissue, and none in kidney, liver, brain or gastrocnemius, whereas in cat urine its concentration was estimated as 185 mgm. per cent[5]. Recently, leucine labelled with carbon-14 and mevalonic acid have been shown to participate in felinine biosynthesis in the cat[6].

We are indebted to Dr. S. Trippett for a sample of 'natural' felinine, and to Messrs. Petfoods, Ltd., for a grant.

J. P. GREAVES
PATRICIA P. SCOTT

Department of Physiology,
Royal Free Hospital School of Medicine,
London, W.C.1.

[1] Greaves, J. P., and Scott, P. P., *Brit. J. Nutr.* (in the press).

[2] Dent, C. E., *Biochem. J.*, 43, 169 (1948).

[3] Datta, S. P., and Harris, H., *Ann. Eugen.*, Lond., 18, 107 (1953).

[4] Westall, R. G., *Biochem. J.*, 55, 244 (1953). Trippett, S., *J. Chem. Soc.*, 363, 1929 (1957).

[5] Tallan, H. H., Moore, S., and Stein, W. H., *J. Biol. Chem.*, 211, 927 (1954).

[6] Avizonis, P. V., and Wriston, J. C., *Biochim. Biophys. Acta*, 34, 279 (1959).

Restoration of Membrane Excitability of Calcium-deficient Muscles by Anodal Polarization

It is well known that marked electrophysiological and biochemical disturbances occur in nerve and muscle immersed in calcium-free Ringer's solution[1]. In the present experiment, isolated frog (*Rana pipiens*) sartorius muscles were used. When they were soaked in calcium-free Ringer solution (112 m*M* sodium chloride ; 2 m*M* potassium chloride ; 2·4 m*M* sodium bicarbonate), initial hyper-excitability was followed by a loss of excitability. This effect of calcium deficiency was enhanced by adding ethylenediaminetetraacetic acid to the medium. In calcium-free Ringer containing 4 m*M* ethylenediaminetetraacetic acid, muscles twitch while the resting potential rapidly drops to 50–30 mV. within an hour. As usual, the electrical activity which ordinarily accompanies stimulation was completely but reversibly eliminated in the 60–120 min. following immersion. This loss of excitability cannot be explained simply by the reduction of the resting potential, since a number of fibres showed, transiently, a relatively high resting potential in spite of a loss of excitability[2]. Whether excitability was maintained depended on the susceptibility of individual fibres ; even a seasonal variation being apparent. For example, the electrical activity of some muscles disappeared instantaneously in calcium-free Ringer, particularly in spring frogs. This seems to suggest that excitability depends on the properties of the membrane *per se*, which may be altered by the presence or absence of calcium ions.

This concept was supported by the following experimental results on muscle fibres registering complete loss of excitability and reduced resting potential (40–20 mV.) in calcium-free Ringer solution (with or without ethylenediaminetetraacetic acid). In these fibres, it was possible to restore the electrical excitability by applying anodal polarization to the membrane, as Fig. 1 shows. Here, one microelectrode in a muscle fibre recorded the membrane potential, and another microelectrode in the same fibre passed both polarizing and stimulating currents. Repetitive anodal square pulses initiated 'break responses' above a critical level of hyperpolarization (record 3). If cathodal stimulations were applied during the passage of these anodal pulses, the action potentials were induced at a certain threshold level (record 2). The spike had higher magnitude during continuous anodal polarization (record 2). A certain magnitude of hyperpolarization and a certain period of passage of the current were necessary for production of action potentials.

In calcium-free Ringer solution, muscle apparently gains sodium and loses potassium (Miyamoto and Koketsu, unpublished observation). Neither reduction of intracellular potassium nor accumulation of potassium in the interfibre space seems to be directly responsible for reducing resting potential and excitability. As a matter of fact, in the present experiments, washing with calcium-free Ringer solution did not restore excitability.

The experiment described here clearly demonstrates that calcium ions in the external solution are not immediately necessary for the production of action potentials (for the opposite conclusion see ref. 3). So far as membrane property was maintained in the excitable state by applying anodal polarization, the membrane was capable of producing action potentials without external calcium. Thus, the loss of electrical activity of the membrane in calcium-free Ringer solution cannot be explained simply by the absence of external calcium ions. Presumably, changes in the physico-chemical property of the membrane resulting from withdrawal of the external calcium are responsible for the loss of membrane excitability. We found a serious disturbance in the metabolic energy supply (Abood and Koketsu, unpublished work) and also in the distribution of sodium, potassium, calcium, and magnesium ions (Miyamoto and Koketsu, unpublished work) when sartorius muscles were soaked in calcium-free Ringer solution with or without ethylenediamine tetraacetic acid.

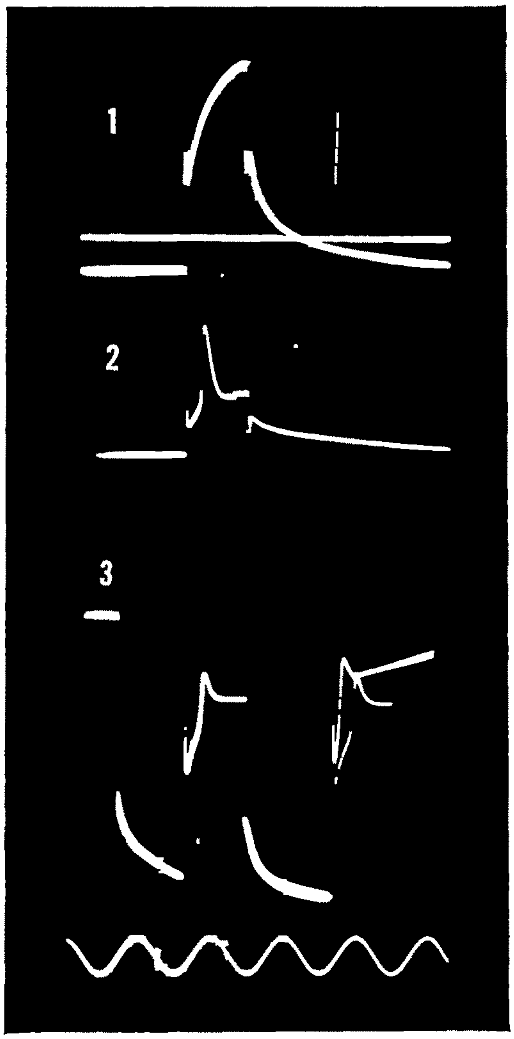


Fig. 1. Restoration of action potentials by anodal polarization of depolarized membrane in calcium-free Ringer solution. All records were obtained from the same muscle fibre, which gave no responses even to strong cathodal stimulation while resting potential was strongly depolarized (record 1, interval of two beams shows value of resting potential). Record 2 is action potential produced by cathodal stimulation when membrane potential was raised to about 100 mV by continuous anodal polarization. Record 3 shows 'break responses' produced by anodal pulses, and also responses produced by cathodal pulses during passage of anodal pulses. Records 1 and 2 are single sweeps, and in record 3 three traces were superimposed with a time interval of 10/sec. Vertical line is 50 mV., and time mark is 100 cycles/sec.

An important problem is to determine whether these biochemical and biophysical disturbances are responsible for the loss of excitability. We may assume that short-lived anodal currents do not affect such

events ; and ther
directly responsit
ability, even thc
integrity of the
strated in memb
explained by cha
membrane, where
an effect similar tc
free solution, bour
out (Miyamoto a
probably disorderi
membrane. The r
be reconstructed
medium or by app
membrane.

This investigatic
of Neurological I
Institutes of Healt

Research
Department
University of Illino
Chicagc

---

[1] Brink, F., *Pharmacol.*
[2] Frankenhaeuser, B., and
[3] Frankenhaeuser, B., *J.*

Parallel Distribu Acid in th

DURING the cour
was found that the
plasma citric acid
onset of reproducti
citric acid-level of in
ml. compared with 2
The present exper
if this fall in blood
changes in the citri
Citric acid was de
chloracetic acid extr
tissues and organs i
pullets (3 months c
6 laying hens[2]. Wi
of the oviduct, the c
of the tissues from t
birds was very simila
with the results repor
Peters[3] for the pigeon
of the oviducts of
particular the isthmu
extent the uterus, we
tain very high concer
acid, and more detai
therefore made on t
The oviducts were
the birds as quickly
death and cooled rap
num was divided trar
the isthmus into 7
into 6 segments.
together with the in
vagina, was then c
longitudinally, one hal
the determination of
the other half for e
prior to analysis for ca
nesium. These metals v
on acid extracts of the

ude that they are not
of membrane excit-
y be linked to the
The changes demon-
es can probably be
ilar structure of the
ation appears to have
Indeed, in calcium-
alcium seems to leak
unpublished work),
ilar structure of the
ar arrangement may
ing calcium to the
urrents through the

ted by the Institute
Blindness, National
650.

K. KOKETSU
K. NODA

edicine,

4).
. *Physiol.*, 137, 218 (1957).
5 (1957).

cium and Citric f the Hen

t investigation[1] it
tantial fall in the
sociated with the
The mean plasma
was 8·2 mgm./100
nl. in laying birds.
signed to find out
s accompanied by
of other tissues.
tri-
ajor
ure
om
ion
ent
of
rell
nd
ons
in
ser
on-
ric
re
m
er
g-
6,
us
t,
id
lf
or
d
.)
g-
d
)-

metric titration with $0 \cdot 001\ N$ ethylenediaminetetraacetic acid after removal of phosphate with an ion-exchange resin[4]. Murexide was used as indicator for the calcium titration (pH 12–13) and Eriochrome Black for the calcium plus magnesium titration (pH 10·0–10·5)[5].

Fig. 1 shows the mean calcium, magnesium and citric acid contents of the various sections of the oviducts of 5 hens. The magnum showed little variation in composition throughout its length, and single figures for the whole of this region are recorded. The most remarkable feature of this graph is the close relationship between the calcium and citric acid in the different sections of the isthmus and uterus. It is well known that tissues such as bone and dentine and secretions such as milk and seminal plasma are rich in both calcium and citric acid, but so far as we are aware, the extremely close parallel between these two cell constituents which we have observed in the hen's oviduct has not been reported in other tissues. The correlation coefficient, r, between calcium and citric acid for the 65 sections of the isthmus and uterus of the 5 hens was found to be $+ 0 \cdot 97$. The regression equation calculated from these data is :

$$y = 0 \cdot 237x + 17 \cdot 7$$

where y = mgm. calcium./100 gm., x = mgm. citric acid/100 gm.

From this equation it may be calculated that for each m.mole increase in citric acid there is an increase of 1·14 m.mole calcium.

The physiological significance of the extremely high level of citric acid in the isthmus is quite obscure. This region is about 10 cm. long and the distal half contains at least 300 mgm. citric acid/100 gm. fresh tissue. It is in this section of the oviduct that the shell membranes are laid down, but so far as is known, shell calcification does not occur until the uterus, which contains very much less calcium and citric acid, is reached.

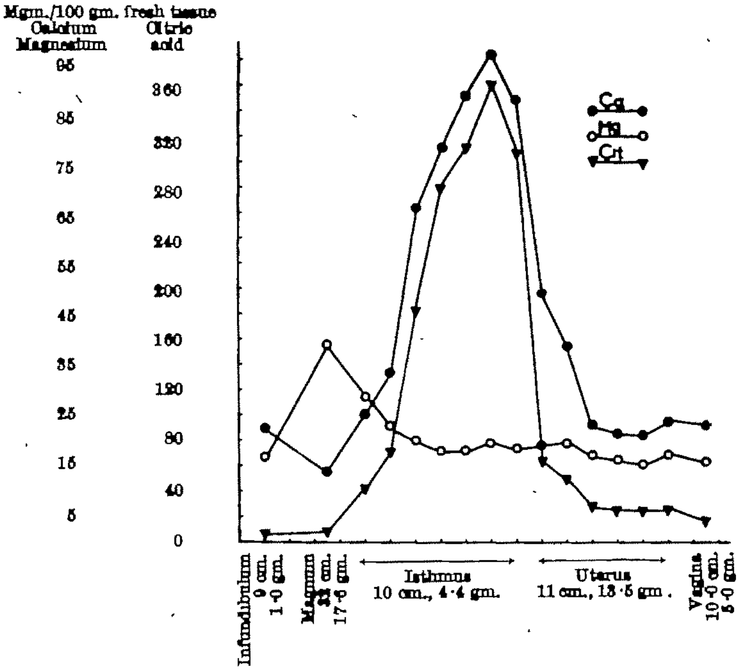


Fig. 1. Mean concentrations of calcium, magnesium and citric acid in the different sections of the oviduct of the hen, and mean lengths and weights of the sections

We have found that the concentration of citric acid in the isthmus is not altered in birds injected with fluoroacetate, and the enzymes of the Krebs cycle which seem most likely to be implicated in the high citric acid content of this region are under investigation.

The tubular region of the uterus adjacent to the isthmus, the isthmo-uterine junction[6], is considerably richer in calcium and citric acid than the thick muscular region where the main process of shell calcification occurs, and this may be due to the fact that the transition from isthmus to uterus is gradual, there being no definite histological boundary between the two regions[7].

Magnesium forms a complex ion with citrate[8] similar to that formed between calcium and citrate; but in spite of the large variations in citric acid in the different segments, the magnesium content of the isthmus and uterus is constant at a level of 15–20 mgm./100 gm. The magnum, however, which is relatively low in citric acid (less than 10 mgm./100 gm.) contains approximately twice as much magnesium (38 mgm./100 gm.) as any other region of the oviduct.

We wish to thank Dr. B. C. Saunders for a generous gift of sodium fluoroacetate.

T. G. TAYLOR
F. HERTELENDY

Department of Physiological Chemistry,
The University,
Reading.

---

[1] Taylor, T. G., Moore, J. H., and Hertelendy, F., *Brit. J. Nutr.*, 14, 49 (1960).

[2] Taylor, T. G., *Biochem. J.*, 54, 48 (1953).

[3] Buffa, P., and Peters, R. A., *J. Physiol.*, 110, 488 (1949).

[4] Lapidus, M., and Mellon, E. F., *J. Assoc. Off. Agric. Chem.*, 41, 411 (1958).

[5] Schwarzenbach, G., "Complexometric Titrations" (Methuen and Co., Ltd., London, 1957).

[6] Richardson, K. C., *Phil. Trans. Roy. Soc.*, B, 225, 149 (1935).

[7] Bradley, O. C., *J. Anat.*, 62, 339 (1927–28).

[8] Hastings, A. B., McLean, F. C., Eichelberger, L., Hall, J. L., and Da Costa, E., *J. Biol. Chem.*, 107, 351 (1934).

Oxytocin in the Neurohypophysis of the Laying Hen

ALTHOUGH it has been well known that the administration of posterior lobe hormones induces premature oviposition in the hen, *Gallus domesticus*[1,2], as in other fowls[3], it remains undetermined whether the hormone(s) plays an essential part in normal oviposition. The results presented here may throw light on the mechanism of oviposition in the domestic fowl.

Twenty-five White Leghorn hens in their first year of production were killed at the following times: (1) 3–4 hr. before expected oviposition; (2) within an hour before expected oviposition; (3) within 5 min. after oviposition; (4) 1–2 hr. after oviposition; (5) 5–6 hr. after oviposition. The posterior lobes of the hypophysis of each bird were extracted with 0·25 per cent acetic acid immediately after removal, and assayed for oxytocic activity against 'Pitocin' (Parke, Davis and Co.) on the isolated uterus of an oestrous virgin rat of Wistar strain, following Holton's method[4]. Dibenamine and atropine were added to the organ-bath.

Fig. 1 shows the mean hormone content per lobe and its 95 per cent fiducial limits. The differences between the lobes removed within 5 min. after oviposition and those removed at other times were significant ($P < 0·01$). These differences were not materially affected by using other criteria of comparison; for example, hormone content per milligram neurohypophysial tissue. No significant difference was found between the weights of the posterior lobes.

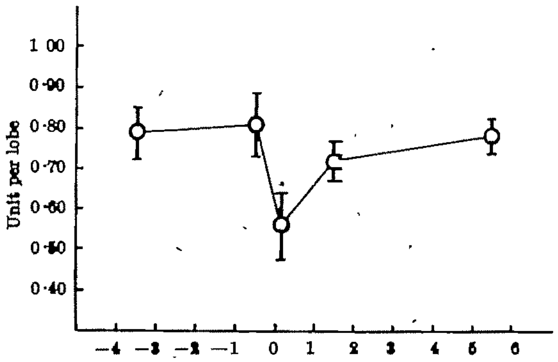


Fig. 1. Oxytocic hormone content in the posterior lobe of the hypophysis before and after oviposition. Each circle represents the mean value of determinations made on five hens. The vertical lines represent the fiducial limits of the mean (degree of confidence, 0·95)

It would appear then that oviposition in the hen follows depletion of oxytocic hormone from the posterior lobe, and that the hormone accumulates in the hypophysis soon after oviposition.

KATUHIDE TANAKA
SHUICHI NAKAJO

Laboratory of Animal Breeding,
Faculty of Agriculture,
Nagoya University, Japan.

Feb. 2.

---

[1] Burrows, W. H., and Byerly, T. C., *Poultry Sci.*, 21, 416 (1942).

[2] Burrows, W. H., and Fraps, R. M., *Endocrinol.*, 30, 702 (1942).

[3] Riddle, O., *Science*, 73, 664 (1931).

[4] Holton, P., *Brit. J. Pharmacol.*, 3, 328 (1948).

Hunger Reduction produced by Injecting Glucose into the Lateral Ventricle of the Rat

IT has been repeatedly shown that the ventromedial nucleus of the hypothalamus is responsible for the satiation of hunger. According to Mayer[1], this is brought about by hypothalamic glucoreceptors. Because of the rapid removal of injected glucose from the blood-stream, direct experimental tests of Mayer's hypothesis have yielded conflicting results.

The technique of intraventricular injection employed in the present experiment is a modification of that developed by Feldberg and Sherwood[2] for use on cats, and details will be published elsewhere. In brief, a stainless steel cannula is stereotaxically implanted and permanently fixed in the lateral ventricle, and the animal is allowed to recover from the anaesthetic. Correct positioning is checked by injecting the satiated rat with a small quantity of 2 per cent saline through the cannula. If the cannula tip is in the ventricular system, the injected fluid reaches the hypothalamic osmoreceptors and the animal responds by drinking water. The validity of this test has been confirmed at autopsy by injecting a dye through the cannula.

The unrestrained animals are injected with an electrically driven micrometer syringe connected to the cannula by polythene tubing at a rate of 0·005 ml./min., to a total volume of 0·2 ml./kgm. body-weight. Such injections *per se* do not appear to

disturb the anim
the cannulas are
Four male hoo
325 gm. were arr
ordered according
design, each anim
the course of the
cannula and had
have been derive
One of four diff
tered at each inj
48 hr. between in
were : (a) 5 per c
B.P.C., (c) 5 per
insulin per gram d
tion of insulin in
are all approxima-
fluid.
Each injection
commenced at the
the animal was hu
test meal the food
to the nearest 0·
eat for a further 4
days served as n
freely available th

y. When not in use
sterile plastic bungs.
ing between 225 and
ive 8 injections each,
alanced Latin square
own control. During
one rat dislodged its
The results presented
aining three animals.
olutions was adminis-
n interval of at least
e solutions so tested
b) 5 per cent fructose
containing 0·5 unit
) a similar concentra-
on. These solutions
ith rat cerebrospinal

n 8 and 13 min. and
½-hr. test meal, when
. At the end of the
he cage was weighed
rat was allowed to
eals on intermediate
ntrols. Water was

Table 1. GRAMS OF FOO HALF-HOUR TEST MEALS

Rat	No injection*	Fruc	lucose	Glucose-insulin
A	5·72	6·5	·5 (4)	5·0 (1)
	$\sigma = 0·48$	6·5	5 (5)	4·0 (8)
B	6·33	7·0	·5 (3)	4·5 (2)
	$\sigma = 0·91$	6·0	·5 (6)	4·0 (7)
C	5·22	4·5	5 (2)	2·0 (3)
	$\sigma = 0·95$	6·5	·0 (7)	5·0 (5)

* Each no injection mea of nine readings. Figures
in parentheses indicate t on.

The results are al
alone nor fructose w
glucose and the g
intake, as compare
approximately 35 p
both highly signifi-
0·001), but the diffe
reductions is not sig
Since both glucos
bolized by central
different effects on
receptor sensitivity
cose, failed to reach
follow if the recepto
of the blood-brain
glucose but not to fr
I wish to thank Pr
facilities and the
providing funds for
experiments were co
Kenneth Craik Resea
Cambridge.

1. Neither insulin
press intake. Both
mixture reduced
by an average of
the reductions are
and 10·3; $P <$
the extent of these

are readily meta-
tem tissue[3], their
either a selective
ctose, unlike glu-
The latter would
on the blood side
n is permeable to

ield for laboratory
arch Council for
instrument. The
ing tenure of the
St. John's College,

. J. HERBERG*

Institute of Experime gy,
1 South Park
Oxford

* Leverhulme Mental He d Fellow.

[1] Mayer, J., *Ann. N.Y. Ac* 1955).
[2] Feldberg, W., and Sherwo ol., 126, 148 (1954).
[3] Tower, D. B., in "Biologic l Bases of Behavior".
edit. by Harlow, H. F J. N., 300 (Wisconsin
University Press, 1958).

Excitation at the Crayfish Neuromuscular Junction with Decreased Membrane Conductance

THE generally accepted mechanism of chemical transmission at excitatory and inhibitory synapses is an interaction of a transmitter substance with the sub-synaptic cell region, causing an increase of membrane conductance for specific ions. Excitatory transmission is essentially a depolarization due to the increased membrane permeability to one or more ions (predominantly Na^+) which have their effective 'electrochemical equilibrium' potential near zero membrane potential. This system has been worked out most thoroughly in the vertebrate nerve–muscle junction by Katz, Fatt and Del Castillo[1]. An interesting variation of the above postsynaptic mechanism is described here.

In a 'slow' crayfish muscle, stimulation of the motor axon at 75/sec. causes excitatory junctional potentials which facilitate and sum, building up to a plateau. The conductance of the membrane was determined by passing a short constant hyperpolarizing current pulse across the membrane of the fibre and measuring the resulting change in electrotonic potential. This was done at rest (lower trace, Fig. 1*A*) and during the plateau phase (upper trace). The electrotonic potential during excitation is decreased, showing the increase in conductance which is expected from analogy with other synapses. If the same experiment is repeated with the Ca^{++} level raised to four times normal (56 m*M*/l.) in the external medium the resting conductance is only little altered (less than 5 per cent), as seen in Fig. 1*B*. During the excitatory junctional potential plateau, however, with a somewhat smaller depolarization than in Fig. 1*A*, the applied current pulse results in an electrotonic potential which is more than 150 per cent of the control in the resting fibre. The membrane conductance, therefore, must have greatly decreased during excitatory transmission.

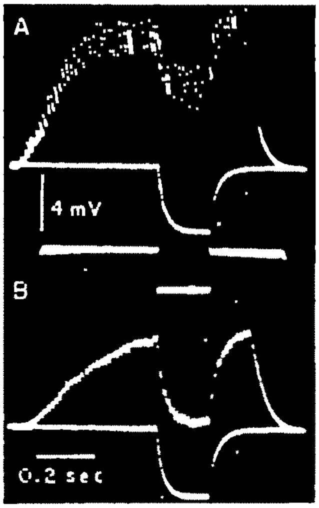


Fig. 1. Intracellular recordings from a muscle fibre in the abductor of the dactyl in the first walking leg of the crayfish (*Orconectes virilis*). In *A* and *B* two sweeps are superimposed, in the upper the excitatory nerve is stimulated at 75/sec., in lower fibre at rest. Trace between *A* and *B* measures current pulse (2·5 × 10^{-8} amp.) passed across membrane in each sweep through the second electrode. Ca^{++} in bathing solution in *A* is normal, in *B* is raised four-fold to 56 m*M*/l.

The following interpretation is offered: During an excess of Ca^{++} the observed conductance decrease is due to the decreased permeability to ions with an equilibrium potential near the resting potential, or more negative than the resting potential. K^+ and/or Cl^+ are the only known ions which fulfil this requirement.

It is thought that Ca^{++} excess does not cause the observed conductance decrease, but merely unmasks it by reducing the larger increase in sodium permeability which normally swamps and obscures the conductance decrease of K^+ and/or Cl^-. In support of this thesis it was seen that the normal excitatory junctional potential actually does not behave as if it were due to a conductance increase to an ion (or ions) with an 'equilibrium potential' near zero. We have found that during hyperpolarization of the resting membrane the excitatory junctional potential does not increase proportionally, as expected if it were purely of the conductance increase type. This had also been observed earlier[2], but the deviation from the predicted curve was attributed to a conductance increase caused by the hyperpolarizing current itself. Such an interpretation seems excluded in the present experiments. Furthermore, in the presence of Ca^{++} excess the excitatory junctional potential may actually decrease during hyperpolarization. Under these conditions one may even expect a reversal of the excitatory junctional potential at large negative resting potentials. This, however, could not be demonstrated experimentally even when the membrane potential was increased from − 80 to − 180 mV.

The following events are thus thought to occur at crustacean junctions: The excitatory transmitter combines with receptor sites at the junctional areas causing simultaneously two types of permeability changes. (1) An *increase* in membrane conductance predominantly to Na^+. (2) A *decrease* in conductance to K^+ and/or Cl^-. Both permeability changes cause depolarization and thus their effects are additive.

JOSEF DUDEL
STEPHEN W. KUFFLER

Neurophysiology Laboratory,
Harvard Medical School,
Boston, Mass.
April 28.

[1] del Castillo, J., and Katz, B., *Prog. Biophys.*, **6**, 121 (1956).
[2] Boistel, J., and Fatt, P., *J. Physiol.*, **144**, 176 (1958).

A Second Mechanism of Inhibition at the Crayfish Neuromuscular Junction

IN crayfish muscle fibres single stimulation of an inhibitory axon sets up small inhibitory junctional potentials (Fig. 1*A*). Fatt and Katz[1] showed that such inhibitory potential changes are caused by an increase of the membrane conductance to ions (K^+ and/or Cl^-) with an 'electrochemical equilibrium' close to the resting potential. This equilibrium potential can readily be determined. For example, in the experiment of Fig. 1*E* short trains of depolarizing inhibitory potentials were repeated every 2 sec. Beginning at the arrow, the membrane was depolarized progressively by passing a current across it. The inhibitory potentials became smaller and eventually reversed their polarity at the equilibrium level. A basically similar mechanism has been found in all inhibitory synapses studied so far, for example, in motoneurons, the atrium of the heart and in stretch receptor neurons of the crayfish[2]. Here an additional mechanism is reported.

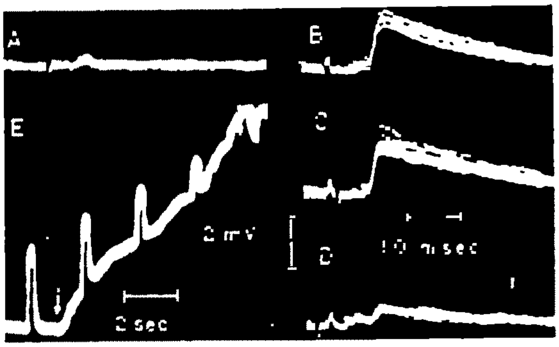


Fig. 1. Potentials recorded during one insertion of an intracellular electrode from a crayfish muscle fibre (adductor of the dactyl in the first walking leg of *Orconectes virilis*). Resting potential 80 mV. *A* to *D*. Single stimuli repeated 5/sec., several sweeps superimposed. *A*, inhibitory junctional potential. *B*, excitatory junctional potential. *C*, inhibitory plus excitatory potential, inhibitory stimulus 1 msec. after excitatory stimulus. *D*, inhibitory plus excitatory potential, inhibitory stimulus 3 msec. before excitatory stimulus. Time calibration 10 msec. for *A* to *D*. *E*, trains of inhibitory stimuli at 150/sec. repeated every 2 sec. At arrow start of membrane depolarization by passing current through second electrode. Broken line at 6 mV. depolarization indicates equilibrium potential of inhibition. Time calibration 2 sec. for *E*, voltage calibration 2 mV. for *A* to *E*

In the experiment of Fig. 1 the resting potential is about 6 mV. more negative than the inhibitory reversal potential, as shown in Fig. 1*E*. The size of the excitatory junctional potential in Fig. 1*B* is less than 3 mV., that is to say, it does not reach the inhibitory reversal potential. If now the conductance increase mechanism described above is the only mediator of inhibition, in this experimental situation the inhibitory potential should add to the excitatory potential and not reduce it. This, in fact, is the case in Fig. 1*C* where the timing is set so that the inhibitory potential (cf. Fig. 1*A*) falls on the peak of the excitatory one (Fig. 1*B*). However, if in Fig. 1*D* the inhibitory potential precedes the excitatory by 3 msec., the excitatory potential is greatly reduced in size. The timing is quite critical (cf. also ref. 3); in this experiment the effect is maximal for an interval 2–3 msec. Such an inhibitory effect cannot be explained by the increase of conductance mechanism, and therefore in addition a second mechanism of inhibition has to be postulated. This could be either a postsynaptic interaction between the inhibitory and excitatory transmitter substances, for example, in a competitive manner[1], or the inhibitor could influence the presynaptic excitatory nerve.

There is no direct method of studying the presynaptic nerve endings, but indirectly the state of excitatory facilitation and the frequency of spontaneous miniature potentials reveal presynaptic conditions. During the first second after a conditioning period of excitatory stimulation at high frequencies a burst of spontaneous miniature potentials is recorded in the muscle fibre[4], and for several seconds the size of single excitatory potentials is greatly increased as the result of presynaptic facilitation. This post-excitatory facilitation as well as the increase of frequency of miniature potentials is reduced if during the conditioning period inhibitory stimuli precede the excitatory ones by 2–3 msec. (as in Fig. 1*D*). If, however, the excitatory and inhibitory impulses are more separated no effect on post-

excitatory fac
post-excitator
are selectively
inhibition a p
endings is stru
The presyna
the transmitter
or by some
excitatory ner
inhibitory axon
of the presyn
applied γ-amin
compounds ha
same actions as
particularly th
potential. If in
butyric acid is
inhibitory nerve
as in Fig. 1D.
to inhibit the pr
to its effect of
muscle membra

iniatures is seen. Since
and miniature frequency
he second mechanism of
ion on excitatory nerve
1.
ı could be mediated by
l by the inhibitory nerve
bition exerted on the
ction potential in the
at the essential features
n can be imitated by
This and some related
ils so far studied, the
transmitter substance;
the same equilibrium
nilar to Fig. 2 γ-amino-
ead of stimulating the
y potential is decreased
butyric acid also seems
tatory axon in addition
ie conductance of the

F DUDEL
PHEN W. KUFFLER

Neurophysiolo
Harvard Me
Boston
Apr

[1] Fatt, P., and Katz, 1, 374 (1953).
[2] Kuffler, S. W., "Har , 176 (1958-59).
[3] Marmont, G., and W J. Physiol., 93, 173 (1938).
[4] Dudel, J., and Orka 186, 476 (1960).

HI ISTRY

A Simple A :hod for Histo-
chemical tion of Acid
se

A NEW diazoni
introduced for sim
Davis and Ornste
the demonstratio
electron-microscop
method using α-na
pararosanilin as c
of acid phosphata
same substrate, an
to techniques us
phosphates[6]. The
the very good l
phosphate is wat
hydrolysed than t
AS' or indoxyl de
mercially available
Best results ar
frozen sections. F
formalin containing
adjusted to 7·0 w
mended. A longer
be used, but result
Fresh material is p
of 24 hr. gives fairly
Frozen sections m
dried at room tem
incubated for 5–30
examined) at room

onium pararosanilin',
coupling methods by
ssfully employed in
at microscopic and
It was found that a
iate and hexazonium
ır better localization
er method[4] using the
em to be not inferior
l *AS'*[5] or indoxyl
this method, besides
e that α-naphthyl
t is more readily
esters of 'Naphthol
reagents are com-
hod works easily.
with formalin-fixed
hr. in 10 per cent
alcium chloride (*p*H
ydroxide) is recom-
od (48–72 hr.) may
ecrease in activity.
autopsy material

uminized slides are
1–2 hr. They are
ding on the tissue
, rinsed in water,

dehydrated in ethanol, cleared in xylol and mounted in balsam or synthetic medium. (After rinsing with distilled water a light blue nuclear staining, for example Weigert hæmatoxylin, may be used. This, however, will somewhat reduce the brightness of the histochemical staining.)

The incubating medium is prepared as follows:

To 20 mgm. of sodium α-acid phosphate (Dajac Lab., Philadelphia), dissolved in 13 ml. distilled water + 5 ml. of Michaelis veronal–acetate buffer stock solution (9·714 gm. sodium acetate $3H_2O$ + 14·714 gm. sodium barbiturate in distilled water free from carbon dioxide, made up to 500 ml.), 1·6 ml. of 'hexazonium salt' solution is added. The hexazonium salt solution is prepared freshly by mixing in a test tube equal amounts (0·8 ml.) of these two stock solutions: (*a*) 4 per cent pararosanilin hydrochloride (*C.I.* 676, National Aniline Division, Allied Chemical and Dye Corporation, New York) in 2 *N* hydrochloric acid, and (*b*) 4 per cent sodium nitrite[7]. The *p*H of the medium is then adjusted by *p*H-meter to 6·5 with 1 *N* sodium hydroxide (about 0·6 ml.). After this the solution is filtered into a Coplin jar and is ready for incubation. The veronal–acetate buffer can be replaced by phosphate or *tris*-maleate buffers.

It is assumed that the diazotization of *p*-rosaniline (triphenylaminomethane) results in the formation of hexazonium salt[1] capable of forming dyes with one, two or eventually three azo groups. The assumption that different compounds are formed is supported by the observation that the colour of azo dye varies with the *p*H. The colour is reddish in acid *p*H, becoming brownish towards neutral *p*H. Further treatment with naphthols results in changes in colour of both the reaction product and of the background staining, suggesting the presence of free diazo groups in the azo dye formed. These free diazo groups, able to form complexes with proteins, may in this way contribute to the insolubility of the azo dye, thus improving the localization. The fresh hexazonium salt is stable enough at acid *p*H to permit incubation at room temperature without change of the incubating medium for 60 min.

The hexazonium pararosanilin seems not significantly to inhibit the acid phosphatase at acid *p*H. However, quantitative data are not available. At neutral or alkaline *p*H the inactivation of acid phosphatase is considerable, indicating a diazonium-type reaction between the hexazonium pararosanilin and the enzyme. When stable diazonium salts are used the inhibition of enzymes is by most authors ascribed to the stabilizer. At acid *p*H the hexazonium salt does not cause appreciable changes in staining for adenosine triphosphatase or 5-nucleotidase, thus permitting combination with these techniques. The excess nitrous acid in the fresh diazonium salt solution seems not to interfere with the staining. Addition of urea to the incubating medium, in order to eliminate the excess of nitrous acid, did not change the histochemical pattern. However, most of the excess nitrous acid can be removed from the hexazonium salt solution by vacuum.

The naphthyl phosphate hexazonium pararosanilin method was employed at *p*H 6·5. This *p*H, chosen empirically, represents a necessary compromise between adequate azo-coupling and optimum enzyme activity. The coupling-rate of hexazonium pararosanilin with α-naphthyl is sluggish between *p*H 4·5 and 5·5. It increases towards neutral *p*H and permits good histochemical localization at *p*H 6·5 or above. Even at pH 6·0 or below the localization is better than with other diazonium salts. On the other hand, the acid phosphatase(s) of tissues examined so far are active at these pH. In the case of rat liver, acid phosphatase activity at pH 6·5 represents about 50 per cent of activity measured at pH 5.

The improved localization given by this technique is attributed to the insolubility and substantivity of the azo-dye formed. The dye is resistant to most of the organic solvents and is insoluble in lipids. It is amorphous or microcrystalline. Its colour and form did not change in mounted slides in 10 months. It gave reproducible, constant results in large series of sections of human, rat and mouse tissues. The applicability of this method to nervous tissue, both animal and human (Anderson, P., unpublished observations), deserves emphasis. It should stimulate the re-evaluation of the distribution of acid phosphatase in nervous tissue, where the results with the Gomori lead method are most questionable. It is hoped that the simple modification described will facilitate the histochemical study of the physiological and pathological significance of the somewhat neglected acid phosphatase.

This work was supported by Grant No. *A*–1783(*C*) of the Division of Research Grants, United States Public Health Service, National Institutes of Health. I am indebted to Miss H. van der Noen for assistance.

TIBOR BARKA

Department of Pathology,
Mount Sinai Hospital,
New York 29.

[1] Davis, B. J., and Ornstein, L., *J. Histochem. Cytochem.*, 7, 297 (1959).
[2] Davis, B. J., *Proc. Soc. Exp. Biol. Med.*, 101, 90 (1959).
[3] Lehrer, M. G., and Ornstein, L., *J. Biophys. Biochem. Cytol.*, 6, 399 (1959).
[4] Pearse, A. G. E., "Histochemistry: Theoretical and Applied" (Little, Brown and Co., Boston, 1960).
[5] Burstone, M. S., *J. Nat. Cancer Inst.*, 21, 523 (1958).
[6] Holt, S. J., *Nature*, 169, 271 (1952).
[7] Taft, E. B., *Lab. Invest.*, 9, 160 (1960).

PATHOLOGY

Vitamin and Coenzyme Content of Hepatomas induced by Butter Yellow

DESPITE the great importance of vitamins and coenzymes to all aspects of metabolism, little attention has been given to the concentration of these compounds in tumours in recent years. In fact, the only systematic study appears to be the work of R. J. Williams and associates[1]. The results of this work demonstrate that the concentration of vitamins in tumours is quite abnormal.

The present investigation was undertaken to study the vitamin and coenzyme contents of one type of tumour in one species. Hepatomas induced by butter yellow (4-dimethylaminoazobenzene) in rats were selected, since they are one of the types of tumour most studied.

Thirty-six male, weanling, albino rats of the Sprague–Dawley strain were fed a 'Purina' diet. After two weeks on this diet, the rats were separately caged and divided into two equal groups. The first group was fed the basal diet as before, while the second was fed the 'Purina' plus 0·06 gm. per cent butter yellow. After 135 days, the animals were killed by decapitation and the livers removed. No tumours were found in the control animals, but of those fed the butter yellow diet 16 of the 18 had large hepatomas. The livers of the control animals, together with the carefully removed hepatomas, were preserved for analysis in the frozen state.

Thiamine assay was conducted with *Saccharomyces cerevisiae*[2], riboflavin assay with *Lactobacillus casei*[3], niacin assay with *Lactobacillus arabinosus*[4], biotin assay with *L. arabinosus*[5], total vitamin B_6 assay with *Saccharomyces carlsbergensis*[6], and pantothenic acid assay with *L. arabinosus*[4] on an enzyme-hydrolysed extract. Vitamin A was detected by the Carr–Price reaction[7], tocopherols by the ferric chloride-α,α-dipyridyl reaction[8] after the removal of interfering substances with concentrated sulphuric acid[9], and ascorbic acid by the 2,4-dinitrophenylhydrazine assay[10].

Diphosphopyridine nucleotide and triphosphopyridine nucleotide were determined by the crystalline alcohol dehydrogenase[11] and *iso*citric dehydrogenase[12] assay methods respectively. The ratio of oxidized to reduced diphosphopyridine nucleotide was determined by the alcohol dehydrogenase method of Holzer *et al.*[13]. Coenzyme *A* was assayed by the arsenolysis method[14].

The results of these determinations are given in Tables 1 and 2.

Table 1. CONCENTRATION OF VITAMINS IN NORMAL LIVERS AND IN HEPATOMAS

Vitamin	Concentration (mean of five determinations, μgm./gm. wet tissue) Normal liver	 Hepatoma
Thiamine	2·8	1·1
Riboflavin	26	4
Niacin	160	33
Biotin	0·85	0·17
Total vitamin B_6	9·0	2·4
Pantothenic acid	91	9
Vitamin A	45·1	8·5
Tocopherols	38	5·1
Ascorbic acid	20	25

Table 2. CONCENTRATION OF COENZYMES IN NORMAL LIVERS AND IN HEPATOMAS

Coenzyme	Normal liver	Hepatomas
Total diphosphopyridine nucleotide (μgm./gm. wet tissue)	480	176
Total triphosphopyridine nucleotide (μgm./gm. wet tissue)	230	24
Diphosphopyridine nucleotide/reduced diphosphopyridine nucleotide	2·2	2·9
Coenzyme A (units/gm. wet tissue)	180	12

It is apparent that the concentrations of many vitamins and coenzymes within hepatomas are very abnormal. Indeed, so different are the concentrations from the normal that they offer an explanation of many of the observed metabolic disturbances of tumours. If tumours have a deranged metabolism because of differences in coenzymes and similar factors, it follows that whatever mechanisms are changing the concentrations must be also the primary causes of tumour incidence. As differences in concentration of vitamins within different cells must primarily depend upon cell permeability, it seems a reasonable hypothesis that the change from a normal to a neoplastic cell may be the result of damage to mechanisms responsible for the transfer of vitamins into a cell.

I wish to
Departments
Cornell Unive
ducting the m

Departme
Victoria Unive
New

[1] Pollack, M. S., T
Research, 2, 73
and Williams,
A., Woods, A.
748 (1942). T
R. J., *ibid.*, 2,
[2] Williams, R. J.,
Pub., 4137, 31
[3] Snell, E. E., and
11, 346 (1939)
[4] Snell, E. E., and
[5] Wright, L. D., an
(1944).
[6] Snell, E. E., in "
York, 1950).
[7] Morton, R. A.,
[8] Emmerie, A., and
[9] Parker, W. E., and
[10] Roe, J. H., Mill
J. Biol. Chem.
[11] Kornberg, A., *J.*
[12] Adler, E., Euler,
32, 1028 (1939
[13] Holzer, H., Gold
Hoppe-Seyler's
[14] Stadtman, E. R.,
191, 365 (1951)

Effect o
Evolution

In 1954, on
Candida albica
the growth of *M*
led to the de
for the detecti
material[3]. Reco
saccharide fract
for the *M. tub*
this yeast, and
inhibited in th
streptomycin.
pigs were given
right groin of 0
culture in 'Twee
(strain $H_{37}Rv$).
the same time
(wet weight) of
albicans. Anot
was inoculated
cent solution of
fraction of *C. alb*
with tubercle b
Another group o
pigs which were
of 1 mgm. (we
C. albicans alon
All the anima
those which were
inoculation, were
the sites of injec
and aliquot par
cultured in an
they contained C
Two of the
suspension of *C*
other two mont
due to *D. pneum*

ral members of the
ry and Bacteriology of
nical assistance in con-
assays.

M. H. BRIGGS

r,
gton,

J., and Williams, R. J., *Cancer*
A., Pollack, M. S., Hofer, M. J.,
(1942). Pollack, M. S., Taylor,
, and Williams, R. J., *ibid.*, 2,
S., Hofer, M. J., and Williams,

and Eakin, R. E., *Univ. Texas*

Ind. Eng. Chem., Anal. Edit.,

. *Biol. Chem.*, 139, 675 (1941).
roc. Soc. Exp. Biol. Med., 56, 95

, 1, 327 (Academic Press, New

ool., 2, 129 (1950).
av. chim., 57, 1351 (1938).
Canad. J. Res., 18, B, 405 (1940).
M. J., and Damron, C. M.,

779 (1950).
., and Plaut, M., *Biochem. J.*,

recht, W., and Helmreich, E.,
297, 1 (1954).
Lipmann, F., *J. Biol. Chem.*,

lbicans on the
ntal Tuberculosis

wed that cultures of
e ability to promote
in vitro. This finding
the tracer technique
bacilli in pathological
re shown that the poly-
albicans is responsible
th-promoting effect of
lar, on tubercle bacilli
tion by exposure to
experiment 60 guinea
ous inoculation in the
weight) of a ten-day
dium of *M. tuberculosis*
ese were inoculated, at
me site, with 1 mgm.
and culture of *Candida*
0 of these guinea pigs
with 1 ml. of a 5 per
moting polysaccharide
guinea pigs inoculated
re kept as 'controls'.
s formed by 20 guinea
cutaneous inoculation
the 5-day culture of

those which died and
twelfth week following
The lymph nodes near
hose in the left groin,
pleen and lungs were
mine whether or not
tuberculosis, or both.
noculated with a cell
one a month and the
tion, from pneumonia
s of the right external

iliac lymph nodes showed that they contained *C. albicans*. No evidence of *C. albicans* was found in the left external iliac nodes, the liver, the spleen and the lungs.

Two of the guinea pigs inoculated with a suspension of *M. tuberculosis* (strain $H_{37}Rv$) alone died with an infection due to diplococci less than six weeks after injection. After ten weeks, 8 of the remaining 18 guinea pigs died with tuberculous lesions in the liver, spleen and lungs.

When guinea pigs were inoculated with suspensions of *M. tuberculosis* and *C. albicans* the combined infection resulted in a faster evolution of the tuberculous disease. More than 50 per cent of the animals of this group had died within six weeks of inoculation. Necropsy examination disclosed that all these had lesions in the right external iliac lymph nodes and, in many instances, tubercle bacilli were recovered from the internal iliac lymph nodes, from liver, spleen or lungs. By the end of the twelfth week, cultures of the liver, spleen and lungs of two to three times as many of these animals as of the animals inoculated with tubercle bacilli alone showed evidence of growth of *M. tuberculosis*.

In no instance did these animals show any signs of disease of the liver, spleen or lungs that could be attributed to *C. albicans*. *Candida albicans* was recovered from the regional lymph nodes and, in two instances, from small abscesses that had formed at the site of the inoculation in animals that died within the first six weeks. After this time, *C. albicans* was not recovered again by cultural methods from any tissue.

The addition of the polysaccharide fraction to the bacillary inoculum also increased the death-rate of the guinea pigs from tuberculosis within the first weeks of the experiment. The ratio of tissular infection with *M. tuberculosis* was higher than in animals inoculated with tubercle bacilli alone, but inferior to that of animals inoculated with tubercle bacilli and the living yeast cells.

The death-rate of the animals in this experiment and the number of cultures of *M. tuberculosis* obtained from necropsy material are summarized in Tables 1, 2 and 3.

Table 1. DEATH-RATE OF GUINEA PIGS INOCULATED WITH TUBERCLE BACILLI ALONE, WITH TUBERCLE BACILLI AND *C. albicans* CELLS, AND WITH TUBERCLE BACILLI AND THE POLYSACCHARIDES OF *C. albicans* IN THE FIRST WEEKS OF THE EXPERIMENT

Interval between infection and death	$H_{37}Rv$	$H_{37}Rv$ and *C. albicans*	$H_{37}Rv$ and polysaccharides of *C. albicans*
2 weeks	—	2	2
3 weeks	—	5	3
4 weeks	1	1	—
5 weeks	—	1	—
6 weeks	1	2	1
Death-rate After 6 weeks	2/20	11/20	6/20

Table 2. DISSEMINATION OF TUBERCLE BACILLI IN ANIMALS DEAD WITHIN SIX WEEKS OF THE EXPERIMENT

Tubercle bacilli isolated from	Animals inoculated with:		
	$H_{37}Rv$	$H_{37}Rv$ and *C. albicans*	$H_{37}Rv$ and polysaccharide fraction
Right ext. iliac lymph node	2/2	11/11	6/6
Int. iliac lymph node	0/2	4/11	0/6
Left. ext. iliac lymph node	0/2	2/11	3/6
Liver or spleen	0/2	4/11	5/6
Lungs	0/2	4/11	2/6

Table 3. Dissemination of Tubercle Bacilli in all Animals under Experiment (Dead or Killed after 12 Weeks)

Tubercle bacilli isolated from	Animals inoculated with:		
	$H_{37}Rv$	$H_{37}Rv$ and *C. albicans*	$H_{37}Rv$ and polysaccharide fraction
Right ext. iliac lymph node	12/20	20/20	20/20
Int. iliac lymph node	11/20	16/20	12/20
Left ext. iliac lymph node	1/20	10/20	7/20
Liver or spleen	6/20	12/20	8/20
Lungs	5/20	12/20	6/20

The results of these experiments show that within the first two months after infection, *C. albicans* increased the invasiveness of the tubercle bacilli. This action can be compared to that of certain extracellular enzymes such as streptokinase or hyaluronidase which are not directly toxic but act as spreading agents for the bacteria which produce them. However, no enzyme that acts on the dissemination of tubercle bacilli *in vivo* has so far been isolated from *C. albicans*. The simultaneous inoculation of 50 mgm. of *C. albicans* polysaccharides reproduced, to a lesser extent, the effect of the living yeast cells by increasing the early death-rate and the dissemination of the tubercle bacilli. The chemical nature of the polysaccharide fraction of *C. albicans* used in this experiment has been studied by Ch. Tanford (personal communication). He pointed out the chemical similarity between this fraction and bacterial 'Dextran UF' described by Greenwood[4,5].

Bacterial dextrans increase the virulence of enterobacteria for rats and mice[6-8]. These dextrans differ in their action from mucin, on one hand, and from the stress-producing substance, adrenocorticotrophic hormone, on the other[9].

The only explanation so far offered for the virulence-enhancing action of dextrans has been proposed by Osalay *et al.*[10], who observed inhibition and destruction of phagocytes in white rats inoculated with dextrans.

The polysaccharide fraction of *C. albicans* represents 10 per cent of the weight of the whole cells[3]. The inoculum of 1 mgm. of yeast cells contained 0·1 mgm. of the polysaccharide fraction. This seems a very small amount of dextrans, unless it is taken into consideration that these cells may have multiplied several times before their ultimate destruction.

This work was supported in part by a National Health Grant.

E. Mankiewicz
M. Litvak

Laboratories of the
Royal Edward Laurentian Hospital,
Montreal.

[1] Mankiewicz, E., *Canad. J. Microbiol.*, 1, 85 (1954).

[2] Mankiewicz, E., *Amer. Rev. Tuberc.*, 75, 836 (1957).

[3] Mankiewicz, E., Stackiewicz, E., and Litvak, M., *Canad. J. Microbiol.*, 5, 261 (1959).

[4] Greenwood C. T., "Advances in Carbohydrate Chem.", 7, 307 (1952).

[5] Greenwood, C. T., "Advances in Carbohydrate Chem.", 11, 388 (1956).

[6] Olitzki, L., Shel :ky, M., and Hestrin, S., *Proc. Soc. Exp. Biol.*, 63, 491 (1946).

[7] Hestrin, S., Shilo, M., and Feingold, D. S., *Brit. J. Exp. Path.*, 35, 107 (1954).

[8] Hestrin, M., *et al.*, *Brit. J. Exp. Path.*, 35, 112 (1954).

[9] Joo, J., and Csizmas, L., *Z. Immunitätsf.*, 114, 215 (1957).

[10] Osalay, L., Lodany, G., and Vajda, V., *Kiserletes Orvostudomany* (Hung.), 7, 596 (1955).

RADIOBIOLOGY

Delayed Recovery of Airborne *Serratia marcescens* after Short-Time Exposure to Ultra-violet Irradiation

The phenomenon of the re-activation of bacteria after exposure to ultra-violet irradiation is well known[1-4]. The possibility exists that products formed in the medium by the response of some bacteria, either by death or by adaptation, might have influenced the re-activation of neighbouring bacilli.

During a study of freeze-dried *Serratia marcescens* aerosolized from the dried state[5] a question arose concerning the extent of injury incurred by the airborne bacteria as influenced by the quantity of ultra-violet irradiation. This communication describes a re-activation phenomenon associated with such brief exposures.

In our experiments dried organisms were dispersed into cubic-meter chambers[6] with the enclosed air stirred by a fan. Air samples were collected at intervals by means of a Bourdillion-type slit sampler directly on to blood agar base ('BAB', Difco) medium and the plates were incubated immediately. The viable bacterial concentration/litre of aerosol was then plotted on semi-log paper versus time to determine the overall decay in viability. Because physical loss was small compared to the loss of viability, no adjustment for the former was employed. Ultra-violet irradiation was introduced at the top of the chamber by a Westinghouse Sterilamp No. 7824-10, which was turned on for desired time-periods (20–120 sec.) at 90 min. after aerosol dispersal. A sufficient number of samples was taken before exposure to establish the rate of decay in the absence of irradiation. Each aerosol, therefore, served as its own control.

In the absence of irradiation, the numbers of viable airborne bacteria decreased in an exponential manner. It was expected from this finding that exposure to the lethal radiation would cause a sudden decrease in the numbers of viable cells followed by a continuation of the established rate of decay by those bacilli not influenced by the ultra-violet exposure.

As predicted, there was a sudden loss of viable airborne cells on irradiation. The log of the percentage of survivors correlated with duration of ultra-violet exposure. However, subsequent behaviour was unexpected. After completion of the exposure, and for 15–20 min. thereafter, evidence of an increased rate of decay followed by a short period of recovery was noted. In some cases a second increased rate of decay occurred which continued for about 30 min. followed by a second period of recovery, usually 60–75 min. after exposure. The numbers of viable bacilli then remaining airborne were at a level which would have been expected had no ultra-violet exposure been employed. Fig. 1 is a composite illustration of the behaviour of 30 aerosols tested in this manner. Although not all aerosols exhibited two periods of decay and recovery, all but two indicated that the bacteria recovered to the extent shown by the solid line in Fig. 1. In three instances injury was such that no organisms were recovered from the aerosol during a short time-period after irradiation, though viable micro-organisms were present after additional time had passed. This unusual behaviour was associated with the use of sampling medium which had been dried[7,8] for a longer time than was usually employed to clear excess water from the Petri plates.

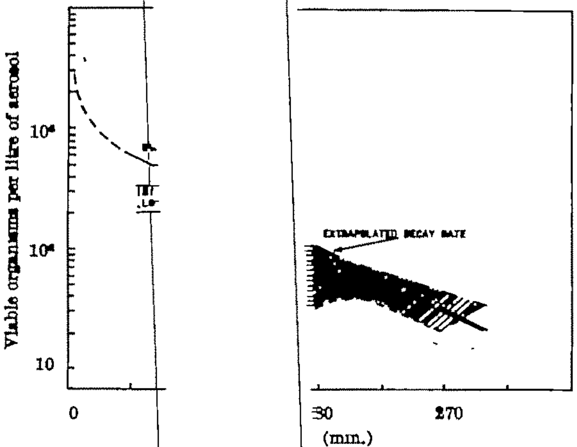


Fig. 1. Composit
Serratia marcesce
radiation. The d
The most co

series of aerosols of powdered
hort periods of ultra-violet
is shown by the shaded area.
shown by the solid line

The possibil
measurements
photoreactivat
light and hold
until incubatio
same. Buntin
'BAB' medium
use of impinge
slit samplers
results.

It should be
the airborne b
equal exposure
that mixing of
conditions empl
To have had po-
tacted maximu
undiluted by ot
possibility. Th
does not seem
instances in whic
strable for a sho
existence of con
be kept in mind

The rate of ph
as calculated by
airborne particl
individual bacte
one organism in
influenced by di
of another bacil
was associated w
plates rather th
decay rate would

Clearly, theref
initial shock of
reproduce immedi
permitted a peri
form colonies. T
cant metabolic
The successive p
caused by absorpt
peroxides[7], or co
one mechanism of
noteworthy that
not occur when b
suspensions, tho
susceptibility was

yndall beam used for
er might have caused
ed by turning off the
ing plates in the dark
l; the results were the
as substituted for the
ge in behaviour. The
of samples rather than
ment produced similar

the individuals among
did not encounter an
But tests have shown
ed particles under the
ete within 15–20 sec.
erosol which had con-
ss the sampling port
tions is a very remote
a received no radiation
ecause of the three
orne cells were demon-
e the less, the possible
qual exposure should

he particulate matter,
owed that most of the
ed the size of the
he death or change of
state could not have
ontact the behaviour
ecovery phenomenon
nment of the Petri
e state, no increased
ed.

ria responded to the
n that if required to
ld not do so; but if
orehand, they could
evidence that signifi-
s in airborne cells.
ased decay might be
uent volatilization of
tative of more than
itution. It is further
on phenomenon did
rosolized from liquid
ot conclusive since
ed. Thus, the freeze-dry step might have modified or selected bacteria so that they possessed enhanced 'adaptability'. How the single bacillus, enclosed in an adverse micro-environment, can adjust to survive such obvious insult presents an interesting question.

This work was sponsored by the Office of Naval Research, U.S. Navy, and the U.S. Army Chemical Corps, Fort Detrick, Frederick, Maryland, under a contract between the Office of Naval Research and the Regents of the University of California.

R. L. DIMMICK

Naval Biological Laboratory,
School of Public Health,
University of California,
Berkeley, California.

[1] Kelner, A., *J. Bact.*, 58, 511 (1949).
[2] Payne, J. L., Hartman, P. E., Mudd, S., and Phillips, A. W., *J. Bact.*, 72 (1956).
[3] Stuy, J. H., *Biochim. Biophys. Acta*, 22, 241 (1956).
[4] Iverson, R. M., and Giese, A. C., *Biochim. Biophys. Acta*, 25, 62 (1957).
[5] Dimmick, R. L., *Amer. Med. Assoc. Indust. Health*, 20, 8 (1959).
[6] Dimmick, R. L., Hatch, M. T., and Ng, J., *Amer. Med. Soc. Arch. Indust. Health*, 18, 23 (1958).
[7] Kramli, A., Pettko, E., and Sipos, M., *Nature*, 178, 1237 (1956).

Relative Availability of Some Strontium-90 Compounds in Soil

ASSESSMENT of contamination of man's food chain by strontium-90 through plants is complicated by variables in the plant's source of this isotope. Thus the content of strontium-90 in plants from fall-out may be influenced by foliar absorption[1], stem-base absorption[2], and the vertical distribution of strontium-90 in the soil profile[3]. In cultivated soils, the low mobility of strontium-90 coupled with normal tillage practices eventually will lead to a relatively uniform distribution of strontium-90 within the rhizosphere. Consequently the availability of strontium-90 from soil to plants becomes an important factor in hazard evaluation. We believe information regarding availability, and any change with time thereof, can be obtained by successively cropping soil cultures which have been uniformly contaminated with strontium compounds of varying solubility.

Compounds labelled with strontium-90 were prepared (Table 1) and carefully mixed with small aliquots of dry soil previously passed through a 105-mm. mesh sieve. This mixture was blended with more soil in a V-shell blender to yield 500 gm. dry soil (105° C. basis) with a final activity of 0·1 μc./gm. soil. Each chemical form was prepared in triplicate for each of the three soils (Table 1). Random sampling indicated uniform mixing of strontium-90 throughout the soil mass. Beans (*Phaseolus vulgaris* var. Red Kidney) were grown, two plants per pot, in the greenhouse to blossom stage (32 days). Leaves from each pot were combined, wet ashed, and assayed for strontium-90 by conventional counting procedures. Stem data were also obtained, but are not reported since they substantiated leaf results. Strontium-90 content of tissue was used for evaluating relative availability of strontium compounds, thereby avoiding the uncertainties in chemical extraction procedures discussed by Bowen and Dymond[4]. During intervals between crops, the soil was subjected to wetting and drying but was not cultivated. The first fallow period was 32 days and the second was extended to 141 days.

Uptake from relatively insoluble forms was similar and tenfold less than uptake from insoluble forms in

Table 1

Soil	Harvest No.	μc. of strontium-90/100 gm. dry* bean leaves						
		Form of strontium-90 added to soil						
		$Sr(NO_3)_2$	$SrCl_2$	$SrSO_4$	SrC_2O_4	SrF_2	$SrCO_3$	$SrHPO_4$
Cinebar silt loam (pH, 5·4; 1 me Ca‡)	1	150 ± 10†	210 ± 20†	20 ± 1†	19 ± 2†	20 ± 6†	18 ± 2†	19 ± 2†
	2	160 ± 10	200 ± 10	29 ± 7	22 ± 1	20 ± 5	23 ± [illegible]	21 ± 4
	3	110 ± 20	140 ± 16	16 ± 2	18 ± 1	10 ± [illegible]	15 ± [illegible]	14 ± 3
Ephrata sandy loam (pH, 8·2; 16 me Ca‡)	1	73 ± 16	79 ± 4	6·9 ± 0·1	7·7 ± 0·9	4·9 ± 0·9	0·56 ± 0·04	0·46 ± 0·03
	2	72 ± 8	67 ± 17	5·7 ± 1·1	5·7 ± 0·7	4·2 ± 0·6	0·48 ± 0·03	0·36 ± 0·01
	3	60 ± 7	61 ± 12	6·7 ± 1·0	6·6 ± 1·1	5·4 ± 1·0	1·0 ± 0·1	0·48 ± 0·02
Millville loam (pH, 8·0; 30 me Ca‡)	1	60 ± 2	54 ± 2	6·2 ± 0·9	5·6 ± 0·9	4·8 ± 1·8	0·69 ± 0·17	0·31 ± 0·02
	2	53 ± 2	52 ± 6	4·3 ± 0·2	5·1 ± 0·3	4·9 ± 1·4	0·83 ± 0·04	0·31 ± 0·02
	3	50 ± 6	45 ± 12	5·2 ± 0·1	4·2 ± 0·8	4·2 ± 0·6	1·6 ± 0·3	0·30 ± 0·03

* Leaf tissue dried at 70° C. † Standard deviation. ‡ Ammonium acetate-extractable calcium in me/100 gm. soil.

the acidic Cinebar soil. In calcareous soils, the same relationship between soluble and insoluble forms held with the exception of strontium phosphate and carbonate, which were another order of magnitude less available than the soluble forms. The grouping of the response-levels suggested that moderate differences in solubility were not identifiable when compounds were mixed with soil. The sulphate, suggested by Libby[5] as possibly beneficial in soils contaminated by strontium-90, was no less available than other forms the solubility products of which differ by 1 or 2 orders of magnitude. Soil reactions were clearly important in the relative availability of phosphate and carbonate from basic compared to acidic soils. Apatite formation in alkaline soils containing calcite has been shown to include calcium-like atoms in the apatite lattice, thereby removing strontium from solution[6]. We presume this reaction accounted for the reduction of availability of strontium-90 relative to other forms. Such a direct explanation is not apparent for strontium carbonate.

The low availability of strontium phosphate suggested phosphate fertilization as a means of reducing uptake of strontium-90 from contaminated soils. We were able to demonstrate a 50 per cent reduction in uptake of strontium-90 from basic soils treated with massive doses of phosphate[7]. No reduction was observed on acidic soil.

During three croppings there was no major change in availability of soluble or insoluble forms such that a general trend toward equilibrium was indicated. This suggested a prolonged period of equilibration and substantiated observations previously made on strontium-90 aged several years in the field[8]. In these field-studies strontium-90 aged nearly four years was taken up by plants to the same extent as strontium-85 added at the time of testing. In the present test some changes in availability pertaining to certain compounds in one soil were noted. In acidic soil the availability of all strontium salts decreased in the final harvest. This decrease could not be accounted for by depletion of strontium-90 from the soil. In alkaline soils the rate of change was much slower and in the same direction except for strontium carbonate, which became more available with time.

No significant difference existed between the Ephrata and Millville soils with respect to strontium availability although the uptake from these calcareous soils was 2–3 times less than from the acidic soil. The lower uptake from calcareous soils has been largely attributed to the quantities of available calcium. In partial confirmation of the calcium effect, it has been possible to reduce uptake of strontium-90 as much as 80 per cent by additions of lime or gypsum to Cinebar soil, which is low in calcium[9]. Such amendments are without effect on alkaline calcareous soils[10]. In fact, with the exception of the phosphate treatment mentioned, no treatment procedures have been described which depressed strontium-90 uptake from calcareous soils.

The results obtained to date establish the extent to which uptake of strontium-90 might potentially be reduced through precipitation reactions. Further studies are required to determine whether an appreciable part of this potential can be realized. However, initial experiments with phosphate fertilization[7] do not permit much optimism on this point.

This work was performed under Contract No. *AT* (45–1)-1350 between the U.S. Atomic Energy Commission and the General Electric Co.

R. L. UHLER
F. P. HUNGATE

Biology Operation,
Hanford Laboratories,
General Electric Co.,
Richland, Washington.

[1] Middleton, L. J., *Nature*, **181**, 1300 (1958).

[2] Russell, R. S., *Nature*, **182**, 834 (1958).

[3] Schulz, R. K., Moberg, J. P., and Overstreet, R., *Hilgardia*, **28**, 457 (1959).

[4] Bowen, H. J. M., and Dymond, J. A., *J. Exp. Bot.*, **7**, 264 (1956).

[5] Libby, W. F., *Science*, **128**, 1134 (1958).

[6] Ames, jun., L. L., McHenry, J. R., and Honstead, J. F., Proc. Second U.N. Internat. Conf. on Peaceful Uses of Atomic Energy, **18**, 76 (1958).

[7] Uhler, R. L., Hanford Biology Ann. Rep. for 1959, *HW*-65500 (1960) (in the press).

[8] Hungate, F. P., Uhler, R. L., and Cline, J. F., Hanford Biology Ann. Rep. for 1957, *HW*-53500, 7 (1958).

[9] Cline, J. F., and Hungate, F. P., Hanford Biology Ann. Rep. for 1955, *HW*-41500, 7 (1956).

[10] Romney, E. M., Alexander, G. V., Rhoads, W. A., and Larson, K. H., *Soil Sci.*, **87**, 160 (1959).

BIOLOGY

X and *Y* Spermatozoa

A HUMAN spermatozoon contains an *X* or a *Y* chromosome, whereas every human egg contains an *X* chromosome. If, therefore, an *X* spermatozoon fertilizes an egg, the offspring is female; but if a *Y* spermatozoon fertilizes an egg, the offspring is male.

Much effort has, naturally, been expended in trying to separate *X* and *Y* spermatozoa, if only because the separation could be exploited to gratify the wishes of prospective parents. Apart from the

wild idea that
the conceptio
of females, an
idea that the
between *X* an
been used to
involves the
between the s
which would e
centrifuge. E
been done on
in spite of the
conclusion is
hypothetical m
tozoa has not
encountered i
variation in th
according to the

A second me
and *Y* spermat
one type has a
and therefore
side of an elec
negatively char
of the field. Sh
the first to asse
claim has been
Nevo, Michaeli
experiments un
bull and rabbit
normal *p*H's, al
negative charge
them therefore
electric field.

Electrophoresi
times done on
One possible in
swimming sperm
in which a swi
electric field depe
of two vectors, c
forward moveme
which it is passi
side of the electri
velocities in a pop
of different 'type
effected in such o
in no sense implie
sperm surfaces.
that *X* spermatoz
or vice versa.

The third meth
tozoa depends o
difference in the
Many measureme
have been made
distribution, or a
as the sum of t
different means,
parameter. No s
Shettles, however
reported that hu
distinct population
type of sperm hea
trally located roun
and contained a c
According to Shett
are nuclear mater
generally thought t
the mature sperm h
thin covering over

nvironment might favour
n acid environment that
but equally unrewarding
mmunological differences
zoa, three methods have
or separate them. One
t there is a difference
X and *Y* spermatozoa,
be separated in a special
test this possibility have
ozoa by Lindahl[1]; but
hopeful at one time, the
that, at present, this
ating *X* and *Y* sperma-
l. A serious difficulty
riments concerns the
ity of bull spermatozoa
peness or over-ripeness[2].
fying or separating *X*
on the hypothesis that
ic charge on its surface
swims) to the negative
reas the other type is
tes to the positive side
abbit spermatozoa, was
appened and the same
rdon[4]. Very recently,
[5] have repeated these
olled conditions with
They found that at
bit spermatozoa have
faces and that all of
rds the anode in an

of this type are some-
tivated spermatozoa.
f positive results on
ollows: the direction
tozoon travels in an
ection of the resultant
spermatozoon's own
her to the force with
towards one or other
re is a distribution of
natozoa[6], a separation
zoa can obviously be
hough the separation
of oppositely charged
ny reason to suppose
than *Y* spermatozoa,

ng *X* and *Y* sperma-
sis that there is a
of the two types.
nalian sperm heads
f finding a bimodal
ich can be expressed
distributions with
urable sperm head
has been found.
t communication[7],
eads fell into two
mediate types. One
ad contained a cen-
the other was large
ed elongated mass.
rally located masses
nuclear material is
y distributed within
the galea capitis, a
of some mammalian

sperm heads. Shettles went on to say that, in one sperm head, three observers independently counted eighteen discrete chromosomes. This is the first time that chromosomes have been 'observed' in a mature sperm head, it having been universally agreed before that discrete chromosomes are not visible in the mature spermatozoon.

Although *X* and *Y* spermatozoa might have been expected to be present in approximately equal numbers, Shettles made no reference to having counted the two types, which is surprising considering the importance of his claim and the ease with which the two types could have been counted.

One photomicrograph, described by Shettles as being of a human sperm head, shows that the head in question is no less than 30μ long, whereas the average human sperm head is 5μ long.

From what has been said, Shettles's claim should clearly not be accepted. The question at issue is: what, in reality, did he observe? Were the round and long black masses distorted vacuoles which occur inside human sperm heads—distorted because of the unusual optical system Shettles used, or because, when dry, human spermatozoa, which are far from being solids of revolution[8], do not always settle on the microscope slide in the same way? Or were the central masses optical artefacts which can easily be demonstrated if crystals in dried human seminal plasma are examined with phase contrast at different focal depths?

To sum up, there is so far no evidence that physical differences have been found between *X* and *Y* spermatozoa.

ROTHSCHILD

Department of Zoology,
Cambridge.

[1] Lindahl, P. E., *Nature*, 178, 491 (1956); *Biochim. Biophys. Acta*, 21, 411 (1956); *Nature*, 181, 784 (1958).

[2] Lindahl, P. E., and Kihlstrom, J. E., *J. Dairy Sci.*, 35, 393 (1952). Kihlstrom, J. E., *Ark. Zool.*, 11, 569 (1958).

[3] Shreder, V. N., *Biol. Zh.*, 1, 24 (1932).

[4] Gordon, M. J., *Proc. U.S. Nat. Acad. Sci.*, 43, 913 (1957).

[5] Nevo, A. C., Michaeli, I., and Schindler, H., *Exp. Cell Res.* (in the press).

[6] Rothschild, Lord, *J. Exp. Biol.*, 30, 178 (1953).

[7] Shettles, L. B., *Nature*, 186, 648 (1960).

[8] Ånberg, Å., *Acta obstet. gynec. Scand.*, 36, 1 (1957). Rothschild, Lord, *Brit. Med. J.*, i, 301 (1958). Fawcett, D. W., *Int. Rev. Cytol.*, 7, 195 (1958).

THE methods of fixation and staining human spermatozoa in the past for bright light and electron microscopy result in alterations and coalescence of the head contents into one mass—a very unnatural state. Consequently, as a result of these changes, the nuclear material of the human spermatozoan head has always appeared very uniform and homogeneous in appearance. It was therefore undesirable to consider the chromatin material in such a state to be normal for the spermatozoan head as it enters the ovum and comes in contact with the egg pronucleus. In his "Developmental Anatomy" (sixth edition, 1954), L. B. Arey states, "The interior of the head contains the tightly packed chromosomes of the sperm cell".

More than a hundred men have now been studied, and the two distinct populations have been repeatedly observed in every semen specimen regarding head and nuclear size and shape, the position, size and shape of the most central chromosomal mass and the pattern of reflected light. The most central mass in each type of head is unequivocally Feulgen-positive, as well

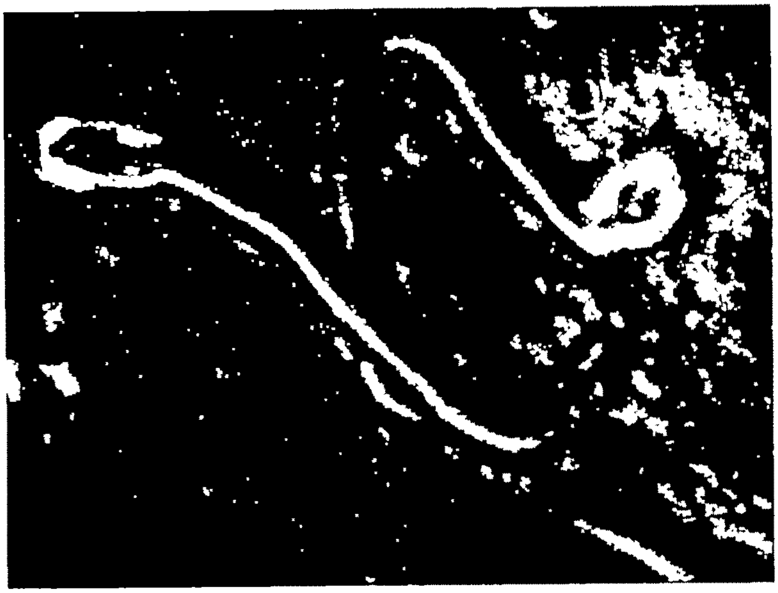


Fig. 1. Living human spermatozoa immobilized in an atmosphere of carbon dioxide Note most central mass in each type of head. Light adjusted to show third dimension. (Original magnification × 1,000. Print provided [by author] has been reduced to ⅔)

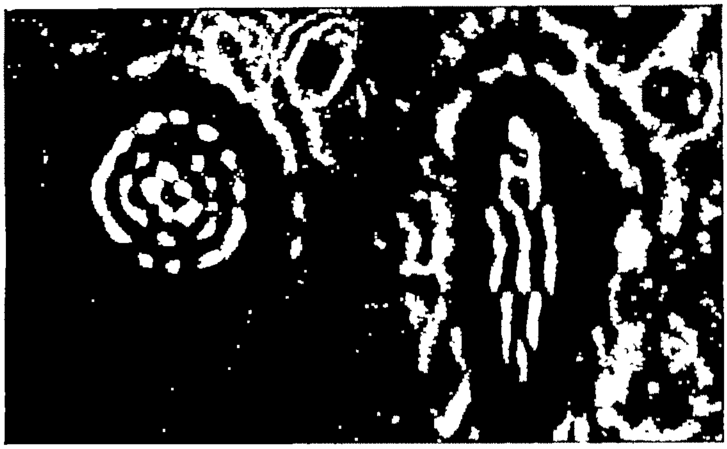


Fig. 2. Dried, unstained human spermatozoon heads showing arrangement of chromosomal material in each type of head. Phase contrast. Heads separated from tails during slight mechanical flattening of heads to facilitate viewing. (Original magnification × 1,000. Print provided [by author] reproduced same size)

as the other compact chromatin masses considered to be the autosomes. Twenty-three chromosomal masses have been counted in some of the rounded type of heads.

The vacuole depicted in the fixed material of the past in bright light and electron microscopic studies can be explained as representing a section taken through the head just beside the most central chromosomal mass (Fig. 1).

Contrary to previous teaching, the ratio of the two types of heads varies from man to man; in most specimens thus far studied, the rounded type predominates. This problem is being studied regarding sex of offspring possibly already produced, frequency of emission and age of individual. Any difference in migratory rates of the two types is also being investigated.

The final enlargement of the illustration referred to by Lord Rothschild and published in my communication of May 21, being enlarged nearly 10,000 times, and its reduction by the printer, do not permit one to figure the original size of the head in microns from the final printing. The length of human spermatozoon heads is often cited to vary from 5 to 8μ; in fact, in some men studied, the larger, normal, elongate types possessed heads 15μ in length.

With a phase-contrast microscope at hand, a semen specimen and glass slides, one can prepare and observe the findings reported in smears directly within just a few minutes. At least 25 different competent observers have been shown preparations; each individual has agreed regarding the two populations.

It has also been found that the two populations can be seen in dried smears viewed in bright light microscopy, with proper adjustment of light intensity. Moreover, the differences in nuclear morphology have been noted in very thin smears of seminal fluid with living spermatozoa immobilized by means of an atmosphere of carbon dioxide (Fig. 1). Furthermore, thin, wet smears observed before, during and after drying under the phase contrast objective of the Zeiss microscope show the two, distinct types of heads. Again, in these the Feulgen test is confirmatory.

There is an exact pattern of arrangement of the Feulgen-positive, concentrically arranged chromosomal material around the most central chromosome in the smaller rounded type of head, and an ovoid pattern in the more elongate type (Fig. 2). Two, most dependable, cytogeneticists have already repeated and confirmed the findings reported regarding the two, distinct populations.

LANDRUM B. SHETTLES

Department of Obstetrics and Gynecology,
College of Physicians and Surgeons,
Columbia University, and the
Sloane Hospital for Women,
New York City.

READING Dr. Shettles's first communication[1] leaves one with a variety of disturbing thoughts. Should one be able to hurdle the compounded artefacts of air-dried shrinkage and phase-contrast optical aberration, there still remain the matters of interpretation and communication. Agreeing, but only for the moment, with Dr. Shettles that his Fig. 1 shows "no intermediate types", wherein lies his evidence for specifying the "most central chromosome" either in theory or in Fig. 3? Furthermore, in the light of considerable recent disagreement concerning even the extent and outline of the sperm nucleus, based on cytochemical and electron-micrographic preparations, the description of the ultrastructural pattern of nuclear

arrangement
hope that so
evidence mig
fully that "c
Y chromoson
ally recogniz
reproduction
It is surpri
ance not to
others in this
jun., who ha
lems—with c

Departm
Carnegie Inst
Wolfe an
E

ndeed. Finally, one would
technique and confirming
before assuming too hope-
osomes" and the "*X* and
is method, be unequivoc-
Fig. 3 lost some detail in

of this potential import-
rences to recent work of
arly that of C. van Duijn,
nvestigated related prob-
ts.

DAVID W. BISHOP

logy,
hington,
eets,

[1] *Nature*, 186, 648

A North

anthoid Crab New to
aln

INVESTIGA
docks in Sw
xanthoid cra
(Smith). Sp
given by Rat
compared w
(Natural Hist
of *N. t. sayi* w
from Florida
and the prese
British Isles.
between the e
and it is no
has been a
previously su
Rathbun anc
have reachec
America in th
has probably
manner. In
especially fro
algae[3]. The
specimens h
Ciona intesti
on wooden p
dock is mudd
piles and tim
their larvæ t
tubes and bal
transported t
In Swansea
the shore crab
crab *Brachyn*
another immi
Mediterranea
water species
to the warm
could extend
the docks. T
the range of
the Gulf of St
be able to tol
in British wa
further sprea
worthwhile tc
Carapace (F
above, with

una of artificially warmed
evealed the presence of
s *Neopanope texana sayi*
well with descriptions
ran[3], and they have been
in the British Museum
vious known distribution
st coast of North America
he Gulf of St. Lawrence[1,2]
ars to be the first for the
pping lines which operate
rth America and Swansea,
us means that the crab
ansported. Wolff[5] has
e crabs *Callinectes sapidus*
peus harrisi Gould may
of Europe from North
s of ships, and *Neopanope*
to Britain in the same
s *N. t. sayi* is reported
ces and on piles among
milar in Swansea where
lected regularly among
other fouling organisms[4]
n where the floor of the
ence of the crabs on dock
o doubt enable them or
ay into ships' condenser
which they could then be
y.
nope occurs together with
nas (L.) and the grapsoid
s (Risso). The latter is
new to Britain from the
Brachynotus is a warm-
es is probably restricted
possible that *Neopanope*
uitable localities outside
the northward extent of
North America (as far as
e species would no doubt
al range of temperatures
of the possibility of the
ies in Britain, it seems
scriptive notes here.
agonal, markedly convex
d and slightly bilobed.

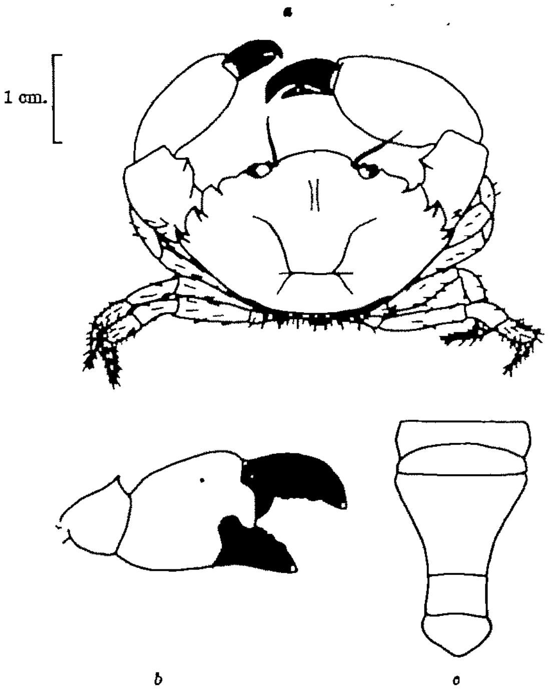


Fig 1. *Neopanope texana sayi* (Smith) ♂: (*a*) dorsal view of whole animal, (*b*) outer view of right chela (enlarged), (*c*) abdomen from below (enlarged)

Inner orbital angle notched. Antero-lateral borders of carapace with five teeth, including outer orbital angle: second rounded and fused with first; third, fourth and fifth sharp and well defined, third and fourth recurved forwards and fifth pointing laterally. Surface smooth except for fine granulations (not pitted). *Chelæ* (Fig. 1*a* and *b*) slightly unequal in size, inflated and smooth. *Walking legs* (Fig. 1*a*) all subequal in length; distal parts, particularly propus and dactylus, fairly densely fringed with fine setæ. Legs and bases of chelæ scattered with longer, plumose setæ which often appear club-shaped owing to the adherence of detritus. *Abdomen* of male (Fig. 1*c*) with segments 3, 4 and 5 fused; narrowest between fused segments and segment 6; segment 7 triangular. Abdomen of female broadly rounded and very densely fringed with setæ. *Colour* of dorsal surfaces reddish-brown. Ventral surfaces yellow. Fingers of chelæ dark brown. Males with the deeply pigmented area of the fixed finger having its border extended postero-dorsally in a lobe on each side (Fig. 1*b*); pigmented area less extensive in the female and posterior border not lobed. Extreme tips of chelæ lighter in colour. *Size*: the breadth × length measurements (mm.) of the carapace of ten specimens were as follows: males, 30 × 21, 30 × 21, 29 × 21, 29 × 20, 26 × 19, 26 × 18·5, 24 × 17, 23 × 16, 17 × 13; female, 21 × 16.

Neopanope texana sayi differs in several respects from *N. t. texana*, a closely related form, which has, in particular, light-coloured fingers on the chelæ and has sharper and more extensively produced lateral teeth on the carapace[1]. *N. t. texana* is a more subtropical form which is found in the Florida Keys and in the Gulf of Mexico[1]. In Britain the immigrant *Neopanope* shows superficial similarities with native species of *Xantho* but it may be distinguished from the latter genus on several points[7]. In *Neopanope* the carapace is more convex than in *Xantho*, while the surfaces of the carapace and chelæ are smooth and not pitted. They are pitted in the British forms *Xantho incisus* Leach and *X. pilipes* Milne Edwards. In *Xantho*, moreover, the second lateral tooth on the carapace is relatively more distinct than in *Neopanope* and teeth 3 and 4 are not recurved forwards.

I am grateful to Dr. Isabella Gordon and Mr. R. Ingle for their help at the British Museum (Natural History). Mr. W. A. C. Morris kindly provided information about shipping which operates between North America and Swansea.

E. NAYLOR

Department of Zoology,
University College of Swansea.

---

[1] Rathbun, M. J., Smithsonian Inst. U.S. Nat. Mus., Bull. 152 (Washington, 1930).

[2] Ryan, E. P., *Amer. Midl. Nat.*, 56, 138 (1956).

[3] Wolff, T., *Nature*, 174, 188 (1954).

[4] Naylor, E., Proc. Fifteenth Int. Congr. Zool., 259 (1959).

[5] Naylor, E., *Nature*, 180, 616 (1957).

[6] Naylor, E., *Ann. Mag. Nat. Hist.*, 12, 621 (1957).

[7] Drach, P., and Forest, J., *Arch. Zool. Exp. Gén.*, 90, 1 (1953).

Earthworm Population Studies: a Comparison of Sampling Methods

SVENDSEN[1] showed that the estimate of an earthworm population obtained by hand sorting soil samples was much greater than that by the prevalent method of bringing worms to the soil surface with potassium permanganate solution, and so emphasized that, although laborious, hand sorting was more accurate for population studies. The accuracy of estimates by hand sorting has not been studied but is likely to depend on soil type and conditions, as well as on the time and care taken to examine the sample. One way to estimate accuracy is to see how many worms can be recovered when samples, already hand sorted, are examined again by a different method.

While investigating the role of earthworms when marginal land is reclaimed, their abundance had to be estimated in experimental plots on a hill farm in Lancashire where the soil is relatively shallow, has a poor, unstable structure, and is covered by a surface mat of vegetation. This mat and the underlying soil were usually wet and often waterlogged, and preliminary work showed that the earthworms were confined to the top few inches of the soil profile. Soil samples were taken for hand sorting, and, to estimate the proportion of the population counted in this way, 9 of the sorted samples, 3 from each of 3 experienced workers, were examined again in the following way.

The vegetation was separated from the mineral fraction by gently washing and shaking the sample in a 2-mm. sieve suspended within a 0·5-mm. sieve standing in a bowl of water. Worms were then collected from the vegetation by teasing it in another bowl of water containing a few c.c. of formalin to make the worms wriggle and so be more obvious. After the mineral fraction was washed through the 2-mm. sieve into the 0·5-mm. sieve, so freeing any worms from soil crumbs, this sieve was shaken in the water for a time to allow silt to pass through it. It was then immersed in magnesium sulphate solution, of density 1·2, when the worms floated and were collected.

Table 1 shows that hand sorting recovered 52 per cent of all the worms found in the samples. This corresponded to 84 per cent of the weight, which shows that hand sorting mainly misses the smaller worms. How this selective loss can affect population estimates is well shown by the results for a small species such as *Eiseniella tetraedra*. Hand sorting recovered only 38 per cent of the total number and 57 per cent of the total weight of this species found in the samples and suggested that it comprised 49 per cent of the total number and 18 per cent of the total weight of all species. When the worms recovered by washing are included, *E. tetraedra* comprised 68 per cent of the total number and 26 per cent of the total weight of the population. Clearly hand sorting was unsatisfactory for this habitat, and the washing method, though no more laborious, was preferable.

Table 1. RECOVERY OF EARTHWORMS FROM NINE SOIL SAMPLES BY HAND SORTING AND WASHING

		Worms found by hand sorting	Additional worms found by washing	Total found	Percentage found by hand sorting
All species	Number	256	236	492	52
	Weight (gm.)	13·47	2·55	16·02	84
Eiseniella tetraedra	Number	125	208	333	38
	Weight (gm.)	2·38	1·81	4·19	57

In similar tests with soil samples from grassland with no surface mat on a light, well-drained soil at Wisbech, and from a heavier, well-drained soil at Rothamsted, 89 per cent of the total number and 95 per cent of the total weight found was recovered by hand sorting, which was also much quicker than washing. In contrast, hand sorting samples from an old arable field with heavy soil and poor structure recovered only 59 per cent of the total number and 90 per cent of the total weight found and was no quicker than washing.

The washing method not only provides a check on the efficiency of hand sorting, but, for some habitats, also provides a much more accurate estimate of the earthworm population. The washing method has the further advantage that it can be adapted to extract earthworm egg capsules and so estimate all stages of the population.

F. RAW

Entomology Department,
Rothamsted Experimental Station,
Harpenden, Herts.
Jan. 27.

---

[1] Svendsen, J. A., *Nature*, 175, 864 (1955).

Modification of the Neurocranium in *Zygaena malleus* and the Nature of the Optic Stalk in Selachii

GENERALLY in Selachii, between the nasal and auditory capsules, on each side, are the orbits in which the eyes are lodged. The orbit is overhung by the supraorbital cartilage which extends anteriorly and posteriorly to the orbit as the pre- and post-orbital processes respectively. The optic capsule, which is represented by the sclerotic cartilage, does not fuse with the brain-case, as the nasal and auditory capsules do; but it is held away from the orbital wall by the cartilaginous optic stalk, which is proximally fused with the orbital wall.

In *Zygaena malleus* only the most anterior and most posterior parts of the supraorbital cartilage are represented, forming the pre- and post-orbital processes. The orbit (Fig. 1, *Or.*) has retained a secondary

position owin
extension of t
(*Pr.Or.Prs.*) is
the brain-case
cated plate, t
anteriorly an
posterior lobe
process (*Pt.O*
twisted, and e
anterior bord
distally fused
process. The
the anterior l
posterior lobe
the postorbit
generally foun
the orbital wa
abnormal, lat
post-orbital p
considered to
tion to which

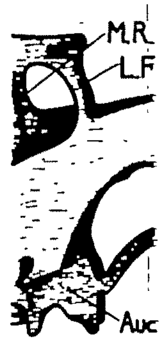
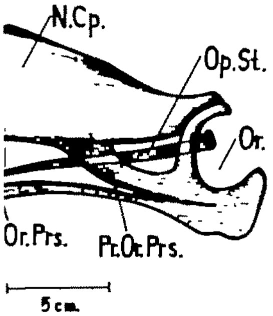


Fig. 1. *Zygaena*
auditory capsul
median rostral
stalk; *Or.*, orb

The optic s
laginous rod e
nearly half-wa
made of softer
provided with
against which
literature conc
Selachii, two
considers the
the lateral sur
believes that
and then beco
wall[2,3]. In *Zy*
stalk appears
from the eye in
case shows th
appears indep
towards the o
fused. Such
close to the or
of support. I
lying far away
fails to fuse w
of the optic s
somewhat firm
is considered
rather than t
Toubi and Ha
stalk is alway
seems that wh

ormal development and
The preorbital process
ge arising far away from
laterally to form a bifur-
be of which is extended
tero-ventrally, and the
rally. The postorbital
what flattened, doubly
ended laterally from the
tory capsule to become
ior lobe of the preorbital
n the space lying between
eorbital process and its
d with the distal end of
Thus the original orbit,
neurocrania adhering to
aterally according to the
of both the pre- and
n position of the orbit is
and due to the modifica-
nium is subjected.



of the neurocranium. *Aud.Op.*,
l rostral cartilage; *M.R.C.*,
nasal capsule; *Op.St.*, optic
reorbital process; *Pt.Or.Prs.*,
process

s a long, tapering, carti-
rds from the orbit, until
the orbital wall. It is
n the neurocranium, and
ped terminal expansion
ball. On reviewing the
ture of the optic stalk in
s were found; the first
a lateral extension from
ital wall[1], and the second
x appears independently
y fused with the orbital
it is seen that the optic
y and extends inwards
of the orbital wall. This
n optic stalk, in general,
extends from the eye
h which it is secondarily
occurs as the orbit lies
l it seems to be a means
illeus, where the orbit is
ital wall, the optic stalk
aur[4] states that the base
ii is always composed of
the rest of the stalk, and
ng to the neurocranium
talk. Hamdy[3] and El-
l that the selachian optic
homogeneous tissue. It
ed by Gegenbaur in this

respect is nothing but the place of the secondary fusion of the base of the optic stalk with the orbital wall.

A. R. HAMDY

I. Zoological Institute,
University of Vienna.

[1] Harrison, B. M., *J. Morph.*, 52 (1931).

[2] El-Toubi, M. R., *J. Morph.*, 84 (1949).

[3] Hamdy, A. R., *Proc. Egypt. Acad. Sci.*, 13 (1957–58).

[4] Gegenbaur, C., "Das Kopfskelet der Selachier" (Leipzig, 1872).

[5] El-Toubi, M. R., and Hamdy, A. R., *Pub. Mar. Biol. Station, Ghardaqa*, 10 (1959).

Plant Hormone Activity: Stilbœstrol applied to the Wheat Seedling

THE presence in plants of substances having œstrogenic activity has been known for some time, œstrone, œstriol and œstrogenic *iso*-flavones having been isolated from a number of plants[1]. Many plant hormones are also known to exhibit hypo-glycæmic activity in animals. On the other hand, this may be the result of inhibition of insulinase and not a hormonal effect, although the auxin and insulinase-inhibiting activities of a number of indole-acids, chloro-phenoxyacetic and chloro-benzoic acids run parallel[2]. There is also evidence to show that the sex of flowers of the normally diœcious *Melandrium dioicum* can be partially influenced by mammalian œstrogenic and androgenic hormones[3].

This communication reports, as a further example of the complementary reaction of plants to substances with hormonal activity in animals, the 'hormonal' activity of synthetic œstrogens on the roots of the wheat seedling.

Fig. 1 shows the tropic response of the roots of wheat grains germinated on the surface of an agar water gel containing 50 p.p.m. of stilbœstrol. This response followed when the roots approached the surface at an angle; those which touched it in a near vertical position grew into the gel, though at a rate only about a twentieth that of roots growing into pure agar gel. A vigorous and certain response was also only obtained when the gel was freshly prepared, probably because this concentration of stilbœstrol is about three times its true solubility at room temperature and its strength gradually falls as crystallization takes place.

An alternative method of demonstrating the effect was to germinate the grain in water until the roots

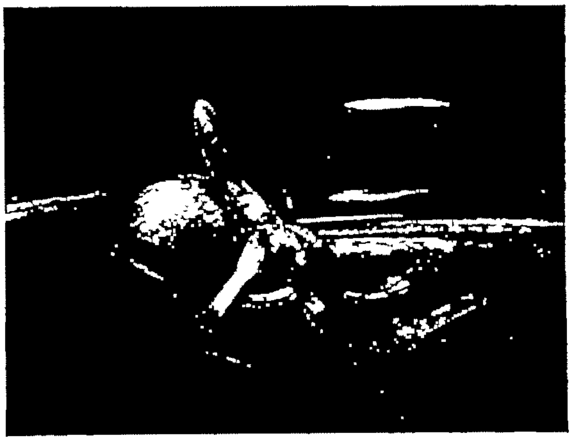


Fig. 1. Curvature of roots of germinating wheat induced by stilbœstrol

were a few millimetres long, when it was transferred to a block of pure agar gel placed in a Petri dish. By placing the grain so that 1–2 mm. only of the root tip overhung the edge of the agar and keeping the dish covered, the roots were kept sufficiently moist to maintain growth. Stilbœstrol was applied as a minute crystal to one side of the tip. Curvature of the root was first noticeable after approximately 2 hr., the curvature indicating increased growth on the side to which stilbœstrol had been applied. Curvature also occurred in other tests, following the application of stilbœstrol, when the root was in a vertical position. When stilbœstrol was applied mixed with lanolin or 'Vaseline', in the manner used successfully in the testing of auxin activity, no response was obtained. The appearance suggested that the greasy base failed to adhere to the moist root surface.

Using this method of direct application to the root, an attempt was made to distinguish the sensitive region. Curvature occurred in the region of extension growth a little way behind the tip, but application of stilbœstrol at this point was not effective. The sensitive region was found to be approximately the root-cap, and application outside this area had no effect.

The coleoptile appeared to be insensitive to stilbœstrol when this was applied in agar as in Went's coleoptile test[4], or as a minute crystal applied to one side of its surface, either unbroken or abraded or at the surface of a cut made completely through the tissue. The application was made at various regions near the tip and at different stages in the growth of the coleoptile. Tests were made on grains held in the dark and in the light, but no curvature was obtained in any of these experiments.

Activity of Allied Substances. E. C. Dodds and his co-workers found œstrogenic activity in other compounds possessing the basic di-phenyl structure of stilbœstrol[5]. Five of these compounds and three natural steroids have been tested.

Diphenylethane and stilbene had no activity. 4-4 Dihydroxydiphenyl induced a slight curvature, but 2-2 dihydroxydiphenyl was inactive. No activity was shown by œstrone, œstradiol, œstradiol benzoate and testosterone.

Phenol in agar in a range of concentration from 0·1 to 400 p.p.m. produced no curvature, but at 400 p.p.m. it inhibited growth. When applied direct to the root, the two dihydroxydiphenyls damaged the tissues at the point of application and the meristem afterwards died. Dilution by thorough mixing with five to ten parts of an inert substance was necessary to prevent harmful effects. In these experiments wheaten flour was used as the diluent.

When hexœstrol was applied direct to the root, curvature followed as with stilbœstrol. Less-certain and sometimes feeble results were obtained, however, from a solution in agar. This was probably the result of its lower solubility in water as compared with stilbœstrol. Approximate figures for the solubilities were measured, using a *p*-nitroaniline reagent[6] and comparing the colour developed with a standard curve prepared with warm solution. They were 7 and 15 p.p.m. respectively.

Interpretation of the results is complicated by the different solubilities in water of the materials tested. In general, it is probable that the natural steroids, which were ineffective, are less soluble than the synthetic œstrogens, and this will affect their rate of movement into and within the root. The same consideration applies to diphenylethane and stilbene, both of which were found by Dodds to possess activity. They had no activity when applied to the root, but the more soluble 4-4 dihydroxydiphenyl, which also possesses œstrogenic activity, produced slight curvature. By evaporating solutions saturated at room temperature and weighing the residue, the solubilities of stilbene and 4-4 dihydroxydiphenyl were found to be of the order of 10 and 70 p.p.m. respectively. The damage to the root tissue following the direct application of the dihydroxydiphenyls, which was not observed with any of the other substances, may also be due in part to their greater solubility.

Stilbœstrol was completely ineffective in producing curvature in the coleoptile under the conditions tested, which include those usually employed to demonstrate and measure the auxin stimulus on cell extension. This leaves its mode of action unexplained. A stimulating effect of stilbœstrol, œstrone and œstradiol on cell division in mouse ear epidermis held in tissue culture has been reported[7]. Such an effect, if it can be demonstrated in roots, would provide an explanation of our observations, but it is apparently contradicted by the considerable check in growth of those roots which actually grew into the gel containing stilbœstrol.

Our thanks are due to Sir Charles Dodds and Prof. L. J. Audus for their advice in the preparation of this communication.

J. J. C. HINTON
T. MORAN

Research Association of British Flour Millers,
Cereals Research Station, St. Albans.

[1] Bradbury, R. B., and White, D. E., "Vitamins and Hormones", 12, 207 (1954).
[2] Mirsky, I. A., Proc. Laurentian Hormone Conf., 1956 (Acad. Press, Inc., New York, 1957).
[3] Löve, A., and Löve, D., *Ark. Bot.*, A, 32, 1 (194); via Audus, L. J., "Plant Growth Substances" (Leonard Hill (Books), Ltd., 1959).
[4] Went, F. W., *Rec. Trav. Bot. Néerl.*, 25, 1 (1928).
[5] Dodds, E. C., "Vitamins and Hormones", 3, 229 (1945).
[6] Swain, T., *Biochem. J.*, 53, 200 (1953).
[7] Bullough, W. S., "Vitamins and Hormones", 13, 261 (1955).

Relative Lengths of Leaf Sheath and Blade with Reference to the Developmental Stages of the Rice Plant

DIFFERENT vegetative characters are taken into consideration for describing the individual groups and varieties of rice (*Oryza sativa* L.), but little importance has so far been attached to the behaviour of the plants with regard to the ratio of the length of leaf sheath to that of leaf blade. With the view of studying the sequences of the ratios in all the successive mature leaves and their relationship with certain important developmental stages, the present investigation was undertaken with three rice varieties, namely, *F.R.*13*A* (aman). *Satika* (aus) and *C.B.*1 (boro).

Seeds of the three varieties were directly sown in pots on June 10, 1959. The lengths of leaf sheath and blade were measured periodically, and this recording was continued up to the harvesting time. The individual length of the leaf sheaths and leaf blades as indicated in the graphs (Figs. 1 and 2) represented an average of about 21 measurements.

The number of leaves on the main culm was recorded to be 18, 11 and 14 in *F.R.*13*A*, *Satika* and *C.B.*1 respectively; their hard culm bases were

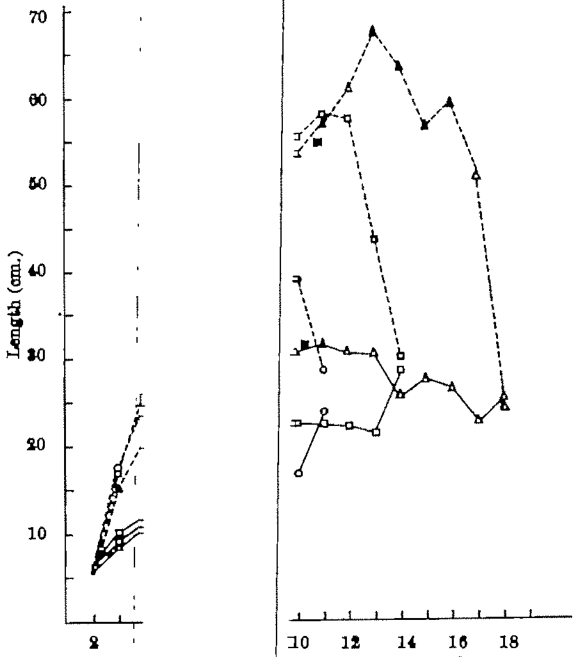


Fig. 1. Rela… th of the successive mature leaf sheath (——) … ----) in cm. of the second to ear leav… Satika (○) and C.B.1 (□)

found to cor…
Extension …
spective las…
Rao[1] menti…
until the fo…
does not …
ing the de…
starts only …
But in the …
dium occurs …
have alread…
Satika and C…

10, 7 and 8 crowded nodes.
started later after the re-
culm base. Ramiah and
g the tillering phase and
imordium ear, a rice plant
ngated internodes, except-
; vigorous shoot growth
ncement of ear formation.
he initiation of ear primor-
n 5, 1 and 3 long internodes
d in respectively *F.R.*13*A*,

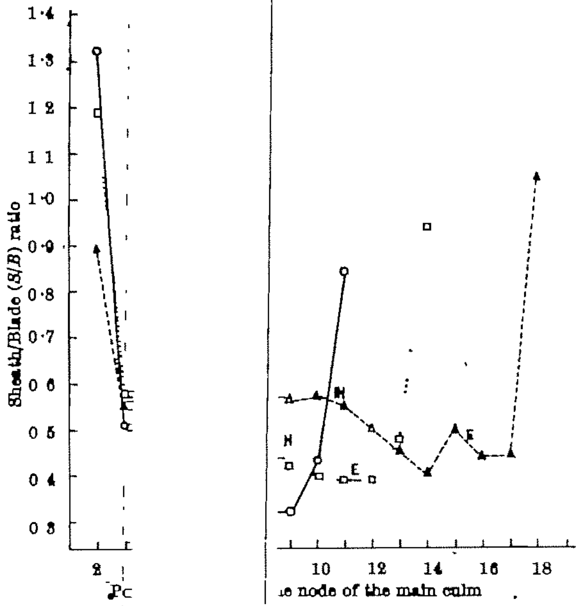


Fig. 2. She… ath/blade ratios in the successive mature leave… Satika (○) and C.B 1 (□). E and *IN* indicate… of ear initiation and that of inter-elongation

The sheaths in almost all the three varieties continued to increase in length until the beginning of internode elongation. The length of leaf blades, however, showed a gradual rise from the second to the eighth in *Satika* and to the eleventh in *C.B.*1. In both of them with the formation of long internodes the length of the leaf blade recorded an abrupt jump and continued to rise until a fall was noted in the last three leaves (Fig. 1).

The sheath/blade ratio of the second leaf was usually more than unity in *Satika* and *C.B.*1 and slightly less in *F.R.*13*A*. In most of the later-formed leaves, the ratios were, however, far less than unity. In *Satika* and *C.B.*1 the sheath/blade ratios increased distinctly from the fourth leaf onwards up to the leaf developing before the formation of long internodes, but with the initiation of internode elongation they showed a definite and gradual fall up to the eighth and eleventh leaf respectively, that is, the fourth leaf from the terminal ear leaf (Fig. 2).

The ratios in the tenth leaf of *Satika* and thirteenth leaf of *C.B.*1 (that is, the second from the terminal one) showed a sharp rise from those of the leaves developing in the culm elongation phase, when the ear primordium was noted to have already developed fairly distinctly. In the ear leaf of *Satika* and *C.B.*1, the ratio was slightly less than unity, which was more in *F.R.*13*A*. The variation in leaf size developing during the ear formation may result from the great consumption of energy and a drop in carbon/nitrogen ratio as indicated by Nagai[2]. Although ear formation becomes apparent from the ear leaf having a blade relatively shorter and broader, this indication could also be noted even much earlier from the size variation of the leaf developing just before the ear leaf.

The culm elongation phase has been noted to be accompanied by a definite fall in sheath/blade ratios, when the main culm forms more than half the total number of leaves in *F.R.*13*A*, *Satika* and *C.B.*1. Ear formation is evident much earlier from the higher sheath/blade ratio of the leaf, second from the terminal leaf.

I am grateful to Dr. B. C. Kundu, director of this Institute, for the facilities to carry out the work and also to the National Institute of Sciences of India for the award of a Senior Research Fellowship.

B. SAHA

Jute Agricultural Research Institute,
Barrackpore, 24, Parganas,
West Bengal, India.
March 14.

[1] Ramiah, K., and Rao, M. B. V. N., "Rice Breeding and Genetics" (The Indian Council of Agricultural Research, 1953).

[2] Nagai, I., "Japonica Rice: Its Breeding and Culture" (Yokendo, Tokyo, 1959).

SOIL SCIENCE

Ammonia released on Treating Soils with *N* Sodium Hydroxide as a Possible Means of predicting the Nitrogen-supplying Power of Soils

THE only reliable method at present available for estimating the potential nitrogen-supplying power to crops of the organic nitrogenous fraction of soils is the incubation procedure. In this, soils are incubated under optimum conditions of moisture and temperature for periods of two weeks or longer and the quantity of nitrogen mineralized taken as a measure of their nitrogen-supplying power. Many workers have shown good correlations between the amount of nitrogen mineralized during incubation and crop production. These results have been well summarized by Harmsen and van Schreven[1]. The main drawbacks of the incubation method are the length of time required and the relative tediousness involved in extracting and determining mineralized nitrogen. A quicker method which also requires less manipulation is obviously desirable, particularly where large numbers of samples are being tested, such as in advisory work.

In some studies being carried out with the view of determining whether any single fraction of the soil organic nitrogen contributed to the nitrogen mineralized during incubation, it was noted for a number of soils that the amount of ammonia released on treating them with *N* sodium hydroxide was positively correlated with the amount of nitrogen mineralized during incubation of the soils. In order to see if this relationship held for a large variety of cultivated soils the two methods were tested on 48 garden and allotment soils ranging in texture from sands to clays, with total nitrogen of 0·01–0·35 per cent, and *p*H of 4·7–8·2, and including 13 soils containing free chalk. The soils were sampled during November and December after digging and subjected to the two procedures within two weeks of being air-dried. After rubbing the soils through a 2-mm. sieve, the incubation test was carried out as previously described[2] (3 weeks incubation at 28° C. with moisture content adjusted to 33 per cent of the maximum water-holding capacity of the soils) and mineral nitrogen was extracted with *N* sodium chloride and determined by the Bremner–Shaw modification[3] of the Conway microdiffusion method. The air-dried soils were also analysed for extractable mineral nitrogen in the same way, the differences between the two results giving the amounts of nitrogen mineralized during incubation. The 'Perspex' cells used in the Bremner–Shaw method were also found to be very satisfactory for determining the release of ammonia on treating the soils with alkali. After preliminary studies on the effect of varying the soil : alkali ratio, degree of agitation and time, the following procedure was adopted: 2 gm. air-dried 2-mm.-sieved soils and 5 ml. *N* sodium hydroxide were placed in the outer ring of the cell without mixing, and 2 ml. 2 per cent boric acid was placed in the central chamber. After sealing the lid with the gum acacia fixative the cell was rotated gently for about 30 sec. to mix the contents of the outer ring, allowed to stand for about 1 hr., agitated again for about 30 sec. and then placed in an incubator at 28° for 40–42 hr. The ammonia absorbed by the boric acid was determined by titration with standard acid using a methyl-red–methylene blue indicator[4].

Fig. 1 shows the relationship between results obtained by the two methods. In the diagram the soils are indicated in three groups, namely, calcareous soils, those with $pH > 6$ and those with $pH < 6$. The linear correlation coefficient is 0·845 and is very highly significant. The pattern of the relationship appears to be independent of soil *p*H and the presence of free chalk. Most of the acid soils give relatively low values, while most of the chalky soils give high values, for both determinations. The amount of ammonia released on treating the soils with *N* sodium hydroxide averaged four times that mineralized during incubation, and accounted for an average of 8 per cent of the total nitrogen present in the soils. The action of the alkali presumably results in the hydrolysis of a certain amount of the organic nitrogenous materials present, resulting in the release of ammonia from the amide linkages of proteins and possibly also from other sources[5].

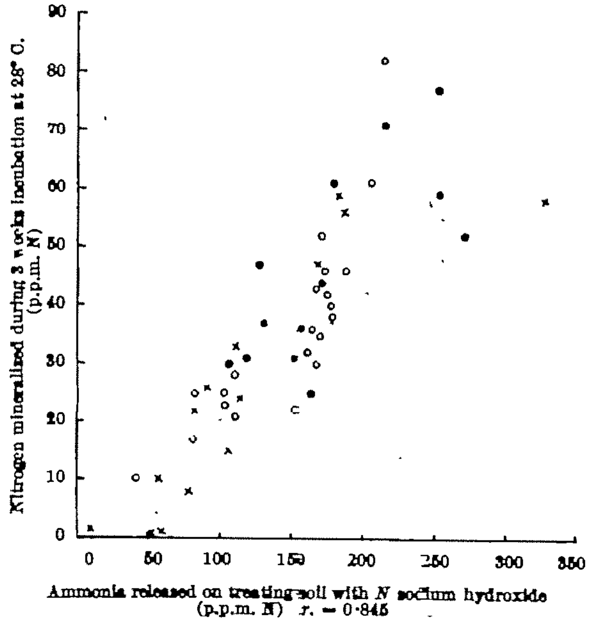


Fig. 1. Relationship between nitrogen mineralized in soils during 3 weeks incubation and ammonia released on treating soils with *N* sodium hydroxide. Linear correlation coefficient = 0·845. ●, Calcareous soils; ○, soils with $pH > 6$; ×, soils with $pH < 6$

In spite of the high correlation between the results obtained by the two methods, individual variations are fairly high. Hence only an approximate prediction of nitrogen mineralized during incubation can be obtained from a knowledge of the amount of ammonia released on treating the soil with *N* sodium hydroxide. However, the method may be useful for advisory purposes and also for screening soils before applying the more tedious incubation procedure.

A. H. Cornfield

Agricultural Chemistry Laboratory,
Imperial College of Science and Technology,
London, S.W.7.

[1] Harmsen, G. W., and van Schreven, D. A., *Adv. Agronomy*, 7, 299 (1955).

[2] Cornfield, A. H., *J. Sci. Food Agric.*, 3, 343 (1952).

[3] Bremner, J. M., and Shaw, K., *J. Agric. Sci.*, 46, 320 (1955).

[4] Yuen, S. H., and Pollard, A. G., *J. Sci. Food Agric.*, 4, 490 (1953).

[5] Bremner, J. M., *J. Agric. Sci.*, 39, 183 (1949).

Aluminium Interlayers in Clay Minerals, Montmorillonite and Vermiculite: Laboratory Synthesis

Aluminium interlayers in pure montmorillonite and vermiculite have been produced experimentally as proposed in an earlier communication[1]. These aluminium interlayers resulted in a stable 14-Å. spacing and a reduced cation exchange capacity analogous to the stable spacing[2–4] and reduced exchange capacity[4] encountered in 'chloritized'[1] soil clays.

The interlayers were experimentally introduced under conditions resembling those where interlayers are naturally found: abundant aluminium ions and

a pH at abo
was brough
1·0 N sodi
continuousl
and vermic
fugations a
and the sa
and set as
shaken.

The trea
and afterwa
300° C. for
diffraction
treated mo
ium interla
of the trea
when heat
contrast to
and vermic
potassium
of alumini
vermiculite
chloritized
stability of

Alumini
repeatedly

um chloride (0·1 N) solution
a slow dropwise addition of
. The solution was stirred
usly. The montmorillonite
were washed by five centri-
in the aluminium solution,
n suspended in the solution
n days, being occasionally

re saturated with potassium
100° C. for 2 hr. and then at
moothed tracings of X-ray
the oriented specimens of
nd vermiculite with alumin-
n Fig. 1. The 14-Å. spacing
lid not close to 10 Å. even
potassium saturation. In
the original montmorillonite
o 10 Å. on saturation with
the laboratory introduction
into montmorillonite and
lays that resembled the
their 14-Å. spacing and the

were also produced by
clays with 1·0 N aluminium

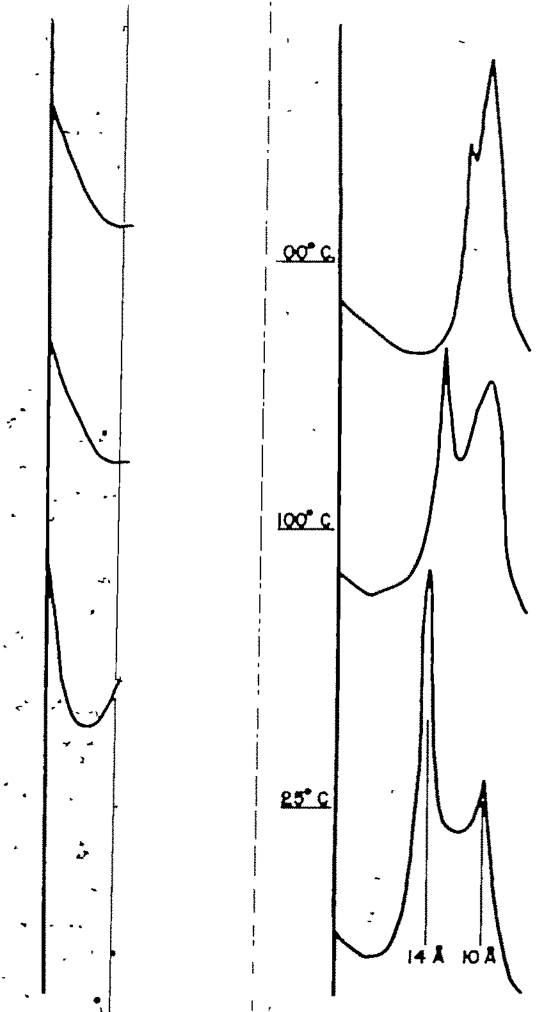


Fig. 1. Sr
fraction fro
(right

X-ray diffraction patterns of clay
nite (left) and Colorado vermiculite
tion of aluminium interlayers

Table 1. Cation Exchange Capacities of Montmorillonites an
Vermiculites, before and after Introduction of Aluminiu
Interlayers

Sample	Fraction size	Cation exchange capacity millieqniv. per 100 gm. Before	After
Montana vermiculite	$<2\mu$	107·7	59·7
Colorado vermiculite	$<2\mu$	132·9	63·1
Putnam clay	$<0·2\mu$	76·8	59·8
Wyoming bentonite	$<2\mu$	91·7	63·9

chloride solution, and then raising the pH of the suspension to 5 and setting the suspension aside for fifteen days.

The introduction of aluminium interlayers in both montmorillonite and vermiculite caused a striking decrease in the cation exchange capacity of these minerals as determined by the method of Sawhney *et al.*[5]. Introduction of the interlayers decreased the exchange capacity 45 and 53 per cent in the vermiculite and 23 and 30 per cent in the montmorillonite (Table 1). The laboratory introduction of aluminium interlayers into montmorillonite and vermiculite thus produced clays that resembled the chloritized soil clays[4] in their reduced exchange capacity.

When chloritized soil clays were extracted with citrate[2] for the removal of aluminium interlayers, their exchange capacity increased and their 14-Å. spacing collapsed to 10 Å. on saturation with potassium[4]. Also, when the samples with aluminium interlayer produced in the laboratory were extracted with citrate, the 14-Å. spacing collapsed to 10 Å. on potassium saturation, and the exchange capacity increased to that of the original minerals.

The laboratory formation of aluminium interlayers in expanding layer silicates, and the similar behaviour of the laboratory products and the natural soil clays lend further support to the hypothesis that 'chloritization' of soil montmorillonite and vermiculite gives rise to the stable 14-Å. spacing, which has characteristics tending towards those of chlorite. The different degrees of chloritization in soil clays is shown by the varying stability of the 14-Å. spacing, and also by the varying increase in exchange capacity elicited by the removal of aluminium interlayers[4]. The aluminium interlayers are probably comprised of the polymers[6] of $Al(OH)_2^+$ ions, which are most abundant at pH 5.

Aluminium interlayer formation or 'chloritization' in expanding layer silicates in soils is analogous to diagenesis of chlorite in sediments[7]. The cationic environment of sediments produces brucitic interlayers as contrasted to the gibbsitic interlayers observed in soil clays. The chloritization process in both sediments and soils produces a 14-Å. spacing, more stable than that of vermiculite but less stable than that of hydrothermal chlorite.

B. L. Sawhney

Department of Soils and Climatology,
The Connecticut Agricultural Experiment Station,
New Haven, Connecticut.

[1] Sawhney, B. L., *Nature*, 182, 1595 (1958).

[2] Rich, C. I., and Obenshain, S. S., *Soil Sci. Soc. Amer. Proc.*, 19, 334 (1955).

[3] Tamura, T., *J. Soil Sci.*, 9, 141 (1958).

[4] Sawhney, B. L., *Soil Sci. Soc. Amer. Proc.* (in the press).

[5] Sawhney, B. L., Jackson, M. L., and Corey, R. B., *Soil Sci.*, 87, 243 (1959).

[6] Ruff, J. K., and Tyree, S. Y., *J. Amer. Chem. Soc.*, 80, 1523 (1958).

[7] Johns, W. D., Grim, R. E., and Bradley, W. F., *J. Sed. Pet.*, 24, 242 (1954).

FORTHCOMING EVENTS

Monday, July 18—Friday, July 22

THE NATIONAL FOUNDATION (U.S.A.) (at Church House, Westminster, London, S.W.1), at 9.30 a.m. daily—First International Conference on "Congenital Malformations".

Tuesday, July 19

PLASTICS INSTITUTE (at the British Plastics Federation, 47/48 Piccadilly, London, W.1), at 2.15 p.m.—Annual General Meeting.

Wednesday, July 20

ROYAL SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 10.15 a.m.—Prof. C. D. Darlington, F.R.S.: "The Chromosomes and the Theory of Heredity". 2.30 p.m.—Sir Alexander Todd, F.R.S.: "New Horizons in Organic Chemistry" (Tercentenary Lectures).

ROYAL SOCIETY (at the Beveridge Hall, University of London, London, W.C.1), at 10.15 a.m.—Sir Christopher Hinton, K.B.E., F.R.S.: "The Evolution of Nuclear Power Plant Design". 2.30 p.m.—Prof. C. F. Powell, F.R.S.: "The Study of Nuclear Disintegrations produced by Particles of Energy" (Tercentenary Lectures).

ROYAL SOCIETY (at The Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2), at 10.15 a.m.—Prof. P. B. Medawar, C.B.E., F.R.S.: "The Problems of Transplantation". 2.30 p.m.—Prof. A. L. Hodgkin, F.R.S.: "The Physics and Chemistry of Nervous Conduction" (Tercentenary Lectures).

Thursday, July 21—Wednesday, July 27

INSTITUTION OF ELECTRICAL ENGINEERS, ELECTRONICS AND COMMUNICATIONS SECTION (in association with the INTERNATIONAL FEDERATION FOR MEDICAL ELECTRONICS, at Olympia, London, W.14)—Third International Conference on "Medical Electronics".

Saturday, July 23

ROYAL SOCIETY (at the Beveridge Hall, University of London, London, W.C.1), at 10.15 a.m.—Dr. Dorothy Hodgkin, F.R.S.: "Molecules in Crystals" (Tercentenary Lecture).

ROYAL SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 10.15 a.m.—Prof. A. C. B. Lovell, O.B.E., F.R.S.: "The Investigation of the Universe by Radio Astronomy" (Tercentenary Lecture).

ROYAL SOCIETY (at the Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2), at 10.15 a.m.—Prof. V. B. Wigglesworth, C.B.E., F.R.S.: "The Metamorphosis of Insects" (Tercentenary Lecture).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (man or woman) IN CHEMISTRY—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey (July 20).

LABORATORY HISTOLOGICAL TECHNICIAN, to train and work in electron microscopy—The Secretary, Institute of Neurology, National Hospital, Queen Square, London, W.C.1 (July 20).

SENIOR LECTURER IN PHYSICAL CHEMISTRY; and a LECTURER IN ELECTRICAL ENGINEERING (ELECTRONICS)—The Registrar, Lanchester College of Technology, Priory Street, Coventry (July 20).

FEMALE RESEARCH ASSISTANT (preferably with experience of survey work, interviewing and typing), for social work in a programme of human genetical research—The Secretary, Department of Biology as Applied to Medicine, Middlesex Hospital Medical School, London, W.1 (July 22).

LECTURER IN ORGANIC CHEMISTRY at the University of New England, Armidale, N.S.W., Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 22).

LECTURER IN PHYSICS—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (July 22).

GRADUATE IN BIOLOGY (male or female, with experience of routine laboratory techniques, in particular biological assay), to work in Central London on testing spermicidal products and to undertake research into methods of fertility control—Mrs. R. Peers, International Planned Parenthood Federation Medical Committee, 19 Clarendon Road, London, W.11 (July 23).

LECTURER IN PHYSICS, and a LECTURER (graduate in pharmacy or physiology, with experience or specialization in pharmacology) IN PHARMACOLOGY—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "D" (July 23).

RESEARCH STUDENTS (2) (graduates in chemistry, biochemistry or physiology) IN THE CANCER RESEARCH DEPARTMENT, for work on the biochemical and immunological aspects of carcinogenesis—The Registrar, The University, Nottingham (July 23).

ASSISTANT LECTURER IN PSYCHOLOGY—The Registrar, The University, Hull (July 25).

RESEARCH ASSISTANT (with a physics degree and a good knowledge of electronics) IN THE GEOPHYSICS SECTION OF THE GEOLOGY DEPARTMENT—The Professor of Geophysics, Imperial College of Science and Technology, London, S.W.7 (July 25).

SENIOR LECTURER or LECTURER (male, British, with a first- or second-class honours degree in physical metallurgy or equivalent, and preferably some teaching experience) IN THE CHEMISTRY AND METALLURGY DEPARTMENT, R.N. College, Greenwich, London, S.E.10—The Director (P/3), Naval Education Service, Admiralty, London, S.W.1 (July 25).

TEMPORARY ASSISTANT LECTURER IN PHILOSOPHY or an ASSISTANT LECTURER IN PHILOSOPHY—The Registrar, University College of North Staffordshire, Keele, Staffs (July 29).

ASSISTANT LECTURER IN THE DEPARTMENT OF METALLURGY—The Registrar, The University, Manchester 13 (July 30).

JUNIOR LECTURER IN BIOCHEMISTRY—The Secretary, Medical College of St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (July 30).

LECTURER (medical or dental graduate) IN DENTAL BACTERIOLOGY—The Secretary, The University, Edinburgh (July 30).

LECTURER or ASSISTANT LECTURER IN MATHEMATICS—The Secretary, Royal College of Science and Technology, Glasgow (July 30).

LECTURER (preferably with experience in teaching biochemistry to medical and science students) IN BIOCHEMISTRY—The Secretary, Medical College of St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (July 30).

LECTURER IN BACTERIOLOGY at the Western Infirmary—The Secretary of University Court, The University, Glasgow (August 1).

PEDOLOGIST AND SOIL SURVEYOR (honours graduate in science or agricultural science with some years research experience, preferably in soils investigations) at the Regional Centre, Commonwealth Scientific and Industrial Research Organization, Brisbane, Queensland, to carry out soil surveys and pedological investigations in a variety of regions to assist in the numerous aspects of land development and irrigation, to facilitate soil fertility studies and to establish fundamental pedological principles of use in the development and application of soil sciences—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 270/237 (August 6).

SENIOR BACTERIOLOGIST, SENIOR CONSULTANT (with a degree in human or veterinary medicine or microbiology with Ph.D. or equivalent) IN THE NATIONAL BIOLOGICAL STANDARDS LABORATORIES, Canberra, for the supervision and recruitment of staff to assay the potency, purity and safety of human and veterinary bacterial and therapeutic agents—The Director-General of Health, Department of Health, Canberra, Australia (August 6).

ANALYST (with a degree in chemistry or biochemistry, or considerable experience in analytical chemistry) IN THE DEPARTMENT OF CHEMICAL PATHOLOGY—The Registrar, The University, Leeds 2 (August 8).

LECTURER IN PSYCHOLOGICAL MEDICINE—The Secretary of University Court, The University, Glasgow (August 13).

ASSISTANT LECTURER (with a veterinary or medical qualification or a degree in zoology) IN HISTOLOGY AND EMBRYOLOGY—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1 (August 15).

LECTURER IN GEOGRAPHY at Rhodes University, Port Elizabeth, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, August 15).

LECTURER (with a good honours degree in physics or equivalent and preferably teaching experience) IN THEORETICAL PHYSICS at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 15).

LECTURERS IN PHYSICAL AND IN ORGANIC CHEMISTRY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 15).

ANALYST, Assistant Experiment Officer grade, for experiments on sugar beet, at first near Lincoln and later near Bury St. Edmunds—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (August 20).

ASSISTANT EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER (graduate in a biological science or agriculture, for experiments on sugar beet, first at Dunholme Field Station, near Lincoln, and later near Bury St. Edmunds—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (August 20).

CHAIR OF THEORETICAL PHYSICS in the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 31).

LECTURER IN ARCHAEOLOGY—The Secretary of University Court, The University, Glasgow (August 31).

PRINCIPAL (with high academic qualifications and appropriate educational and administrative experience) OF THE NORTHERN POLYTECHNIC—R. H. Currell, F.C.A., Clerk, Northern Polytechnic, London, N.7 (October 15).

ASSISTANT BIOCHEMIST, Basic grade (with an appropriate science degree or Associateship or Graduate Membership of the Royal Institute of Chemistry) IN THE DEPARTMENT OF PATHOLOGY—The Superintendent, Northampton General Hospital.

ASSISTANT LECTURER (Grade B) IN ORGANIC CHEMISTRY—The Registrar, Hatfield Technical College, Hatfield, Herts.

ASSISTANT LECTURER, Grade B (with an honours degree in physics and research or industrial experience in some branch of applied physics) IN THE DEPARTMENT OF PHYSICS—The Registrar, College of Science and Technology, Ashley Down, Bristol 7.

BIOCHEMIST (Senior or Basic grade) to the Rochdale Group of Hospitals, to work under the Consultant Pathologist and to carry out biochemical work for the hospitals and clinics of the group—The Group Secretary, Rochdale and District Hospital Management Committee, Birch Hill Hospital, Rochdale, Lancs.

BIOLOGIST, to carry out research on certain aspects of *Tilapia* fish culture in East Africa—work to be based at the East African Fishery Research Organization at Jinja in Uganda and the Inland Fishery Research Station at Sagana in Kenya—The Director, Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1.

BIOMETRICIAN, Scientific Officer or Senior Scientific Officer (graduate in mathematics with an interest in biology) IN THE SECTION OF STATISTICS—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 60/10.

ELECTRON MICR
Peacock, Royal
Glasgow, C.3.
HONOURS GRAD
research on biolog
of Colloid Science
LECTURER (with
industrial experie
—The Principal,
Acton, London, W
NUCLEAR PHYS
H.N.C. or equiv
reactor or nuclear
devices), to assist
investigating neut
(1726/34), United
Research Establis
PHYSICIST (resea
icists and mathe
in applied mechan
processes for meta
Steel Research A
MW/19.
RESEARCH FELL
gate the serologica
Medical School, L
RESEARCH TECH
background of ch
experience) IN TH
the research in the
Turner Dental Sc
15.
SENIOR LECTUR
teaching of bioche
low and high vo
H.N.C., B.Sc. and
courses as well as
to the Governors,
of Art, Forest Ro
SENIOR SCIENT
degree in enginee
graduate experie
for scientific adm
tical and Scienti
quoting B.282/0A
TECHNICIAN (W
IN THE DEPARTME
(University of Lo
TREE PHYSIOLO
National Resourc
tree physiology
Columbia—Civil
Canada.

REPORTS

(not i

Philosophical Tr
Biological Science
and Faunal Study
Hallam. Pp. 1–4
High Altitude C
Flight to the Moo
planetary Society
Normalair, Ltd.,
Bulletin of the
No. 4: The Ordo
W. T. Dean. Pp.
Contributions tow
By William A. Go
(Natural History
Scottish Field
Geography of the
By Dr. Joy Tivy
tion, c/o Departm
Metropolitan W
the Bacteriologic
London Waters fo
116+4 plates. (L
The Applicatio
Pp. 24. (Publicat
Ltd., 1960.)
Decimal Coinag
(A joint report o
for the Advancem
bers of Commerce
Publications, 196
Scottish Marin
Reprints Nos. 30
Biological Associ
Forestry Comm
Commissioners fo
plates. (London
A Revised Geo
from *Trans. Edin*
Oliver and Boyd
The Earthquak
courtesy of *Nucle*
General Electric

m cancer research—Dr. P. R.
Hospital, 132–138 Hill Street,

to undertake physico-chemical
s—Dr. P. Johnson, Department
Cambridge.
nd preferably some training or
biochemistry) IN BIOCHEMISTRY
Technology, Woodlands Avenue,

ist (with G.C.E. at "A" level,
h the experimental aspects of
rably an aptitude for mechanical
eam in fundamental experiments
erators—The Personnel Manager
nergy Authority, Atomic Energy
Didcot, Berks.
), to join a small team of phys-
ating on fundamental problems
long-range developments of new
rsonnel Officer, British Iron and
k Lane, London, W.1, quoting

MENT OF PATHOLOGY, to investi-
ums—The Dean, Guy's Hospital

(with H.N.C. or equivalent, a
es, and good general laboratory
F PROSTHETICS, to take part in
al materials—Prof. E. Matthews,
y, Bridgeford Street, Manchester

OCHEMISTRY, to take part in the
subjects, paper chromatography,
ophoresis and ion exchange to
its and to Laboratory Technician
postgraduate courses—The Clerk
x Technical College and School
London, E.17.
a first- or second-class honours
with at least three years post-
(Headquarters), London, S.W.1,
—The Ministry of Labour, Tech-
6 King Street, London, S.W.1,

fications and some experience)
—The Secretary, Bedford College
rk, London, N.W.1.
rtment of Northern Affairs and
lertake a research programme in
gy to Douglas Fir in British
n of Canada, Ottawa, Ontario,

T PUBLICATIONS

ly *Books Supplement*)

and Ireland

oyal Society of London. Series B:
(14 April, 1960): A Sedimentary
of Dorset and Glamorgan. By A.
l Society, 1960.) 17s. [254
ure Suits and their part in Manned
ill. (Lecture to the British Inter-
April, 1960.) Pp. 40. (Yeovil:
[254
atural History). Geology. Vol. 4,
unas of South Shropshire, 1. By
-19. 30s. Zoology. Vol. 6, No. 6:
of Modern Isospondylous Fishes.
. 15s. (London: British Museum
[254
n. Annual Report, 1959. The
Central Highlands in Miniature.
: Scottish Field Studies Associa-
e University, 1960.) 2s. 6d. [254
y-eighth Report on the Results of
Biological Examination of the
958. By E. Windle Taylor. Pp.
an Water Board, 1960.) 21s. [254
iculture. By Dr. W. M. McKay.
ndon: The Mond Nickel Company,
[294
System: Should Britain Change?
inted by the British Association
the Association of British Cham-
London: Butterworths Scientific
[294
lation. Collected Reprints, 1959.
sle of Cumbrae: Scottish Marine
[294
Annual Report of the Forestry
0th September 1959. Pp. 78+13
Office, 1960.) 5s. 6d. net. [294
By Arthur Holmes. (Reprinted
Part 3, pp. 183–216.) (Edinburgh:
d. [294
for Japan. Pp. 16. (Printed by
March 1960 issue.) (Erith, Kent:
Energy Division, 1960.) [294

Other Countries

A Clinical and Genetico-Statistical Study of Schizophrenia and Low-Grade Mental Deficiency in a Large Swedish Rural Population. By Bertil Hallgren and Torsten Sjogren. (*Acta Psychiatrica et Neurologica Scandinavica*, Supplementum 140, Volumen 35, 1959.) Pp. 65. (Copenhagen: Ejnar Munksgaard, 1959.) [254

Centro Brasileiro de Pesquisas Fisicas. Notas de Fisica. Vol. 5, No. 14: On the Observation of Π Mesons Emitted in the Interaction in Emulsions of K^--Mesons. By M. C. Amerighi, F. Baldassare, M. Beniston, A. Bonetti, D. H. David, M. Di Corato, C. Dilworth, D. Ferreira, E. Frota-Pessoa, W. B. Lasich, N. Raina, M. René, J. Sacton and A. E. Sichirollo. Pp. 181–189. Vol. 5, No. 15: Paper Chromatography of Inorganic Ions in Nitrate Media. 2: Separation of Se–Te–Po and RaD–RaE–Po. By M. C. Levi and J. Danon. Pp. 191–195. Vol. 5, No. 16: Alguns Resultados Recentes Sôbre Equacões Diferenciais Parciais Lineares de Coeficientes Constantes. By Leopoldo Nachbin. Pp. 197–206. Vol. 5, No. 17: On the Physical Interpretation of Complex Poles of the *S*-Matrix—I. By G. Beck and H. M. Nussenzveig. Pp. 207–253. (Rio de Janeiro: Centro Brasileiro de Pesquisas Fisicas, 1959.) [254

United States Department of Agriculture. Leaflet No. 468: The Cotton Leafworm—How to Control It. Pp. 6. (Washington, D.C.: Government Printing Office, 1960.) 5 cents. [254

Union of South Africa: Department of Commerce and Industries. Division of Fisheries Investigational Report No. 40: The South African Pilchard (*Sardinops ocellata*) and Maasbanker (*Trachurus trachurus*). A Preliminary Study of the Salps and Doliolids Off the West and South Coasts of South Africa. By R. P. Van Zyl. (Reprint from *Commerce and Industry*.) Pp. 31. (Pretoria: Government Printer, 1960.) [254

Population Reference Bureau, Inc. *Population Bulletin*, Vol. 16, No. 3 (April, 1960): A Protestant Views the Population Crisis. Pp. 45–64. (Washington, D.C.: Population Reference Bureau, Inc., 1960.) 50 cents. [254

Sandia Corporation Bibliography. Civilian Application Releases through 1959. By the Technical Information Division. (SCR-150. Special Category-Bibliography. TID 4500, 15th Ed.) Pp. 88. (Washington, D.C.: Office of Technical Services, Department of Commerce, 1960.) 2.25 dollars. [254

Comparative Biochemistry and Physiology. Vol. 1, No. 1 (January 1960). Pp. iv+100. Subscription rate (including postage): (A) For libraries, government establishments and research institutions, 20 dollars per volume; (B) for individuals who write to the publishers and certify that the journal is for their personal use, 15 dollars per annum. (New York and London: Pergamon Press, 1960.) [254

United States Department of Agriculture: Agricultural Research Service. Agriculture Handbook No. 174: Potato Blight Epidemics Throughout the World. By A. E. Cox and E. C. Large. Pp. iv+230. (Washington, D.C.: U.S. Department of Agriculture, 1960.) [254

Tanganyika. Records (Annual Report, Part II) of the Geological Survey of Tanganyika, Vol. VII, 1957. Pp. ii+106+16 plates. Shs. 17/50. Quarter Degree Sheet 70 S.W.: Mbeya. (Dar-es-Salaam: Government Printer, 1958 and 1959.) [254

Western Australia: Geological Survey. Bulletin No. 112: Miscellaneous Report for 1955. Pp. 218+31 plans (in separate atlas). (Perth: Government Printer, 1959.) [294

Osaka University: Faculty of Science. Annual Report of Scientific Works, Vol. 7. Pp. ii+255. (Osaka: Faculty of Science, Osaka University, 1959.) [294

Indian Forest Records (New Series). Vol. 2, No. 4: Fungal Diseases of Sal (*Shorea robusta Gaertn.*). V: The Heart-Rot of Sal Caused by *Trametes incerta* (Curry) Cooke. By K. Bagchee. Pp. 1+61–69+2 plates. (Delhi: Manager of Publications, 1959.) Rs. 1.50 nP.; 2s. 3d. [294

Food and Agriculture Organization of the United Nations. Indo-Pacific Fisheries Council—Proceedings, 8th Session, Colombo, Ceylon, 6–22 December 1958, Section 1. Pp. iv+189. (Bangkok: I.P.F.C. Secretariat, F.A.O. Regional Office for Asia and the Far East, 1959.) [294

The International Nickel Company of Canada, Ltd. Address to Shareholders, Annual Meeting, April 27, 1960. By John F. Thompson. Pp. 16. (Copper Cliff, Ontario: International Nickel Company of Canada, Ltd., 1960.) [294

United States Department of Health, Education and Welfare. Public Health Service Publication No. 740: Research Program in Aging, 1959—Summary of N.I.H. Pp. v+16. (Washington, D.C.: Government Printing Office, 1960.) 15 cents. [294

Fonds National de la Recherche Scientifique. Trente-deuxième Rapport Annuel, 1958–1959. Pp. 277. (Bruxelles: Fonds National de la Recherche Scientifique, 1960.) [294

Companhia de Diamantes de Angola (DIAMANG). Serviços Culturais. Dundo–Lunda–Angola. Museu do Dundo. Subsidios para o Estudo da Biologia na Lunda. Publicacoes Culturais No. 48: Estudos Diversos (XVIII). Pp. 120. (Lisboa: Companhia de Diamantes de Angola, 1959.) [294

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

THE ROYAL SOCIETY

"THE Royal Society of London for Improving Natural Knowledge", as the Society is described in its second charter of 1663, is celebrating the three hundredth anniversary of its foundation, and the presidential address by Sir Cyril Hinshelwood is printed in this issue (p. 274). Thus the Society is one of the oldest learned institutions in the world and is unique in its unbroken record of activity. During the years, its influence has varied in response to the circumstances of history, but it is worth emphasizing that even during periods of great national stress, such as the Napoleonic Wars, its Fellows were able to continue their investigations and even to correspond actively with, and to meet, scientific colleagues in other countries.

From its beginnings with private meetings in Oxford and London, the Royal Society has advanced, under a succession of distinguished presidents and officers, keeping in touch with current affairs, and steadily establishing the world-wide prestige in which it is now held. This curious combination of respect for the past and its gracious ways—the Society's present meeting room with the out-moded arrangement of the officers' seats is a case in point—with lively concern for modern topics, such as space research, is perhaps typical. The Society provides an outstanding example of adaptation or evolution in the conduct of human affairs.

It is not always realized how wide is the range of activity of the Royal Society in modern times. Thus it not only provides a forum for the discussion and publication of scientific papers, but also undertakes a number of public responsibilities. It is the 'adhering organization' for the United Kingdom with regard to the International Council of Scientific Unions and appoints delegates for meetings of the Council and of the several component Unions. This is done through national committees for the several subjects represented by the International Unions. On behalf of the Committee of the Privy Council for Scientific and Industrial Research, the Royal Society is responsible for the management of the scientific work of the National Physical Laboratory. It also takes an important part in the management of the affairs of the Royal Greenwich Observatory, and it is the custodian of one of the four copies of the Imperial standard yard and pound. The Society also appoints or nominates representatives to the governing bodies of the British Museum, the Spectator Committee, the Times Holding Company, and many scientific bodies, research institutions, schools, etc. In this way the Society is enabled to keep in touch with the changing scene, and also to give advice and counsel. A number of trust funds providing for research appointments are also administered by the Society. In addition, it is responsible for Parliamentary grants-in-aid for scientific investigations, for scientific publications and for international research associations and scientific congresses; these grants, some of which began in the 'fifties of the last century, have grown to substantial sums, and their use has proved to be of considerable importance, for example, for the publication of scientific papers, etc., not by the Royal Society alone, but through other channels. Incidentally, it may be noted that it is specifically provided that committees of the Society, except those dealing with the Society's domestic affairs and joint committees with other bodies, have power to suggest to the Council the names of additional members who may, or may not, be Fellows of the Society; and, in fact, many of the Society's committees include non-Fellows who are brought in for their special knowledge in a particular field.

The Royal Society now consists of some six hundred Fellows and foreign members. Broadly speaking, the fellowship is representative of the whole range of natural science. That this should be so is in part the result of the method of election. Candidates are proposed by Fellows on the basis of their scientific achievements. These nominations are scrutinized by the Council, which selects by ballot a limited number annually; at present the number is twenty-five. It is not always realized that in making its recommendations for election to the fellowship, the Council takes account of the general balance of subject interest among the Fellows; by this means it is ensured that all subjects are represented, and the domination of the Society by sectional interest is avoided. This form of election has been criticized, but it seems to provide the general balance of interest required. In addition, the Council has the power to nominate for election "persons, who . . . either have rendered conspicuous service to the cause of science, or are such that their election would be of signal benefit to the Society"; the numbers are, however, limited to one a year unless no election has been made in any year, in which case two nominations can be made in the following year. Foreign members are nominated from time to time on the grounds of the eminence of their scientific attainments, but not more than four can be elected annually. Ordinary fellowship of the Society is limited to British subjects and citizens of Eire. Women were tardily admitted to the Society under a curious statute which reads: "Nothing herein contained shall render women ineligible as candidates".

Human institutions which have survived for three hundred years are sufficiently rare in these days of continual and ever-increasing pressure of events to be worthy of special comment. The present high esteem in which the Royal Society is held throughout the world is due in part to the eminence of its Fellows, and in part to the wisdom with which it discharges its responsibilities to science and to the nation. It can now enter on a further century of endeavour, adding to the reputation which has been steadily built up over the years, and sustained by the good wishes of scientists throughout the world.

T ER-DEVELOPED COUNTRIES OF THE WORLD

THE Inte
which re
of Commons o
was introduc
accept the A
International
which has be
articles were
directors of t
tion and Deve
The main pr
payment of
the Associati
national Ban
period of ye
nearly £47 m
scription is t
States, which
of the total
subscriptions,
scription to

In introdu
Secretary to
explained th
to the econo
to press too
who would h
finance from
of potential
those in Part
countries, w
scriptions in
whereas the
will pay only
in gold or
remainder in
the Associati
currencies or
without the
the other han
the countries
notes not be
demand by t
of the United
in the first ye
following yea

With the
to which Mr
panying rep
International
emphasizes
finance furth
areas of the

lopment Association Bill,
nd reading in the House
Royal Assent on June 8,
the United Kingdom to
eement of the proposed
Association, the text of
as a White Paper*; the
proved by the executive
al Bank for Reconstruc-
bmission to Governments.
e new Act concern the
ingdom's subscription to
an affiliate of the Inter-
organization, and over a
cription will amount to
rtible sterling. This sub-
rt to that of the United
for 320 million dollars out
ollars, and, like the other
proportional to the sub-
al Bank.

March 29, the Economic
, Mr. A. P. L. Barber,
riptions were related first
each country, so as not
less-developed countries,
order to be eligible for
. Secondly, the schedule
divided into two parts:
rialized or more-advanced
the whole of their sub-
y convertible currencies,
countries listed in Part II
their initial subscription
tible currency, and the
currencies. This portion
free to convert into other
nce purchases of exports
country concerned. On
of the subscriptions from
y be paid in the form of
and cashable at par on
ation. About £11 million
bscription will be payable
£9 million in each of the

eement, the White Paper
rred includes an accom-
ecutive directors of the
January 26, 1960, which
ociation is intended to
nt in the less-developed
within the Association's

members; and while the Association is given wide latitude, such financing is intended to be for purposes which are of high priority for development in the light of the needs of the areas concerned and, except in special circumstances, for specific projects. Moreover, finance is not to be provided by the Association if, in its opinion, such finance is available on reasonable terms from private sources or could be provided by a loan of the type made by the International Bank. Article I, in fact, defines the purposes of the Association as to provide economic development, increase productivity and thus raise standards of living in the less-developed areas of the world included within the Association's membership, particularly by providing finance to meet their important developmental requirements on terms which are flexible and bear less heavily on the balance of payments than those of conventional loans.

The Association is thus intended to further the developmental objectives of the International Bank for Reconstruction and Development and to supplement its activities. As Mr. Barber explained in the House of Commons, the International Bank itself is not designed to help countries with sound and important development projects which they are unable to finance simply because of the weakness of their balance of payments. The new Association will be empowered to lend in such cases on special terms which may, for example, include a long period of repayment, or a period of grace before repayment commences, or even waive interest for an initial period. Apart, however, from being complementary to the work of the International Bank, Mr. Barber pointed out that linking the Association with the Bank is also a matter of confidence and will enable the Association to operate as a going concern from the start.

In commending the Bill to the House of Commons, Mr. Barber also referred to the considerably enlarged part Great Britain is now playing in providing assistance for overseas development; but our capacity to do more, he said, is inevitably limited. The commitment to contribute to the International Development Association had been foreseen for some time, and the Government has decided to give priority to this measure to supplement the existing operations of the International Bank and to increase the united funds available for development. This point of view was generally welcomed in the House of Commons, although Mr. H. A. Marquand and some other speakers questioned even so whether enough is being done for the under-developed areas.

Mr. Marquand referred particularly to the White Paper, "Assistance from the United Kingdom for Overseas Development"*, also mentioned by Mr.

---

* International
approved for sub
of the Internati
26th January,
Directors dated
H.M. Stationery

ciation. Articles of Agreement as
ments by the Executive Directors
construction and Development on
anying Report of the Executive
Pp. 16. (Cmnd. 965.) (London:
8d. net.

* H.M. Treasury. Assistance from the United Kingdom for Overseas Development. Pp. 20. (Cmnd. 974.) (London: H.M. Stationery Office, 1960.) 1s. net.

Barber which sets forth both the growth and the present magnitude of this effort. From £61 million in 1951–52, after a decrease to £49 million in 1952–53, this has increased, apart from a slight recession in 1956–57 and 1957–58, to £110 million in 1958–59 and an estimated £138 million in 1959–60. The bulk of this takes the form of grants, loans and payments for technical assistance under arrangements made directly with the recipient country, totalling £86·1 million and an estimated £117·7 million in 1958–59 and 1959–60, respectively, compared with £23·4 million and an estimated £20·7 million in contributions to international bodies working in this field.

Under the former, described as bilateral assistance, is included that given to the Colonial territories, for which altogether some £220 million was made available under the Colonial Development and Welfare Acts during the period 1946–60; of this total, about £45·5 million was unspent by March 31, 1959. Subsequent legislation has provided an additional £95 million for the period up to March 31, 1964, and of the figures already quoted for 1958–59 and 1959–60, £49·4 million and an estimated £62·7 million are for the Colonial territories, £26 million and an estimated £40·6 million for the independent Commonwealth countries and £10·7 million and an estimated £14·4 million for other countries. These figures include a considerable contribution to education, though such expenditure is not distinguished separately in the White Paper, and contributions to technical assistance totalling £4·4 million in 1958–59 and an estimated £5·2 million in 1959–60.

This technical assistance may be provided for Colonial territories through the Colonial Office, and to independent countries of the Commonwealth and to other countries under arrangements made direct, under the Colombo Plan, and through the Foundation for Mutual Assistance in Africa South of the Sahara and the Central Treaty Organization. For example, the cost of training 473 out of 2,181 officers in the public services of the Colonial territories, who in 1959 attended training courses in the United Kingdom, was met from Colonial Development and Welfare Funds, and in the past five years the Post Office has trained more than 1,000 people from overseas in postal, telephone and telegraph operations and in telecommunications engineering. The White Paper refers also to the work of the Overseas Research Council and of the various advisory bodies on Colonial Research without, however, giving any estimate of expenditure on scientific research in this way.

When private investment of about £100 million is taken into account, the White Paper estimates that about 1·25 per cent of the national income of the United Kingdom goes to benefit the less-developed countries, and since the War some £2,500 million has been devoted to those countries from United Kingdom sources in the form of private investment and Government assistance. Such assistance can only be provided if the economy of the United Kingdom continues to develop on the right lines, and the Minister of State for Commonwealth Relations, Mr. C. J. M. Alport, was at pains to stress this aspect in winding up the debate from the Government side. Incidentally, it should be noted that, as Sir Henry d'Avigdor-Goldsmid pointed out in the debate, the Association is specifically empowered to provide technical assistance and advisory services at the request of a member, and such assistance may, at the discretion of the Association, be provided with or without reimbursement.

The brief debate when the Bill received its second reading in the House of Lords on May 17 followed rather different lines. In introducing the Bill for the Government, the Earl of Dundee said that the United States and Japan have already introduced legislation to provide for the adherence of their countries to the Association, and pointed out that the Bill is only part of a general effort to assist the more-undeveloped countries of the Free World. He also suggested that it is more scientific to measure our effort as a percentage of our exports rather than of our national income; that figure is about 7 per cent and not 1·25 per cent. He also quoted the reference in the communiqué from the Conference of Commonwealth Prime Ministers to the desirability of co-operative action among members of the Commonwealth in assisting the economic development of Commonwealth countries in Africa which have recently attained or are approaching independence. Indeed, the Conference had recognized the urgent need to maintain, and where possible increase, the flow of economic assistance to the less-developed countries and had specifically welcomed the decision to establish the International Development Association.

Lord Ogmore, in welcoming the Bill, stressed particularly the importance of technical assistance, and in this connexion he said that in his experience in the past few years one of the greatest shortages in the under-developed countries had been in competent managers. They are short also of people with technical experience at the professional and the technician-level, and this could greatly affect the execution of a scheme; he was glad that the Government has already recognized the importance of technical training for apprentices. In his reply for the Government, the Earl of Dundee directed attention to the powers which Sir Henry d'Avigdor-Goldsmid had noted in the House of Commons.

The bearing of the International Development Association on technical assistance is not the only reason why the new Act merits some attention from the scientist and technologist. Finance is not the sole consideration which determines the possibility of particular schemes. Both the debates in Parliament and the White Paper on Assistance from the United Kingdom indicate how complex have now become the relations between the overseas territories and the Colonial Office and the Office of Commonwealth Relations. These relations have not been adequately debated, but with the increasing number of Commonwealth overseas territories which have attained or are on the verge of independence, strong arguments can be advanced for reviewing the relations between the Colonial Office and the Commonwealth Relations

Office, if not
be that me
Commonwea
Commonwea
solution to
not merely
pendent ter
overseas ser
the availabi
required in
The estal
Council was
but more m
is to be ful
not to be h
first place,
clear thinki
to the new
account bo
the nation
countries, t
the debate
respects le
and yet a
which are
opportunit
The othe
should be
to under-d
nical field
Coming A
Mr. A. S
March 3.
the impor
resources a
and Mr. M
attack on
Communi
calculatio
dollars wo
way of hel
theless, n
characteri
derived la
are the d
and the
merely li
economic
economy
prosperity
in the les
the inter
interests
Mr. Sh
the point
ductive
much in
standard
from its
is avoide
under-de
can adv
1970's or

Office also. It might well
Colonial Office with the
Office in a new single
ld provide a constructive
ting difficulties, including
ons with the newly inde-
o some of the problems of
, in fact, largely determine
the professional assistance
of technical assistance.
the Overseas Research
ve in the right direction ;
if the work of the Council
if technical assistance is
n-power problems. In the
is undoubtedly need for
tructure most appropriate
that structure must take
al service problems and of
f the newly independent
ion was rightly directed in
It must be one which fully
hal pride and aspirations,
o achieve administrations
rnal control, and eliminate
and corruption.
scientists and technologists
this question of assistance
tries, whether in the tech-
appears in a talk, "The
ld Poverty", broadcast by
printed in *The Listener* of
vigdor-Goldsmid recognized
w Association, provided its
in the war for men's minds ;
is clearly anxious for a world
s, including help from the
, referred to Mr. Hoffman's
15,000 and 20,000 million
over the next ten years by
developed countries. Never-
the note of urgency which
field's talk, and which is
changes in conditions which
the application of science ;
greement of the Association
-operation for constructive
development of the world
tenance of peace and world
ion of economic development
untries with the interests of
nity as a whole as well as the
ries.
, urges that we have reached
thinks that unless the pro-
under-developed countries is
g the next few years, the
ome places may even recede
w present level. Even if this
uch more difficult to bring the
ries to the stage where they
n their own initiative in the
nis apart from the risk of them
becoming Communist States in the meantime. This, Mr. Shonfield believes, would be a further obstacle, for he is convinced that the West could give these countries the fruits of modern technology more quickly than they could possibly obtain them otherwise.

Mr. Shonfield is optimistic as to the generosity of the West, but he is very realistic as to the sustained good sense that will be required and the readiness to compromise, at least in the early stages of development, with many of our cherished ideals and standards. The International Development Association is indeed a welcome step forward, but much more will be required. Apart from constructive thinking about the whole structure of government as it affects the conditions of service and operation, there must be real determination to use to the full all existing instruments such as the Colonial Development Corporation and the Overseas Research Council.

SPACE RESEARCH

Satellites and Scientific Research

By Desmond King-Hele. Pp. xii+180+6 plates. (London: Routledge and Kegan Paul, Ltd., 1960.) 21*s*. net.

THE launching by the U.S.S.R. on October 4, 1957, of the first artificial Earth satellite may be said to have opened the era of outer-space research. Subsequent developments have been rapid. The second *Sputnik* was launched by the U.S.S.R. on November 3, 1957. The first successful launching of a satellite by the United States occurred on February 1, 1958. Since then the Americans have successfully launched several more satellites. In addition, space vehicles (*Luniks*) have been launched by both the Russians and Americans, some of which will orbit the Sun and may be termed artificial asteroids. The Russians have succeeded in hitting the Moon with one of their *Luniks* and transmitting a photograph of the back face of the Moon by another.

This book is concerned solely with the artificial satellites, the equipment installed in them, the purposes for which the equipment was designed, and some of the scientific results that have been derived. The preface is dated April 1959, only 18 months after the first successful launching of a satellite, though mention is made in the text of the launching of the three American satellites, *Explorer* 6 on August 7, 1959, and *Discoverers* 5 and 6 on August 13 and August 19, 1959, respectively. Brief reference is also made to the launching of two space-vehicles, the Russian *Mechta* or *Lunik* on January 2, 1959, and the American *Pioneer* 4 on March 3, 1959.

A satellite can provide scientific information in two ways. In the first place, careful tracking of the orbit of the satellite and of the changes in the orbit with time can provide information in two directions. The equatorial bulge of the Earth causes the orbital plane to rotate slowly about the Earth's axis, in the opposite direction to the satellite's motion. From the analysis of these changes in the orbital plane, the ellipticity of the Earth's figure can be derived and also some information about any asymmetry of the Earth about its equator. The drag of the atmosphere on the satellite produces progressive changes in the shape of the orbit, the distance of the satellite at apogee decreasing more rapidly than the distance at perigee, so that there is a progressive reduction both in the orbital period and in the eccentricity of the orbit. From the changes in the shape of the orbit information about the density and temperature of the upper atmosphere at different heights can be inferred. The information that has already been derived from the study of these orbital changes, to whose analysis the author of this book has made substantial contributions, has substantially modified previously accepted ideas. This information is independent of any instrumental equipment carried in the satellite.

In the second place, each satellite is provided with instrumental equipment designed to obtain information in specific directions from coded signals telemetered to the Earth. Some striking and unexpected information has already been obtained, though more information will become available when the signals have been fully analysed.

The value, f, of the ellipticity or flattening of the Earth, that has already been derived from the satellite data is $1/f = 298 \cdot 20 \pm 0 \cdot 03$. The value previously accepted, derived from geodetic data and from the analysis of changes in the Moon's orbit, was 297·1. The change is substantial; the previously accepted value was based on many investigations, which had given reasonably accordant values. It is also tentatively inferred that the Earth is slightly asymmetrical about its equator (slightly pear-shaped), the north pole being about 50 ft. higher and the south pole about 50 ft. lower than on a spheroidal earth. This conclusion is not yet definitely established; further observations will eventually lead to a more accurate result. It is to be expected that higher terms in the gravitational potential field of the Earth will in course of time be evaluated, when data from a number of satellites with differing orbital inclinations have become available for analysis.

The analysis of the changes in the shape of the orbits has led to the definite conclusion that the density of the atmosphere decreases more slowly with height than had previously been believed, largely from the extrapolation of data provided by rockets. At heights of 120–250 miles, the atmosphere is 3–11 times more dense than was previously believed. The inferences about the temperature of the atmosphere at these and greater heights are as yet only tentative, though it appears that at great heights the temperature is considerably higher than has hitherto been supposed. There is also some evidence that the air density at heights of 100–500 miles varies with a period of about 27 days, being presumably influenced by solar activity.

The most striking discovery so far obtained from the instruments carried by satellites is the existence of two belts of hitherto unsuspected intense radiation around the Earth which are attributed to charged particles trapped by the Earth's magnetic field. Much more information will in the course of time be obtained about these belts, their nature and their changes. It is thought that the inner belt may be caused chiefly by cosmic-ray debris and be composed mainly of protons, while the much larger outer belt is fed by particles from the Sun and is composed mainly of electrons. The further study of these belts will provide information about the aurora and about the Earth's magnetic field.

Such wide interest has been aroused by the launching of satellites and space probes that this book, describing how and what information has been derived from satellites, is very timely. It is written so far as possible in non-technical language, and is well illustrated with many figures. The author has given an extensive list of books and scientific papers relevant to each chapter, which will be of use to those who wish to obtain further information on any of the subjects discussed in the book.

H. SPENCER JONES

CYBERNETICS AND MANAGEMENT

Cybernetics and Management

By Stafford Beer. (Management Science Series.) Pp. xviii+214. (London: English Universities Press, Ltd., 1959.) 25*s.* net.

IT is a sign of the importance of cybernetics that eleven years after Weiner defined the study of control mechanisms as a new discipline, inquiries about its nature and utility have become more topical and not less so. In directing his contribution on this topic to the "scientifically educated and imaginative manager", Beer recognizes that such interest extends well beyond academic halls.

Approaching a brief answer to the general question, Beer says the importance of cybernetics derives from the backwardness of the concepts of 'control' that prevail in our society. For cybernetics, control is an attribute of system function, an attribute that may be produced by diverse and sometimes quite subtle means. The diversity of their controls makes biological systems valuable models for industrial cybernetics.

In industrial application, cybernetics is not solely concerned with automation on the assembly line. Indeed, its main target is managerial: a control device, seeking optimal strategies, amplifying the intelligence of its human components, learning from experience and adapting itself to its environment. The 'device' is quite general, includes not only computers and other hardware but also methods of organization, of fact finding and of decision making that involve human agents. Present managerial methods, with all their various components, are instances of such systems. Moreover, because they show goal-seeking behaviour and attempts to maintain equilibria against varying disturbances, they belong to the general category of 'homeostat' that includes many biological systems as well.

Its jacket describes this book as a presentation of the basic principles of cybernetics without a mass of mathematics. Such a presentation it certainly contains, and delightfully clear it generally is. In places, however, a surfeit of detail and perhaps a few tracks of hobby horses tend to obscure the main trail of the description. Nine pages of preface and seven pages of connective summary, possibly designed to rectify this 'noise', will aid the selective reader to follow the main thoughts. In his role as a philosopher he will be well rewarded.

For the reader as a manager the value of this doctrine is not so clear. He will regard this as the second major move in fifteen years to construct a managerial science. The sphere of the first, operational research, was more limited than that of industrial cybernetics. It functioned within, as part of,

the control
cybernetics.
netic is th
science, bu
To him, op
probabilisti
exceedingly
not a gen
possibility t
he is being
On the
modes of t
gerial prob
industrial
convincing
fresh way
the notion
that orga
regarded a
ideas Bee
may best
"in other
Creative t
As seri
even as
this book

is under study by Beer's
recognizes that the cyber-
us attack on managerial
at there is room for both.
ch is the study of complex
reas cybernetics deals with
ems of this type (which is
l definition). There is a
sentative manager may feel
xceeding complexity.
r's clear prose offers novel
nay well clarify some mana-
ample, the concept of the
'homeostat' is certainly
o provoke new ideas. A
material is also provided by
of a machine, which implies
inorganic material may be
chanically. These and other
eed cybernetics as a whole,
ent by stimulating thought,
bout problems of control.
that this is no mean gift.
the intelligent layman and
or the cybernetics student,
mulating.

J. A. Easterbrook

BE

IENCE FICTION

Human P
By Dr.
George A

hy. Pp. x+340. (London:
n, Ltd., 1960.) 25s. net.

PHIL
the s
and wo
beyond
Speculat
upon th
generall
intellect
upon th
time of
for im
re-prese
modern
psychol
placent
'The
nature
motiva
progre
and by
mecha
constit
may
drives
pounds
elemen
of se
origin
fying
of mo
of hu
huma
deduc
fall a
trend
himse

wadays seem to have replaced
le point by semantic wrangles,
lack the courage to look
their professional competence.
n's place in the cosmos, or
changes in human nature, are
-minded mystics or second-rate
urphy's thesis brings to bear
opics the full weight of a life-
arship, coupled with a facility
constructive thinking. In
e-old questions in the light of
ngs in biology, sociology and
ds in challenging one's com-
with startling new perspectives.
pted scientific view of human
at depressive flavour. Personal
to primitive drives, and social
rigid rules of group thinking
pressure to uniformity of our
py. But these aspects may not
ruth. Certain human attributes
xplicable in terms of visceral
properties of chemical com-
in terms of their constituent
hy argues that the processes
ion and of learning, although
t to visceral needs, become satis-
ves leading to a whole new system
w motivations lead to new ways
n and whole new dimensions of
could not have been foreseen or
s the writers of science fiction
hey merely extrapolate existing
account of the changes in man
of new dimensions of interaction

with the environment. The world of the ancient Greeks or of the contemporary 'organization man' are something more than mere extensions of the habits of our simian ancestors. As he puts it rather colourfully at one point (p. 308): "If it is katydid nature to scrape, frog nature to croak, warbler nature to warble, it is human nature to play the *Air for G String*". The potentialities of human nature must lie beyond the limited historical and social expressions of it that we know at present.

In putting forward his plea for the larger view of human nature, Dr. Murphy takes fully into account the evidence of our grosser individual limitations. He dwells at length on such matters as the development of fixed habits of thinking and perceiving which blind the individual to culturally unpopular viewpoints. Although the increasing tendency to standardization of thought and feeling in modern society clearly threatens to stifle creativity, he gives reasons for hoping the creative urge may win through.

In the field of genetics, for example, he points out that the scope for evolutionary change is greater than is generally appreciated. Concentration on the effects of pathological genes has diverted attention from the inheritance of variations of temperament, and from the possibilities of readier manifestations of particular attributes in particular environments. Some stocks may be increasing in numbers and others decreasing so as to alter the predominant temperamental patterns of the group. Qualities of sensitivity and of equanimity could be gaining at the expense of toughness and aggressivity. Just as height is increasing (perhaps due to favourable environment and especially nutrition) so may be capacities of learning and intelligence.

In his more far-reaching speculations Dr. Murphy seems to imply that highly organized groups develop a life of their own beyond the individual personalities involved. Artistic and scientific achievements ultimately become impersonal or interpersonal. In the findings of telepathy research, it appears as if the individual consciousness reaches out so that the boundaries between mind and mind or between mind and the environment become blurred.

Scorning the traditional timidity of the social psychologist in the face of value systems and judgments, Dr. Murphy plunges into discussion of political systems. He sees the present day as a period of crisis in which man may destroy himself in atomic conflict before intelligent control of social development becomes possible. For the immediate future the most hopeful prospect seems to be a rapid economic development. In this the West may overtake their opponents, who will end up by capitulation or imitation, or the two camps may both progress so fast that their leaders can allow peaceful competition between the two systems for some time to come. If this respite is allowed us, then humanity will have time to choose between such possibilities as an authoritarian hierarchy or a leaderless, group-centred life on the ant-hill model. Among these long-range prospects he sees the greatest hope of a viable civilization in some system in which the governing forces are reliably guided by intelligent feed back from the middle and lower levels. Any such system would call for revolutionary development of education, and also freedom to indulge individual artistic and cultural interests beyond the immediate needs of the corporate technocracy. At present education tends to be too didactic, geared too closely to the task of imparting technical skills, instead of encouraging creative thinking and discussion among the young on out-of-school family and community problems.

Because of the range and complexity of the problems discussed this book cannot be digested quickly nor reviewed comprehensively. But it is well worth studying from cover to cover. D. J. WEST

FOSSILS FOR THE NATURALIST

Fossils

By Prof. H. H. Swinnerton. (The New Naturalist: a Survey of British Natural History.) Pp. xiv+274+25 plates. (London: William Collins, Sons and Co., Ltd., 1960.) 30*s.* net.

THE volumes of Collins's New Naturalist Series are delightfully produced books, splendidly illustrated and written by acknowledged authorities. They make ideal presents, and are a delight to possess. It is also true that most naturalists are born collectors; and these books are eminently collectable. But these facts do not alone explain the success of the series. It succeeds because these books are mostly written by naturalists for naturalists. They appeal to the faculties of wonder and delight in Nature which (rather than the spirit of curiosity and the pure desire for knowledge) are the particular characteristic of the naturalist. The present volume, the forty-second of the Series, is no exception. It is in the direct line of descent from Hugh Millar and is a naturalists' book and not just another popularization of science.

Prof. H. Swinnerton's approach to his subject is historical in two different senses. He is most successful in conjuring up pictures of the successive extinct faunas and floras in which the animals and plants are brought vividly before us as living things in their changing natural environments. We follow in separate short chapters the evolution of the main phyla of plants and animals, first in the Palaeozoic, then in the Mesozoic and finally in the Cainozoic. At the same time, by a series of cleverly interwoven digressions, we learn of the history of the growth of palaeontology, and our interest is cunningly sustained by stories of the lives of many of the collectors and research workers whose discoveries he describes. It is all very well done, and the book is eminently readable.

All this being said, it is the more unfortunate that an unqualified welcome cannot be given to this book which at first sight seems so well to fill an obvious gap in the New Naturalist Series. It is not that the vividness of the reconstructions of the geological past is often obtained by the presentation of detail the conjectural nature of which is not made sufficiently apparent. Nor, since the book is not intended for palaeontologists, does it matter much that a number of names used are out of date, as are also some of the ideas (for example, the derivation of *Caninia*, *Palaeosmilia* and *Dibunophyllum* from '*Zaphrentis*' in the Lower Carboniferous, and other ideas about the evolution of corals and graptolites). The pity is that there are a number of confusions of matters of some importance.

Thus it is regrettable that the graptolite zooid is described as possibly not unlike a hydroid polyp, while the dendroid graptolites are said to be comparable with *Cephalodiscus*. It is also unfortunate that the old classification of the East Anglian crags in the Pliocene is retained, especially as confusion is created by the remark that the deposits underlying the Cromer Forest beds have been shown to be of Pleistocene age. This particular confusion is worse confounded by the caption to plate 21, "Marine Fossils of the Quaternary", which illustrates both crag and Eocene fossils. Presumably for Quaternary, Cainozoic should be read. Other confusions are of serpulite (*Salterella*) with *Serpula*, the alleged presence of *Archaeocyathus* in Scotland and the inclusion of the reindeer in a list of extinct animals.

The illustrations are, with one or two notable exceptions, well chosen and well reproduced. However, there are several illustrations where a number of fossils are represented on very different scales without any indication of the relative or absolute size of the specimens. Finally, it is necessary to say that there are far too many misprints, and that these chiefly affect the descriptions of the plates (at least fourteen corrections required). S. SIMPSON

THE FIRST DECADE OF DDT

DDT

The Insecticide DDT and Its Significance. Edited by Paul Müller. Vol. 2: Human and Veterinary Medicine. By W. J. Hayes, Jr., S. W. Simmons and E. F. Knipling. Edited by S. W. Simmons. (Lehrbücher und Monographien aus dem Gebiete der Exakten Wissenschaften, Chemische Reihe, Band 10.) Pp. 570. (Basel und Stuttgart: Birkhäuser Verlag, 1959.) 66 Swiss francs; 66 D.M.

THIS second volume of a series on DDT contains three contributions by American authorities on insecticides and their use: "Pharmacology and Toxicology of DDT", by W. J. Hayes, jun.; "The Use of DDT Insecticides in Human Medicine", by S. W. Simmons, and "The Use of DDT in Veterinary Medicine", by E. F. Knipling. The first two of these are almost equal in length and comprise about 400 pages of the book, each concluding with a list of some 600 references; the shorter veterinary section has about 200 references.

Dr. Hayes deals first with clinical, pathological and physiological aspects of DDT toxicity as observed in animals. Human toxicity risks are then discussed from data on experimental and accidental intakes by man, on workers handling DDT, and in relation to DDT residues accumulating in water, in milk or in foodstuffs derived from treated animals or vegetable sources. This is summed in terms of administrative policies for toxic residues in general in consumable goods. DDT is safe when used as recommended. Hazards to domestic mammals, birds and insects (bees notably) and to various forms of wild life from medical and veterinary usages of DDT form concluding chapters to the section.

The contribution by Dr. Simmons (also editor of this volume) is not merely about DDT for the control of arthropods of medical importance. It is valuable and noteworthy for its emphasis, well illustrated graphically, on the effects of vector control by DDT on the incidence of the diseases concerned. Much of this part of the work is about mosquito-borne infections and mainly on malaria control, arranged geographically. Other chapters are on other biting flies, houseflies, lice, fleas, triatomid bugs and on the mites and ticks. The acarines are less susceptible to DDT than the insects. It seems scarcely justifiable, in view of general experience and what is recorded in the relevant text, that, for example, scabies and

scrub typhu
way they ar
ning of this
Cockroaches,
creatures ar

Dr. Knip
recapitulate
to stock. I
special tec
outlined an
throughout t
with the m
extensive e
controlling
flies, lice, f
veterinary c
effective t
clearly set c

What mig
title or intr
published i
beyond 1954
by then w
greatly affe
in some ins
use of alte
world well
out in the
Dr. Simmo
by concludi
tance, as it
prospects.
on resistan
ably, not
borne in m
well-docum
facts abou
usage, its s
of insectici
DDT had f
entomology
at the end
chapter co
references i
and illustra
to handle a

should be included in the
seases listed at the begin-
as controllable by DDT.
and other troublesome
a chapter on pests.
rinary applications, first
ssentials of DDT toxicity
are then compared, and
raying- and dipping are
y numerous photographs
is some overlap inevitably
t here is found the more
DT in tick control, and for
insects, blowflies, myiasis
clusively or primarily of
ations of insecticides more
certain arthropods are

een indicated clearly in the
is book is that, although
ject-matter is not covered
oblems of toxicology being
DDT, this aspect is not
e lag. But DDT-resistance
useflies, had compelled the
ides in some parts of the
This is, of course, brought
f the medical section, and
attention on the problem
ral appraisal of DDT-resis-
, with comment on possible
ork on DDT-resistance and
tact insecticides is, inevit-
is book. Provided this is
ne is undoubtedly notable,
aluable compilation of the
ent of DDT for large-scale
lures, and the early impacts
on the new outlook which
le in medical and veterinary
ndex ; this may be intended
An introductory table of
sub-titling and some cross-
the good quality of printing
o make this a pleasing book

D. S. BERTRAM

INCEN

FIREWORKS AND ARMS

A History
By Prof.
bridge : W

e and Gunpowder
on.; Pp. xvi+381. (Cam-
Sons, Ltd., 1960.) 70s. net.

IN his
history
thorough
“Origins
He has t
sources of
in the se
which ha
twenty-on
reproduce
The bo
diaries u
'Greek fir
was one o

f. Partington surveys the
and gunpowder in the same
aracterized his well-known
nt of Applied Chemistry”.
re to inspect the original
nd he quotes them at length
ated chapters of this book,
ted by good indexes and
some of which are seldom

a discussion of the incen-
warfare, culminating in the
led the Crusaders and which
he Byzantine Empire. Many

of these ancient incendiaries contained one of the numerous types of crude oil found in Mesopotamia or the regions north of that country. The author believes that the basis of the earliest Greek fire was liquid rectified petroleum or volatile petrol, which was projected in hand-grenades, or ordinary petroleum in tubs shot from *ballistae*. The mixture of petrol and resinous substances, thickened into a jelly, and the mechanical means of projecting it constituted the invention of Greek fire, an achievement of chemical engineering.

In his second chapter the author turns to the examination of "The Book of Fires of Mark the Greek", which he compares with passages from Albertus Magnus's "De Mirabilibus Mundi" and Roger Bacon's "De secretis operibus artis", from which he concludes that there seems to be no reasonable doubt that Roger Bacon was well acquainted with the preparation and properties of gunpowder, though probably ignorant of its use as a propellent. He may have derived his knowledge about its composition from the "Liber Ignium", which is probably of Arabic origin.

The next chapter is devoted to the "Legend of Black Berthold", the imaginary German monk said to have invented gunpowder and cannon. The earliest picture of a cannon is found in an English document, its earliest mention in an Italian one of 1326. He then proceeds to discuss the earliest English, French, Burgundian, German and Italian cannon and their nomenclature. A further chapter discusses miscellaneous fifteenth-century treatises on military arts and their knowledge of the use of gunpowder and firearms, mines and rockets.

Chapters 5 and 6 are devoted to a systematic discussion of gunpowder and firearms in Muslim lands and in China. Here the author dispels many erroneous statements of earlier authors by carefully examining the original texts and consulting such experts as Holmyard and Needham. His conclusions are that saltpetre was known under the Sung dynasty (A.D. 960–1279), and that around 1044 certain 'proto-gunpowder' mixtures were used in bombs but not as propellents. About 1233 we find the prototype of a gun described in Chinese literature, and true gunpowder was known towards the end of the Mongol Yuan dynasty (A.D. 1260–1368), when it was also known in Europe. Though there is a possibility that gunpowder was discovered in China, we are not certain that cannon were invented in that country; as the information about cast-iron Chinese guns, said to date back to 1356, is unsatisfactory. The Arabs seem to have introduced gunpowder from the East, first using it as an incendiary like Greek fire. Cannon and firearms seem to play a part from the fifteenth century onwards only in Ottoman warfare.

The last chapter is devoted to the history of saltpetre. Here the author could have consulted with profit M. Levey's essays on chemical technology in ancient Mesopotamia rather than the much older evidence he quotes; although his discussion of the classical and post-classical evidence of this most important ingredient of gunpowder is excellent and provides us with many useful data on the ancient manufacture of saltpetre.

Prof. Partington has again given us a handbook which not only the artillery expert and the chemist but also the historian of technology will consult with profit for many years to come.

R. J. FORBES

Birds in Colour

Illustrated by Karl Aage Tinggaard. With descriptions by Bruce Campbell. Pp. 103+256 plates. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1960.) 21*s*.

IT must be exceedingly difficult to produce yet another moderately priced book on birds that has its own merits and justifies itself as a purchase both for beginners and experts. The compiler of "Birds in Colour" has managed to do this by producing an outstandingly straightforward reference book that makes bird recognition comparatively easy for "those who go about in the towns, in the country and by the sea in the British Isles—and those who look observantly out of their kitchen windows"; at the same time producing a very beautiful book of pocket-size.

The book has two main sections. First, there are 256 coloured paintings of all the birds likely to be seen and recognized in the British Isles, arranged, roughly, in the Hartert order. Each bird takes up half a page, and similar birds, likely to be confused, are on adjoining pages. This makes it possible for four similar birds to be compared at a glance. The second part of the book is devoted to the descriptions, which bear the same number as the paintings earlier in the book, thus enabling speedy reference. This section gives such information as habitat, appearance, voice, habits; and a very helpful note on the other birds with which this one is likely to be confused. This is particularly helpful for a beginner. At the end of the book is a short section of flight sketches, followed by a list of books to read, an index of Latin names, and, lastly, an index of English names.

The book is of the standard 'Penguin' size, but has a stiff, colourful cover, and each of the 256 paintings are not only realistic but also pleasing to the eye. The simplicity of the book is its main asset, as, while giving the maximum help in bird recognition, it avoids all technical terms and irrelevant data. All essential points are lucidly written—fitting companion notes for the Danish artist's paintings, which cannot be too highly praised.

B. J. G. MAITLAND

Flat Rolled Products

Rolling and Treatment. Edited by T. E. Dancy and E. L. Robinson. (Metallurgical Society Conference, Vol. 1.) Pp. xix+128. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 30*s*.

THIS book, the first of a series on various branches of metallurgy, is a report of the proceedings of a conference arranged by the Mechanical Working Committee of the American Institute of Mining, Metallurgical and Petroleum Engineers, all the contributors being connected with steel firms in the United States or in Canada. To this extent, the title may be somewhat misleading, since non-ferrous practice is touched on only by implication.

Six papers are included of which half the book is devoted to two on the factors affecting strip profile in hot- and cold-strip mills and on the closely related influence of hot-strip profile on subsequent operations. The remaining contributions are concerned with heat-treatment practice, the continuous normalizing of flat-rolled products, the continuous annealing of deep-drawing sheet and the theory and evolution of coil-heating practice in steel mills.

To the reviewer the most interesting part of these proceedings is a two-page paper dealing with the annealing of strip in liquid sodium. Considerable laboratory work has been done during the past few years with results sufficiently encouraging to justify pilot-scale operation. The main advantages envisaged include increased rapidity of heating and cooling, a reduction in the space required and lower maintenance costs due to simplification of the plant.

F. C. THOMPSON

The Nuclear Handbook

Consulting Editor: Prof. O. R. Frisch. Pp. xv+640. (London: George Newnes Ltd., 1958.) 50*s*. net.

THIS book is described in the foreword as having been designed as a day-to-day reference for use by scientists and technicians working in nuclear science and related fields. There are nineteen sections of varying length written, generally, by specialists. The topics include, among others, the nuclear properties of isotopes and natural radioelements, and of fission product and transuranic elements; the theory of nuclear reactors and the properties of fuels and other materials used in them; and related technologies such as particle accelerators, vacuum techniques, and electronics

The technical level and the style of the contributions vary a good deal. The first section, for example, contains an elementary description of the structure of the atom whereas the mathematical discussion of nuclear reactions in section 19 makes few concessions to the unsophisticated. This last section consists of a collection of equations and formulæ, with tables and graphs, connected by the minimum of narrative; the section on natural radioactivity is prefaced by two pages of history beginning with Becquerel.

The "Handbook" was published shortly before the second Geneva Conference on atomic energy, so that some of the data were outdated within a short time of publication. Nevertheless the book is a compact source for a wide range of information and should be useful, provided that reference is made to the periodical literature to check data in fields known to be changing rapidly.

K. E. B. JAY

Guide to Reference Material

Edited by Dr. A. J. Walford, with the assistance of L. M. Payne. Pp. viii+543. (London: Library Association, 1959.) 80*s*.; 12 dollars. (Members of the Library Association, 60*s*.; 9 dollars.)

THIS volume provides an annotated list, classified on the 1957 abridgement of the Universal Decimal Classification, of leading reference books and bibliographies, with emphasis on current publications and particularly material published in Britain. Maps, anthologies and most source books have been omitted, as well as the vast majority of periodicals, but in certain scientific and technical subjects, textbooks have been included, for want of more comprehensive works. It is intended for librarians, in the building up and revision of reference library stock; for use in general and special library work; and for students taking the Library Association examinations. Its 3,000 selected entries are the result of the work of some 70 contributors, and an admirably produced volume is well designed to serve as a point of departure for a much-needed series of detailed annotated guides on specific subjects, as is the hope of the editor, Dr. A. J. Walford.

R. BRIGHTMAN

THE ROYAL SOCIETY*

By Sir CYRIL HINSHELWOOD, P.R.S.

IN the ye
On the e
are as noth
they consti
in Newton'
the matrix
measured I
of years tl
for a few t
round the
has been I
quest of k
has so lar
foundation
conscious
ment the
infinite w
human ev
existence.
can arous
of our ow
scope, an
enough t
lived in
human h
King hin
not yet g
For all
and recr
who orig
sense th
removed
portraits
to read,
them sc
and pay
infused
What
memora
At tl
when tl
propour
present
Sir Ro
Goddar
Wren,
In h
and M
any ra
surmo
ments
served
at Oxf
Unive
he ma
incluc
Evely
tions
of the
Ro
Chym

oyal Society was founded.
o evolution three centuries
he measure of human life
sive span of history. Time
lowed uniformly on, but as
gnificant to men it is not
For thousands of millions
lactic cycle has continued,
ization has been spreading
r a few hundred only there
st rapidly accelerating con-
power over Nature which
the world of to-day. The
Society was symbolic of the
this endeavour. In achieve-
years have exceeded all the
ionary time: by the scale of
the fullest and longest in all
es, in whom the dramatist
recreating the events even
s, they have, in virtue of their
randeur. Yet they are short
another way. The men who
ign are still familiar to us as
n picture in imagination the
choes of his witty sallies have

ge that continuously dissolves
of human activity the men
yal Society and who are in a
e present age are no further
our nearer ancestors. Their
us, their words remain for us
know them and have towards
filial piety. We honour them
o them, and our admiration is
ss and warmth.
en were they whom we com-

eting on November 28, 1660,
foundation of the Society was
cord states that there were
ncker, Mr. Boyle, Mr. Bruce,
r Paul Neile, Dr. Wilkins, Dr.
, Mr. Ball, Mr. Rooke, Mr.
.
a attributes to Brouncker, Boyle
, if not for the first initiative, at
erance of the project and for the
nitial difficulties and disappoint-
an Irish peer, had at one time
s. He had studied mathematics
ater a doctor of medicine of that
said to be a good linguist and
matical discoveries of importance,
ntinued fractions. He and John
l, often discussed scientific ques-
. He became the first president
y.
famous author of "The Sceptical
in many tongues, devoted the leisure of a great gentleman to a life of study and was renowned not only for his learning but also for his piety, his religious and moral writings being probably as numerous as his scientific works.

A very different figure was Sir Robert Moray, who combined the qualities of a scholar with those of a man of action. He had served as a soldier under Louis XIII and had been with King Charles in France. After the Restoration he held public offices, enjoyed the confidence of the King and was described by Huygens as the soul of the Royal Society, to which at various times he made communications on geology, natural history and comets. He has been spoken of as a chemist and a mathematician and, according to Pepys, was interested in music.

A man who in the opinion of some deserves to be thought of as the real originator of the Society was John Wilkins, warden of Wadham College, Oxford, and later Bishop of Chester, wise, tolerant, conciliatory, continuing his work both under Protector and King. He was the central figure around whom gathered the group of learned men which later turned itself into the Society. He had a forward-looking mind, and not only wrote a work on the Moon as a habitable world but composed also a discourse on the possibility of a passage there by 'volitation'.

There are philosophers of history who would maintain that the Royal Society had to come into being when it did, irrespective of individuals, because the climate and temper of the age demanded it. They may be right. It must needs be, perhaps, that such things come, but all honour, nevertheless, to the men by whom the necessity is fulfilled. If the individual does not determine the event he profoundly influences the manner of it.

These men, in whom the elements were thus diversely mixed, initiated the humane tradition of the Society, the union of thought and action, the partnership between men of the study and men of the world, which has been maintained throughout its existence, is preserved, we would like to hope, to-day, and will decide its future.

In illustration of a preconceived thesis, the reception of the new Society could be represented in diametrically contrasted manners. Names like Christopher Wren, John Evelyn, Samuel Pepys and John Dryden bear witness to the width of its appeal. Could we indeed quote anything like so varied a list at the present time? The sympathy of the literary world was not lacking. Addison styled Robert Boyle "an honour to his country", persons of consequence consigned their sons to the care of Warden Wilkins, and the patronage accorded to the Royal Society by established authority was neither purely formal nor mere lip service. Prince Rupert made communications on his own account. The Earl of Sandwich, sent to escort Catharine of Braganza from Portugal, allowed himself to be set the task of making observations for the Royal Society on the tides and on the saltness of the sea. The King himself was on terms of friendly intimacy with many of the members, often visiting with Sir Robert Moray the laboratory established in Whitehall.

---

* A
Londo

the Formal Opening in the Albert Hall,
ary Celebrations on July 19.

If the illumination is suitably adjusted, however, a less-mellow picture emerges. The Warden of Wadham might be a leader of the new movement: Dr. Fell, the formidable dean of Christ Church, would have none of it. The Public Orator of the University of Oxford declaimed against the Royal Society in the Theatre built by Wren, and Antony Wood declared it to be an obnoxious body. Bishop Wilkins, Bishop Ward and Bishop Sprat might defend the new philosophy with every strength of argument and eloquence, Robert Boyle might write the "Christian Virtuoso", every protestation and example of piety and orthodoxy might be offered by the Fellows, none of this prevented attacks from the pulpit, and the strangest accusations from other quarters.

The complaints openly made by the objectors were of atheism, impiety and subversion, or if not the practice or countenancing of these things then at least the creation of a philosophy which would lead the weaker brethren into evil thoughts or be used by the wicked as a cloak and excuse for their depravities. Besides operating on the side of the godless and corrupting the innocent, the Royal Society was at the same time supposed (though scarcely, it may be presumed, by Catholics) to lend itself to popish schemes. It elevated sensual ideals, and it encouraged great expense of spirit in the pursuit of vain truths. It might challenge the authority of the universities and invade the province of the physicians.

Much of this was still reverberating yesterday and even lasts to-day, and in this respect the three centuries assume perhaps their shortest perspective. In our own time scientific studies have received extravagant praise and intemperate criticism. One great novelist of this century saw the millenium about to be realized through science. Lesser literary figures of the moment have laid every defect or misfortune, from intellectual arrogance to social obscurity, at its door.

Every complaint and reproach levelled in the seventeenth century, every fear expressed, every resentment, interested or disinterested, openly or secretly working, can be paralleled in the recent past. Every anxiety, misgiving, criticism or reserve voiced to-day has been countered by the seventeenth-century apologists. Nor can the threat of destruction by the release of nuclear energy really have aggravated the issue, for the perils of atomic warfare are at least no more terrible than the prospects of eternal damnation to which many in the earlier age believed the new doctrines were leading men.

If criticism could have restrained or gibes deterred, if any combination of polemic and persuasion could have mollified or silenced, the issue would have been settled once for all. But these strange contests of seemingly incompatible philosophies have periodically renewed themselves, rising to great climaxes like the controversy over evolution in the nineteenth century and the quarrels about the use of nuclear energy in the twentieth century. The origin lies more in emotion than in reason: genuine fear of the unknown, reverence for established things, but most of all in the strangely partisan instincts of men, the manifestation of their combative and yet gregarious nature. What happened after the foundation of the Royal Society was largely a reflexion of a permanent or at least a strongly persistent pattern.

But the most significant circumstance is that the attitude of the world at large probably did not seriously determine the course of science. In the seventeenth century the contest was largely a battle of the books. The opponents of the Royal Society did little effectively to hinder it. For indeed, after the first flush of enthusiasm, did the majority of its non-scientific or fashionable supporters do very much actively to help it. The record of sermons, pamphlets and other forms of the written word is the raw material of a one-sided story. The literary basis of so much history can easily falsify the perspective. Writers express their views and other writers, by the natural working of affinity, often attach undue importance to the evidence that these afford. A few dramatists can characterize a whole period as licentious, even resolutions of undergraduate debating societies if they catch the fancy of the journalists may help to fix a label on an age. But the future germinates unknown and silently.

From the time of the foundation of the Royal Society onwards there was a steady increase in the number of dedicated men who, by the concentration of their minds, the skill of their hands and the sweat of their brow, worked to uncover the secrets of Nature. Their labours were largely unknown to their contemporaries; they are but perfunctorily recorded by historians, and yet they have ended by transforming the face of the globe and the life of humanity. The literary battles of the detractors, the satirists and the apologists had little effect. The men of science lived up to the motto proposed for the Royal Society by Evelyn *Nullius in Verba*, accepted the authority of none, and were on the whole unmoved by praise or blame.

The nature of things is such that two of the early criticisms of science have refuted one another. It was, some said, too much concerned with material ends: it indulged, according to others, idle curiosity to the good of nobody. The answer to-day is clear. The technology which has transformed practical existence is largely an application of what was discovered by these allegedly irresponsible philosophers. On the other hand, their shortsighted and earthy preoccupations have entrained an upheaval of the whole of human thought. By what strange workings of destiny does this come about? The propounding of ambitious practical aims seldom leads to their fulfilment. "Find me a way" an ancient despot might have said, "to send invisible messages round the world, and I will ennoble and enrich you". The reward would never have been won. "Find out", he might less plausibly have said, "about the strange force in this little piece of amber". This apparent frivolity contained the secret of his first requirement, but remote and unforeseeable.

The full fruition of scientific work depends upon three things: the desire to know, the initiative to find out and the awareness to apply. Highly special conditions have to be fulfilled before the plant will bloom, before the flower will fruit and before the fruit will ripen.

Let us have no illusions about one thing. To-day we commemorate the doings of a minority and of a small minority. The King himself was a rare figure among the rulers in history. The glamour shed on the Royal Society by his patronage ensured the respect of the eminent but not their subscriptions, and in the year 1700 the corporate income did not exceed about £100.

But if the men of science did not continue to receive much material support they were not for that reason without significance to their time. Who is representative of an age? The acclaim of the day seldom anticipates the verdict of posterity, since the germinal things are almost always hidden or unrecog-

nized. Most
and waning
wars and the
been deemec
The advent
seldom been
cler, nor has
Yet they h
of life but t
above all of
of men wh
among the

What th
three centu
of history,
the change
What does
face with g
ledge any
What ther

After N
gravitatio
an orderec
Galileo ar
grew in g
Laplace
wedded t
modern
the mas
length t
Twentiet
of Einst
fundame
energy ;
been or
adventu
nuclear
the gre

The
of elect
into th
provid
tronic
of whi
faith c
were
pursue
he ha
televi

The
the a
The s
when
at la
comp
comp
deve
inter
been
desc
quar
that
moc
sta
a M
an
ma
tel
fur
m

istory records the waxing
novements, the course of
ic ambitions. These have
naterial for polite studies.
ovements of science have
ne attention of the chroni-
ually been rated as humane.
ransformed the conditions
oduct of human genius, and
tion, sacrifice and devotion
that account be deemed
sentatives of their day.
pen of science done in these
ve they changed the course
ions raise further ones. Is
further or come to a halt ?
? It has brought us face to
s. Can the pursuit of know-
n the concern of the few ?

ynthesis, the law of universal
ion of the stellar universe as
nade probable by Copernicus,
d no longer be in doubt, and
he continuous elaboration of
sors. Newtonian mechanics,
ness of practical men, created
d thereby made man largely
vironment, bringing him at
ld of extra-terrestrial space.
s, largely under the influence
more abstract character to the
f space and time, matter and
ange paradox of Nature it has
t recondite and immaterial of
led directly to the release of
nfronted mankind with one of
problems it has ever faced.
pparently unrelated curiosities
netism were unified at long last
electromagnetic doctrine. They
electrical engineering and elec-
ntricate to trace in detail, but
surely was guided by the simple
t these two great natural forces
patient genius with which he
n was in its way prophetic, but
ention of electric railways, of
mation.
ntly disreputable operations of
y into the science of chemistry.
fruitful after two thousand years,
ad replaced speculation, revealed
ecret of Nature's elements and
uided the creation by man of
never knew. The stages in the
omplicated, the interrelations and
of ideas and discoveries have
ond the possibility of any brief
ributions might come from any
l probably be agreed, for example,
any through whom the wonderful
industry traces its descent there
gentleman, a French State official,
oolmaster, a German professor and
dustrial research chemist. Truly
th where it listeth, and no man can
eth and whither it goeth.
lants and animals, the structure and
parts, have slowly unveiled their
iology has joined with chemistry to create the modern art of medicine. All the sciences have now converged on the study of life, from the simple cell to that most wonderful of instruments—the human brain.

In the last hundred years the pattern of daily life has been transformed. Things which in the reign of Charles II would have seemed like the dreams of visionaries or indeed the impostures of charlatans are now part of the common scene. Flight, speech and vision across the world, cures as by miracle from deadly illnesses, machines to which men delegate heavy toil, dextrous manipulation or mental exertion far beyond their own unaided powers, colours surpassing the rainbow in variety, all these things and more have come into being. The keys to unlock atomic energy have placed in man's hands undreamed of powers which he may use for good or evil. The keys which unlock some of the secrets of human personality are slowly being cut, and men may soon be using them to do we know not what.

Is this not history ?

In the realm of ideas the story has been even stranger and more turbulent. The conception of the universe as a mechanism suggested a materialistic view of all existence, though not to Newton himself, and possibly less often to men of science than to onlookers unconscious of the real intention of scientific hypotheses. The time-scales revealed by geology and biology appalled those who confused the literal truth of "Genesis" with the basis of religion and morality. And when the theory of evolution completed the outrage of man's expulsion from the centre of the universe by denying his special creation, resistance rose to its height. The opposition subsided only to be renewed at intervals against scientific doctrines, all of which have been of unquestioned utility in their own spheres, about the unconscious mind, about the chemical basis of genetics, the functioning of the brain and nervous system, or about the influence of hormones on personality.

Yet the men of science themselves, so far as can be judged, have numbered about the same proportion of religious believers as the generality of people. Nor have they been conspicuously less well endowed with kindness or morality. Indeed, an assurance that ultimate values of goodness and beauty can never be shaken by the pursuit of truth, wherever it may lead, is perhaps the sign of a robuster faith than is shown by recoil from every new and seemingly disturbing fact.

Meanwhile, in the natural course of discovery and interpretation, and uninfluenced either way by real or supposed philosophical or theological implications, scientific ideas evolved in a direction where they largely lost again their mechanical and materialistic semblance, and acquired a curiously abstract character. Indeed, some physical principles (though not, I think, adequately understood), have even been used in the present century in support of idealistic philosophies or to provide a doubtful support for the otherwise respectable doctrine of free will.

The quantum theory added a new element, that of discontinuity to the Newtonian conception of the world. Electrical particles, the building blocks of matter, filling the universe with electromagnetic waves by their motions had offered for a time a synthesis of grand simplicity, powerful enough to create the whole technology of radio communications, and a major part of the electrical industry, yet itself destined for a revolutionary metamorphosis. Nature gradually disclosed that the invisible substratum of

A selection of the outstanding new titles from Pergamon Press

ANTARCTIC METEOROLOGY

This is a report of the proceedings of the symposium arranged by the Australian Bureau of Meteorology, under the auspices of the Australian Academy of Science and with the endorsement of the Special Committee for the I.G.Y. and the Special Committee for Antarctic Research. The papers include studies of large scale circulations and other phenomena over the Antarctic which were imperfectly known before the International Geophysical Year. **£5 5s. net ($17.50)**

International Series of Monographs on Earth Sciences
Volume 5

CLAYS AND CLAY MINERALS

Proceedings of the Seventh National Conference on Clays and Clay Minerals, Berkeley, California

Edited by **ADA SWINEFORD**

The latest of these volumes, published annually, covers a wide variety of topics. The papers stress regional clay mineralogy, the effect of saline water on clay minerals, genesis and identification of soil clays, and viscosity of clay suspensions. **60s. net ($8.50)**

Proceedings of the 8th Conference in preparation

Volume 7

PRINCIPLES OF METEORITICS

by **E. L. KRINOV**

This book contains a broad exposition of problems dealt with in meteoritics, covering the study of the material composition, structure, morphological and physical properties of meteorites, together with the study of the conditions under which meteoric bodies move through the Earth's atmosphere and in interplanetary space. **70s. net ($12.00)**

ANALYTICAL CHEMISTRY OF THE RARE EARTHS

by **R. C. VICKERY**

The first volume to be devoted specifically to the analytical problems encountered in dealing with the rare earths, it covers all phases of the problems from decomposition of the analytical sample to ultimate element determination. Particularly adaptable for graduate and undergraduate students of analytical chemistry as well as the specialist analyst. **In preparation**

A GUIDE TO MATHEMATICAL TABLES

by **A. V. LEBEDEV and R. M. FEDOROVA**

Working mathematicians and technical librarians have long felt the need for a thorough guide to the mathematical tables available in the world literature. The translation of the present compilation prepared for the Computing Centre of the U.S.S.R. Academy of Sciences, fills this need. **£5 5s. net ($15.00)**

A Guide to Mathematical Tables

SUPPLEMENT NO. 1.

by **N. M. BURUNOVA**

Since the translation of *A Guide to Mathematical Tables* by Lebedev and Fedorova was prepared for press, the U.S.S.R. Academy of Sciences has issued a supplement which brings the Guide up-to-date with respect to tables published throughout the world up to the end of 1958. An English translation of this supplement is also available from Pergamon Press. **50s. net ($9.00)**

International Series of Monographs on Pure and Applied Mathematics
Volume 14

ANALYTICAL QUADRICS

by **B. SPAIN**

This outstanding volume by Dr. Spain, head of the Mathematics Department of Sir John Cass College, is intended to serve as a concise introduction to the analytical geometry of three dimensions. **30s. net ($5.50)**

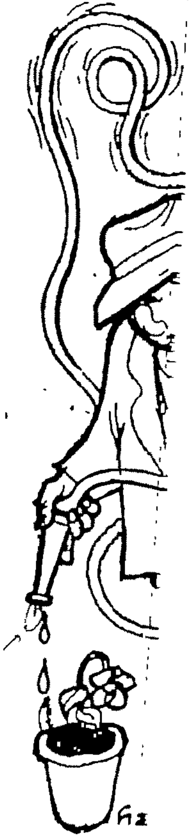
THE APPLICATION OF GROUP THEORY IN PHYSICS

by **G. Ya. LYUBARSKII**

The author had three aims in writing this book: to present in detail those parts of the theory of representations of finite and continuous groups that are most important in application; to consider groups of interest in theoretical physics; and, finally, to demonstrate the principles according to which the abstract concepts and the theorems of representation theory are applied in theoretical physics. **63s. net ($10.00)**

Fully descriptive leaflets sent on request

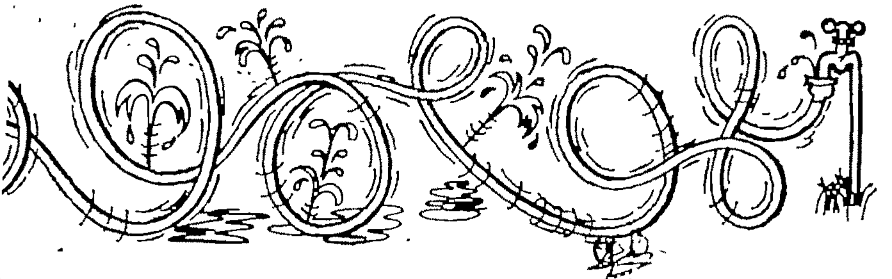
PERGAMON PRESS OXFORD LONDON NEW YORK PARIS
Headington Hill Hall, Oxford 4 & 5 *Fitzroy Square, London W.*1 122 *East 55th Street, New York 22, N.Y.*



MICF

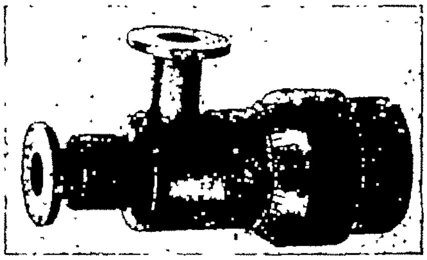
Full p

R (



SOME LEAKS ARE USEFUL...

For High Vacuum Engineering precise leaks are necessary. Our dosing valve is accurate from 2×10^{-1} lusecs upwards.

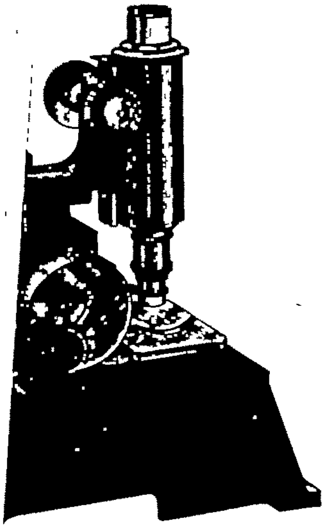


LEYBOLD

Agents for Leybold, Germany

LEYBOLD VACUUM SALES LTD.
Colquhoun House
27/37 Broadwick Street · London · W.1
GERrard 9641

ECK
R MICROSCOPE
in measurement



LTD • 69/71 MORTIMER STREET
LONDON, W.1

GREEN'S PURE FILTER PAPERS

Made since 1915

Write at once for descriptive Catalogue, which contains charts of ash, comparative tables and 40 pages of information, vitally interesting to all chemists.

Write at once for this
free Catalogue N.G.58.

J. BARCHAM GREEN LTD.,
MAIDSTONE ENGLAND

things, electrons, particles and waves could no longer be described at all in terms applicable to the macroscopic world of the senses. Intuitive notions of space and time had been called in question by the theory of relativity; the idea of a sub-atomic particle now became expressible only in terms of an abstract mathematical equation. Electrons themselves proved subject to the peculiar rule that only so many of them could be present in one system as were absolutely distinguishable by individual values of certain numbers which prescribe their state. Separate existence and experimental distinguishability were essentially linked. It is this almost metaphysical principle which accounts for the complete system of the chemical elements, with all their rich and varied detail. Particles appearing in nuclear disintegrations at high energies, mesons and the like, possessing the character of transience and decaying into others, present to-day an enigma which will probably not be solved until radically new principles have been discovered. The mysteries of the minute world of the atomic nucleus are found in magnified reflexion in those of the stellar universe. How did the present cosmic era start? Will it be renewed? Is the so-called ultimate particle itself a cosmos of still smaller things? Is the known universe contained within a particle belonging to some higher order? Mystery and fascination have no end, the pursuit of knowledge has no limit. Three hundred years have witnessed the most colourful adventure ever undertaken. Is this too not history?

In the broader sense this story is that of the Royal Society, for its membership has known no restriction of race or nation. It has been proud to number a goodly proportion of the world's greatest men of science among its Foreign Members.

The real actors in the drama of these centuries have been individuals, often rare individuals. What then in it all has really been the role of the Royal Society as a corporate body? This question is related to that most profound of problems, the relation of the individual to the community.

The hierarchical ordering of things, which can be seen both in the inorganic world and in the organic world, makes the community of one order the individual of the next order, not only through the gradations of human society and the animal kingdom, but also in the relation of cells to tissues, electrons to atoms and atoms to crystals. An almost metaphysical principle rules communities of electrons, chemical influences co-ordinate the lives of separate cells, and, to quote a single instance from biology, some mysterious kind of transmission beautifully regulates the flight of certain flocks of birds.

The modes of communication in human societies are known; but what remains mysterious is the blend of rational and emotional influences that determines the response. The great movements of thought and even the lesser ones of whim and fashion spread from leaders. Only minorities in general exercise an independent taste and judgment or produce original thought. Yet at one time a prophet is followed and at another he cries in the wilderness. Avogadro and Mendel achieved their fame posthumously. Literary reputations wax and wane. The shrewdest are unable to predict with certainty what public response to anything will be. The propagation of an idea demands the right conjunction of unknown human factors, but even when these are propitious nothing will initiate the change save the operation of a minority small enough to defy statistical considerations. Often indeed the minority begin with a single individual who alone would be helpless; and thus the majority and the minority are held in mutual dependence.

Scientific investigation needs material ways and means, and the further knowledge advances the more lavish becomes the scale. The individual in isolation becomes, except under rare conditions, correspondingly impotent. But the community as a social and political whole cannot be expected to possess the detailed understanding to support him. Nor, to-day, with the tremendous issues at stake, can it remain indifferent. What therefore must be created to mediate between the individual and the major group is a specialized minor community large enough to command prestige and confidence, but with membership confined to those who place the claims of knowledge first. The principles which should govern the constitution of such a body are highly important.

Specialized organs of the Government are by themselves unsafe, being too exposed to the changing winds of expediency. Universities suffer from the disadvantage that on one hand a given branch of knowledge is divided and scattered among many of them and, on the other hand, that they have competing preoccupations of importance to them commensurate with that of learning.

An academy therefore is the natural body to provide for several vital things—non-commercial periodicals for the publication of discoveries, a measure of financial support for ideas still too embryonic to be of immediately obvious practical application, the mutual stimulus of association and discussion and the immaterial reward of honour for intellectual achievement. Governments may act as patrons. They can and do solicit and receive the help of learned men, they favour and encourage enterprises which they judge to be timely; but they cannot provide for men of science the intangible yet powerful encouragement which comes from acceptance and election by their peers. The academy, if it maintains high standards of unquestioned impartiality, sets the tone throughout the scientific community, and its influence is felt in every quarter. It is no rival to government organizations or to industry, and should maintain the closest connexions with them by electing into its number the leaders from both. Because men of action and men of authority esteem it an honour to be elected, the academy exerts its influence far beyond the confines of the learned world. The professional men of science hear of the needs of the State and of industry which in their turn are irrigated by the currents of scientific thought. The intercourse on terms of equality between the representatives of these different estates of the nation is like a sensitive nervous mechanism endowing the community which possess it with capacities and potentialities realizable in no other way. The subtle co-ordinating action of an academy can no more be replaced by a bureaucratic organization or a system of economic incentives and deterrents than the intricately evolved biological controls of a living organism can be replaced by crudely devised mechanical appliances.

As Nature herself takes infinite pains over the perpetuation of the species, making this indeed in most respects her first concern, so the right choice of its members is a matter demanding the most anxious care of the academy, and is perhaps the most important thing it has to do.

This, then, is the conception of the Royal Society, implicit already in the personalities of its original

members and
and moulded
that it shoul
the communi
and on the
The record
tributed to
that this hu
Science h
of nations, a
of the Roy
Nor is it to
and of go
contributed
adverse cir
mony of all
On this
Society lay
the world,
also forwar
Extrapol
principle,
the presen-
the future
predicted
science, by
the agenc
nuclear w
have bee
upward f
ledge mul
and as m
own furt
less-spect
or gently
at least
afflicts a
is scarce
ever, in t
was not
response
has inde
equipped
worse eq
also to
The t
It is to
tainties.
exclusiv
would s
scientifi

ion to its royal Founder,
e tradition of 300 years,
ween the individual and
on the loyalty of the one
derstanding of the other.
atural sciences have con-
t should justify the claim
has borne good fruit.
restricted by the confines
claim the Foreign Members
eading actors in its story.
tain that the flow of ideas
scientific channels has
ontribute, sometimes in
wards the peace and har-

moration, when the Royal
of its stewardship before
ok not only backwards but
o be the future of science ?
y is impossible, perhaps in
ractice. The equations of
ossible types of solution for
nd catastrophe have been
d or another, in spite of
n and starvation, or, through
by wholesale destruction in
ued and accelerated progress
oretold, the curve sweeping
r as each advance in know-
ibilities of further discovery,
iously assumes control of his
Between lies the third and
, that the curve will level out
t the equations are insoluble,
we know. The uncertainty
e people ; but their timidity
useful. There has seldom, if
ry been a time when existence
ree precarious, yet the right
in action. Faith in the future
t survival value. The better
more likely to survive than the
t only to save themselves but

n of science is therefore clear.
leterred by any of the uncer-
nce is not incompatible with or
kind of faith. Indeed, there
inconsistency in believing that
itself one of the great instru-

ments of higher ends. However that may be, duty, expediency and the zest of living unite their voices in calling for unremitting effort, not in the certainty but in the hope and faith that knowledge may advance, mastery over environment increase, drudgery be abolished, sickness healed, the people fed and life made happier. If social and moral problems are raised they are not essentially new but part of an age-old drama, and should neither be allowed to cause despondency nor to justify obstruction or abstention. The ancient choice between good and evil is in principle unchanged by the scale or fullness of existence. Men have always had to struggle with their environment, with one another and with themselves. Not exemption from danger, hostility or temptation but the power to sustain their impact has made men what they are. The great weapons have been the things of the mind, and among the greatest of these is knowledge. While the old men dream dreams and the young men see visions we should go forward undeterred, that the dreams may become reality and the visions be fulfilled.

This commemoration is for us a great event in our history. The future is unknown. The chronicles record the actions and the thoughts of men, and if, as well may be believed, thought is a creative process, then the future is more than deeply hidden: it is uncreated. The golden promises offered by the release of nuclear energy, by the exploration of outer space, by the discoveries of genetic mechanisms may in one way or another be redeemed, but the best are yet unspoken. A great upheaval of ideas may come with a complete re-orientation of science in its relation to philosophy and to the conception of possible worlds. But we know neither the day nor the hour.

It is the duty of the Royal Society not to predict, not to legislate, but to maintain within the larger community the smaller one in which creative activity can flourish. Its members owe a multiplicity of loyalties, none of which can be fulfilled without the others: to mankind in general, to their native land and to the Royal Society itself. But that is not all, for there are communities in time as well as space. The most original minds, in some sense isolated in all contemporary groupings, find their true affinities in continuing the sequence of their predecessors, and their fulfilment only in their successors. In a measure this is true not only of genius but of all men. It is what moves us in history. It is what the honouring of this occasion means.

TRI T : DISCOVERIES IN THE CHESHIRE–SHROPSHIRE BASIN

By Sir WILLIAM PUGH, O.B.E., F.R.S.
irector, Geological Survey of Great Britain and Museum of Practical Geology

TH
B
under
Britai
by t
Rese
rocks
depo

e mile survey of the Cheshire
xtension into north Shropshire
Geological Survey of Great
s programme of work authorized
t of Scientific and Industrial
ching completion. The Triassic
concealed by thick superficial
cene sands and clays; detailed

stratigraphical knowledge was lacking of the Keuper rocks and, in particular, of the number and extent of the rock-salt beds within them. To facilitate the interpretation of the disposition of these rocks below the Pleistocene cover and to assist in the mapping of them, a scheme of shallow exploratory boreholes was utilized. A series of twenty-five boreholes, 300–1,000 ft. deep, were drilled within an area of 800 square miles in the Cheshire Basin; and one deep borehole has just been completed at a depth of 5,531 ft.

This deep borehole was undertaken to prove the succession of Keuper rocks beneath the Liassic strata exposed in the Prees outlier, which extends south-westwards from south Cheshire into Shropshire. Sited at Wilkesley (Cheshire) about five miles east of Whitchurch (Shropshire), the borehole revealed a thickness of 4,969 ft. of Keuper rocks, and a concentration of rock salt in two groups (each with subordinate marl partings) which together total 1,952 ft. in thickness. An abridged log of the borehole is set out below, using names for the newly established divisions of the Keuper:

	Thickness (ft.)	Depth (ft.)
PLEISTOCENE: sands and clays	58	58
LIASSIC: clay with limestone bands: both sub-zones of the *Psiloceras planorbis* zone are provisionally identified	460	518
RHAETIC: mudstone and black shale	44	562
TRIASSIC: Keuper		
Upper Keuper Marl: marl, 'tea-green' in top 50 ft.; gypsum at 960–70 ft.	579	1,141
Upper Keuper Saliferous Beds: rock salt with subordinate beds of marl	1,327	2,468
Middle Keuper Marl: marl with subordinate gypsum and anhydrite	1,073	3,541
Lower Keuper Saliferous Beds: rock salt with subordinate beds of marl	625	4,166
Lower Keuper Marl: marl with subordinate anhydrite	843	5,009
Sandstone, provisionally called *Upper Keuper Sandstone*	346	5,355
Siltstone, mudstone and silty sandstone, provisionally identified as *Keuper Waterstones*	176	5,531

The borehole failed to reach the base of the Keuper Beds; Permo-Triassic rocks older than the lowest bed reached are about 3,000 ft. thick in other parts of the Cheshire Basin, but not necessarily at Wilkesley.

The finding of two groups of saliferous beds in this borehole, rather than one as previously believed, has important consequences when the lateral extent of each group is delineated. The old-established salt industry of Northwich and Winsford is now known to be based on the lower group; on the other hand, the industry farther south at Sandbach and Middlewich appears to take its salt from the upper group, the lower group not yet having been exploited in that southern region.

The area occupied by the lower group from its western and northern margins to the eastern boundary fault of the Cheshire Basin is about 400 square miles and that of the upper group is about 170 square miles. The reserves of salt which could reasonably have been computed before the drilling of the Wilkesley Borehole have been at least doubled; a provisional estimate amounts to 400,000 million tons, of which more than 60 per cent is in the lower group.

The outcrops of the main divisions tabulated above will be shown on the forthcoming official geological maps of the Cheshire–Shropshire Basin. Their recognition will enable a new degree of precision to be brought to the long-term planning and execution of brine-pumping. The salt encountered in the boreholes was cored and is being systematically analysed so that details may be made available for industry.

It is interesting to record that one of the shallow boreholes near the western margin of the basin, namely, that at Old Beachin Farm, six miles south-south-east of Chester, entered barren Upper Coal Measures beneath the Pleistocene deposits enabling the mapping of an inlier of Coal Measures surrounded by Permo-Triassic rocks. The borehole was deepened to 993 ft. and a sequence comparable with the Erbistock Beds of the Wrexham Coalfield was encountered. However, workable coals, if present beneath the central parts of the Cheshire–Shropshire Basin, are likely to be at depths too great for present-day exploitation.

PERIODIC MAGNETIC FIELD FLUCTUATIONS IN THE *SCEPTRE* DISCHARGE

By Dr. N. L. ALLEN

Research Laboratory, Associated Electrical Industries, Aldermaston Court, Aldermaston, Berkshire

ALTHOUGH the discharges in *Zeta*, *Sceptre III* and *Perhapsatron* appear to be stable against gross wriggling[1–3], measurements with magnetic probes have invariably shown fluctuations of magnitude about 10–20 per cent of the average magnetic fields in the discharge and mean frequencies in the range 10^4–10^6 c.p.s.[4]. Also, some correlation has been observed between striated bands of light, termed 'bars', on rotating-mirror photographs and the magnetic fluctuations[5,6].

A possible theoretical explanation of these fluctuations has been given by Ware[7]. This has recently been extended[1] by including the Hall e.m.f. in the electron conduction equation, and it has been suggested that a hydromagnetic instability will propagate as a wave. The experiments reported here form part of a search for discernible instabilities of this type.

Experimental Arrangement

The arrangement is shown in Fig. 1. Ten small search coils, each of 120 turns of No. 44 s.w.g. copper wire, were wound at intervals of 1·25 cm. on a 4-mm. diameter 'Bakelite' rod. The assembly was enclosed in a T-shaped tubular glass envelope, with the coil leads taken out through the side tube. It was then inserted into the torus through a slit window and rotated until the common axis of the coils was parallel to the toroidal axis (neglecting the curvature of the latter over the length of the coil assembly).

The coils were positioned at radii up to 10 cm. from the centre of the toroidal tube, which had a minor diameter of 30 cm.; thus they were 5 cm. from the outside wall of the vessel at the mid-point of the coil system. The output of each coil was led to an integrator and then displayed on a multi-channel oscilloscope. Hence, correlation in time between the response of the individual coils was obtained on a single photograph.

The plasma was produced by discharging a 35,000-joule condenser bank through the primary winding of the machine. The condensers were charged to 20 kV.

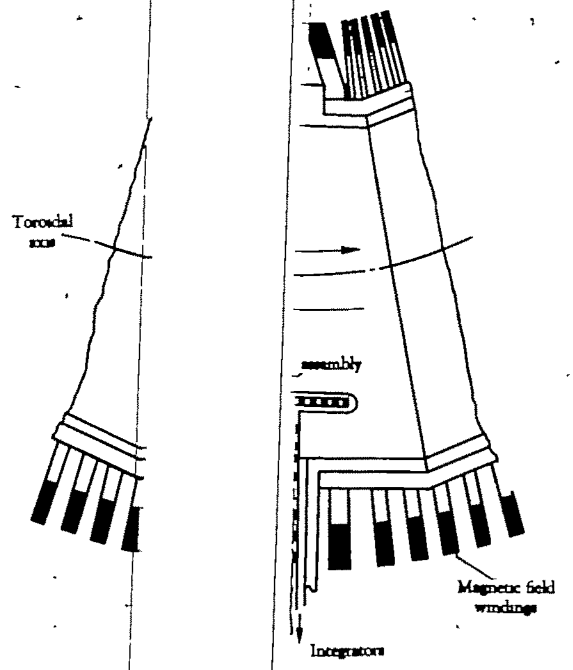


Fig. 1. Diag

ion of 10-channel probes inside
III

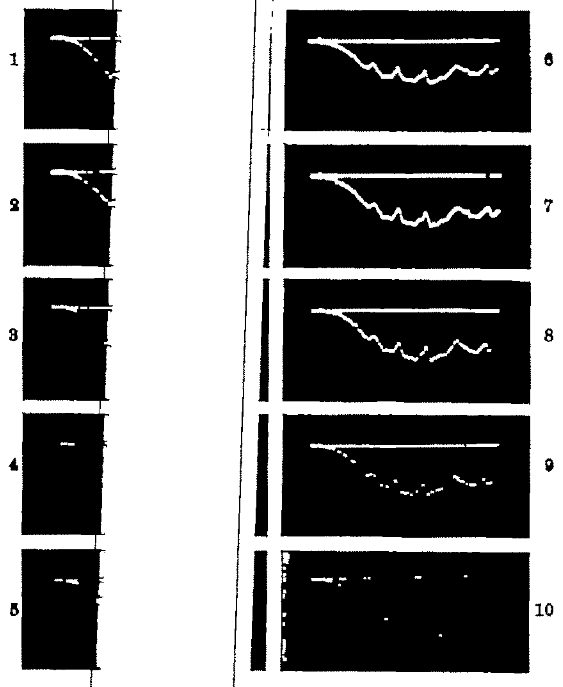


Fig. 2. O
system. F

al obtained from 10-channel probe
r and move along from No. 1 probe
e. (350 μsec. sweep)

With a st
initial sec
volts. Th
damped,
140,000 a
magnetic
applied.
10^{-3} mm.

ratio of 16 : 1 this gave an
e per turn in the gas of 1,250
e, which was nearly critically
. duration, rising to a peak of
. from the start. An initial
gauss at the toroidal axis was
euterium pressure was 1·4 ×

Fluctuation Behaviour

Typical oscillograms obtained with this arrangement are shown in Fig. 2. The pattern of periodic 'dips' or minima in magnetic field was obtained in a region between 6 and 10 cm. from the centre of the discharge tube along radii towards the outer wall. Further probe measurements showed the existence of similar patterns at corresponding radii near the other walls of the torus. The pattern was found to be repeated in these regions in 65 out of 86 discharges examined; in the remaining 21 cases the pattern was less regular, or showed few recognizable 'humps'. The magnitude of the 'dips' varied from ~ 200 to ~ 1,000 gauss.

The time-intervals between pairs of minima varied between 25 μsec. and 100 μsec. with an average of ~ 45 μsec. for 113 cases examined. A histogram showing the frequency distribution of these intervals

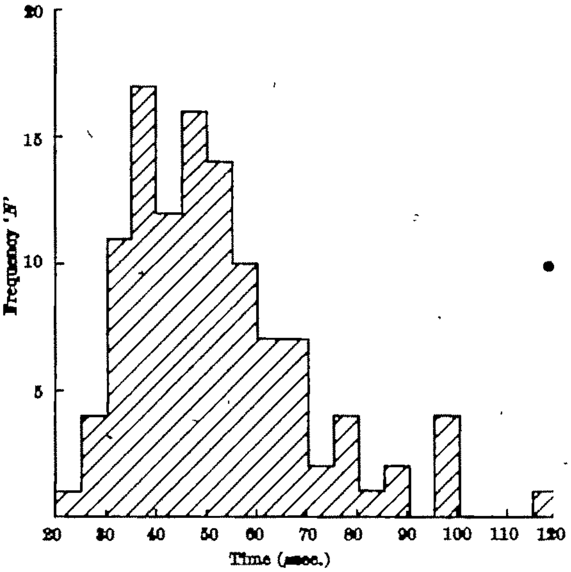


Fig. 3. Histogram showing frequency distribution of intervals between minima. No. of periods measured = 113

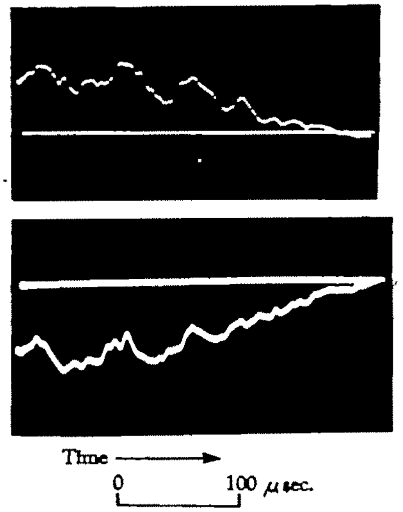


Fig. 4. Oscillograms of signals from probes placed on opposite sides of discharge. (350-μsec. sweep)
Upper, No. 4 probe, centre + 5 cm.; lower, No. 8 probe, centre − 5 cm.

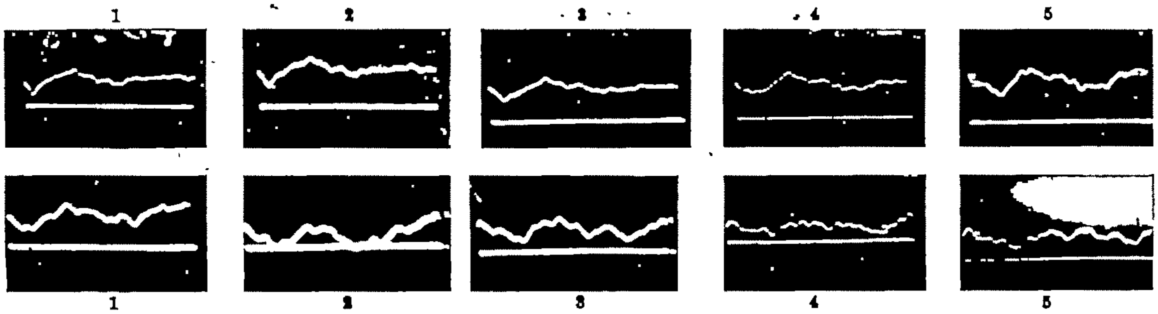


Fig. 5. Oscillograms of signals from T-probes along radii at right angles to each other. Upper row: probes 7 5 cm. from outside wall of torus; lower row: probes 7 5 cm. from upper wall of torus. Base line in each oscillogram 0–100 µsec.

is given in Fig. 3. Measurement with a travelling microscope showed an increasing time-lag between minima on No. 1 coil and those on succeeding coils up to No. 10. The average time-displacement between the end coils for 72 minima investigated in this way was 8 µsec. over the total length of 11 cm. covered by the coils, with intermediate time differences recorded by the intermediate coils.

Further investigation into the nature of the fluctuations was made by inserting a 10-channel probe across the discharge to measure axial field changes at 2·5-cm. intervals. Specimen oscillograms obtained are shown in Fig. 4, from which it is clear that an anti-phase correlation existed between peaks and dips occurring on opposite sides of the centre of the discharge.

Fig. 5 shows the relationship between the patterns obtained with T-shaped probes inserted along radii at right angles to one another in the same cross-sectional plane. The interval between peaks on the individual oscillograms (shown here on a fast sweep) was ~ 80 µsec. and the minima were displaced about 15–20 µsec. with respect to one another.

In Fig. 6, the average axial and azimuthal components of the discharge magnetic field relevant to the observations quoted above are shown. These are plotted, at peak discharge current, against tube diameter for the same initial conditions. The T-shaped probe covered the areas about *A*. They are on steeply rising parts of the B_φ component in which the resultant magnetic field 'wave-lengths' ($2\pi r\, B_\varphi/B_\theta$) vary between 26 and 175 cm.

Discussion

The time-displacement of minima along the probe assembly indicated either a velocity component of the pattern in the axial direction or a rotational motion in the azimuthal direction of a disturbance lying at some angle to the probe axis. The techniques used here could not distinguish between these two alternatives.

Taking the former possibility: a total of 72 minima was followed in their progress along the probe assembly and a spectrum of axial velocity component obtained as in the histogram of Fig. 7. The velocities showed a maximum in number at about $1\cdot5 \times 10^6$ cm./sec. A group of 17 minima existed in which a velocity was not resolvable, since they showed no significant time displacement along the probe. These are shown here as having a velocity $> 5 \times 10^6$ cm./sec. However, these minima could equally well correspond to a pattern of zero axial velocity component appearing simultaneously on all probes. The resolvable velocities (55 cases) were in the direction of positive ion drift in every case.

The alternative of azimuthal motion of an angled disturbance would indicate an angular frequency spectrum similar in profile to that of the distribution of Fig. 3, where the time axis is replaced by the reciprocal of the frequency. At a mean radius of 8 cm. from the centre, this corresponds to a mean peripheral velocity of the order $1\cdot0 \times 10^6$ cm./sec., assuming only one perturbation for each rotation.

The results are consistent with a model of a helical disturbance moving, axially or azimuthally, in the discharge. This model is supported by the observations, with probes on either side of the discharge centre, of an antiphase correlation and by the observation of a phase shift between the two probes at right angles. The results suggest the presence of an $m = 1$ type of instability. Such behaviour has been reported by other experimenters[9,10] at lower discharge currents. The present results do not depend critically on discharge current values, since the fluctuations occur over a considerable part of the pulse.

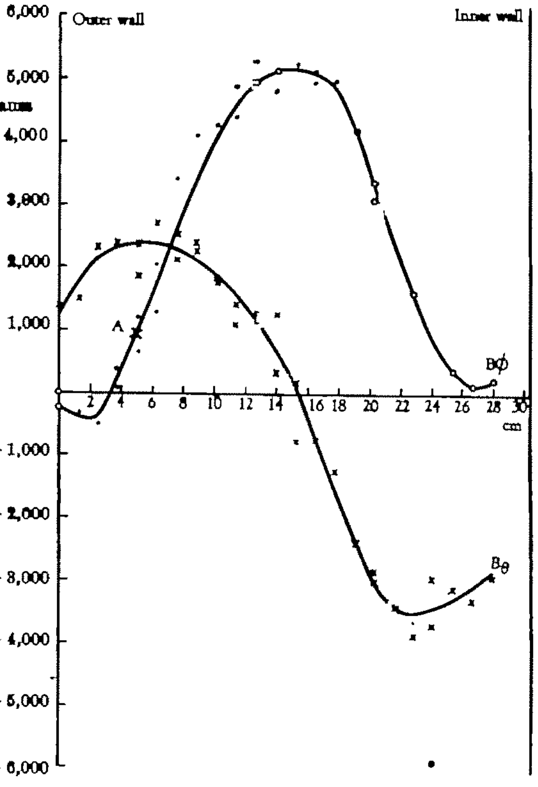


Fig. 6. Average values of magnetic-field components B_θ, B_φ as a function of position in discharge tube

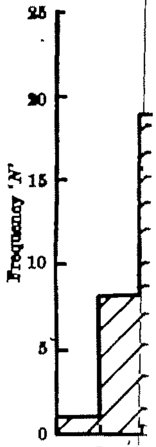
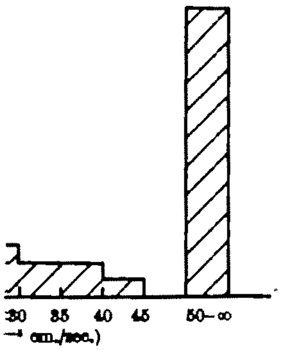


Fig. 7. Histo



l velocity component spectrum.
inima = 72

Assuming
to be cause
67 cm. is indi
Over the re
(4 cm.), the
26 cm. to 1
length derive
expected fr
perturbation
identified w
interval bet
largely acc
discharge, fo
It may al
observed on
the dischar
the field plo
the edge o
result, agai
Sawyer *et* a

, of average value 45 μsec.,
notions, a wave-length of
ocity of $1\cdot5 \times 10^4$ cm./sec.
discharge radius studied
wave-length changes from
Fig. 6). Thus, the wave-
ations lies within the range
etic field helicity. If the
tic field wave-lengths are
ner, the variation in time
n a given discharge may be
lateral movement of the
erturbation velocity.
re that the fluctuations are
cm. wide annular region of
ensity plots, derived from
now this to be the region of
ge current channel. This
semblance to the result of

Conclusion

Strong periodic fluctuations in the axial magnetic field component suggest the existence of a helical type of instability near the discharge channel surface. The instability is moving either in the axial direction with an average velocity of $1\cdot5 \times 10^4$ cm./sec. or in the azimuthal direction with an average rotational frequency of 2×10^4 c.p.s. or could be a combination of both types of motion. Variation in the fluctuation period during the pulse-time is probably due to general movement of the discharge as a whole.

I wish to thank Messrs. H. B. Mundy and V. C. Cloke for their operation and maintenance of *Sceptre III*. I am grateful to Mr. M. J. Bolton for experimental assistance, to Dr. J. A. Wesson for discussion and assistance with measurements and to Dr. A. A. Ware for his interest and advice on the programme. Thanks are due to Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries, Aldermaston Court, for permission to publish these results. The work has been supported in part by the United Kingdom Atomic Energy Authority and is in association with the Controlled Thermonuclear Research Programme of the Atomic Energy Research Establishment, Harwell.

[1] Butt, E. P., *et al.*, Proc. Second U.N. Int. Conf. on the Peaceful Uses of Atomic Energy, 31, 42 (1958).
[2] Allibone, T. E., Chick, D. R., Thomson, G. P., and Ware, A. A., Proc. Second U.N. Int. Conf. on the Peaceful Uses of Atomic Energy, 31, 169 (1958).
[3] Tuck, J. L., Proc. Second U.N. Int. Conf. on the Peaceful Uses of Atomic Energy, 31, 3 (1958).
[4] Allen, N. L., and Isley, B. S., Proc. Fourth Int. Conf. on Ionization Phenomena in Gases, 2, 937 (Uppsala, 1959).
[5] Allen, N. L., and Payne, R. M., A.E.I. Res. Rep., 1960 (in preparation).
[6] Ware, A. A., *Proc. Inst. Elec. Eng.*, 106, Pt. A, Supp. 2, 30 (1959).
[7] Ware, A. A., Proc. Fourth Int. Conf. on Ionization Phenomena in Gases, 2, 931 (Uppsala, 1959).
[8] Ware, A. A., *J. Nuclear Energy*, Part C (to be published).
[9] Sawyer, G. A., Scott, P. L., and Stratton, T. F., *Physics of Fluids*, 2, 47 (1959).
[10] Bernstein, W., Kranz, A. Z., and Tenney, F., *Physics of Fluids*, 2, 713 (1959).

CTRAL REFLECTIVITY OF ORE MINERALS

By I. GRAY and DR. A. P. MILLMAN
rtment of Mining Geology, Royal School of Mines, Imperial College of Science and Technology, London

RECEN
under
by Camero
quantitati
polished s
hardness,
by Nakhla
found, tha
provides
identificati
Althoug
published
have been
standards
establishe
establishm
tivity whi

study of opaque ore minerals
g ore-microscope, reviewed
l at their identification by
Two mineral properties in
ly, reflectivity and micro-
e subject of investigations
nd Taylor[3,4], and it has been
nt of these two properties
ystematic method for the
erals.
ese values are absolute, the
ta are only relative, since they
y comparison with arbitrary
alues of which have not been
is communication records the
rd absolute values of reflec-
ed by other workers for cali-

bration of their equipment, and for standardization of measurements. In addition, the application of a photo-conductive cadmium sulphide cell is described which has been used successfully for measurement of the spectral reflectivity of opaque minerals for different wave-lengths of incident light.

Standardization

Published reflectivity values in white light have been based on pyrite as a relative standard with which other mineral surfaces have been compared. The choice of this mineral as a standard is unsatisfactory, however, due to variation in composition and inherent anisotropy.

For calibration purposes, measurements have been made of absolute reflectivity throughout the spectrum

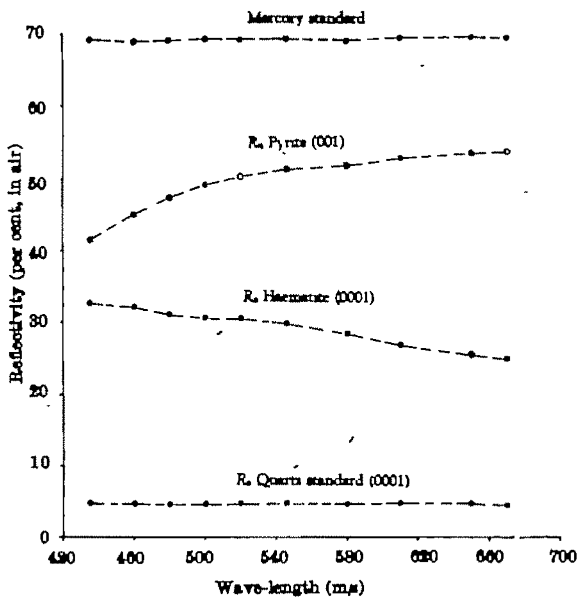


Fig. 1. Spectral reflectivity of quartz and mercury standards, and profiles of pyrite (FeS_2) and hæmatite (Fe_2O_3) as determined by the National Physical Laboratory. Computed white-light reflectivity (per cent): mercury, 69·3; pyrite, 52·7; hæmatite, 26·4; quartz, 4·5

for standard reference surfaces. The standards selected were chosen for their reproducibility and permanence, and were: (1) polished basal section of quartz, and (2) natural surface of pure mercury under a glass cover-slip (thickness 0·216 mm., refractive index 1·52). These two standards normally suffice for the photo-conductive cell which gives a linear response. As a check on the linearity of our equipment, two other surfaces were measured; these were (3) natural basal crystal face (0001) of hæmatite, Fe_2O_3, and (4) polished cube face of pyrite, FeS_2.

The reflectivities of these four surfaces, at ten points throughout the spectrum, were determined by the National Physical Laboratory (NPL Reference O.1959.34), and the results are shown in Fig. 1. The method of measurement employed for each specimen was specular reflexion from an area 0·6 mm. × 0·45 mm. for a cone of radiation, semi-angle 4°, angle of incidence 5°. From these results white-light values were computed which allow for the energy distribution of a tungsten-filament lamp run at a colour temperature of 3,050° K., and for the response profile of the cadmium sulphide cell.

Equipment

The standard values determined by the National Physical Laboratory were used for calibrating our equipment for the measurement of monochromatic and white-light reflectivity. The apparatus consists of a Mullard ORP.11, cadmium sulphide photoconductive cell fitted into the Wright ocular of a Cooke, Troughton and Simms ore-microscope. The cell is in circuit with a variable 0–100 V. d.c. energizing source, the current output being recorded on a spot galvanometer. For spectral determinations, Ilford filters of effective band-widths not exceeding 250 Å. are used; the wave-lengths of maximum response of the measuring system allowing for the spectral characteristics of light source, filters and cell are as follows: blue 470 mμ, green 520 mμ, yellow 575 mμ, orange 600 mμ, red 700 mμ. Under standard conditions, with an objective of 0·65 N.A., a 10° cone of incident light, and a stabilized 6 V. 48 w. tungsten-filament light source, the output of the cell varies between 1 μamp. and 5 m.amp. according to the surface measured and wave-length employed.

Results

To illustrate some of the characteristics of spectral profiles of anisotropic opaque minerals, three examples have been selected from the many oriented minerals which have been examined in plane-polarized light.

Fig. 2 shows the spectral profile in the two principal directions of reflectivity, R_e and R_o, in the case of covellite, CuS. At yellow wave-lengths, which approximate to white light, $R_o > R_e$, but in blue, green and red light, $R_e > R_o$ (although to the eye $R_e < R_o$). Moreover, at about 550 and 640 mμ, $R_e = R_o$, that is, the mineral is no longer bireflecting and anisotropic. This 'bireflexion reversal' has not been observed before in opaque minerals due to intensity insensitiveness, and chromatic bias of both the human eye and the conventional selenium photoelectric cell. This phenomenon of reversal is analogous to similar properties of directional refractive index in transparent minerals, based on sign of character of uniaxial or biaxial birefringence. The suggested notation for opaque minerals is 'positive bireflectance', where $R_o > R_e$, and 'negative bireflectance', where $R_e > R_o$.

In Fig. 3, a comparable type of profile is shown for umangite, Cu_3Se_2, with strong absorption at yellow wave-lengths. In this case, however, there is no reversal of bireflectance; minimum bireflectance occurs at 580 mμ. This mineral is particularly interesting since visual estimates of colour and intensity suggest opposite bireflectance at red wave-lengths. Also illustrated in Fig. 3 are the profiles of pyrrhotite, $Fe_{1-x}S$, with higher reflectivity but lower bireflectance. R_e is consistently greater than R_o (negative bireflectance), and maximum reflectivity occurs at green wave-lengths, with absorption towards the blue and red ends of the spectrum.

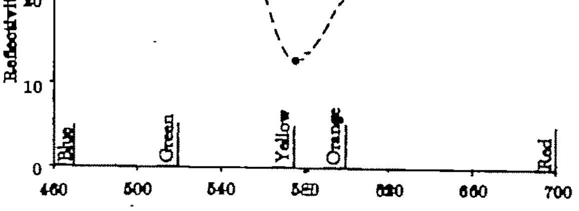


Fig. 2. Profiles of reflectivity R_e and R_o against wave-length in the principal directions of oriented sections of covellite (hexagonal CuS, Sardinia). For R_e, plane of polarization is parallel to c-axis direction; for R_o, it is normal to c-axis direction. White-light values (per cent): R_o, 24·0; R_e, 17·6. Field N, negative bireflectance with $R_e > R_o$; Field P, positive bireflectance with $R_o > R_e$; I, isotropy with $R_e = R_o$

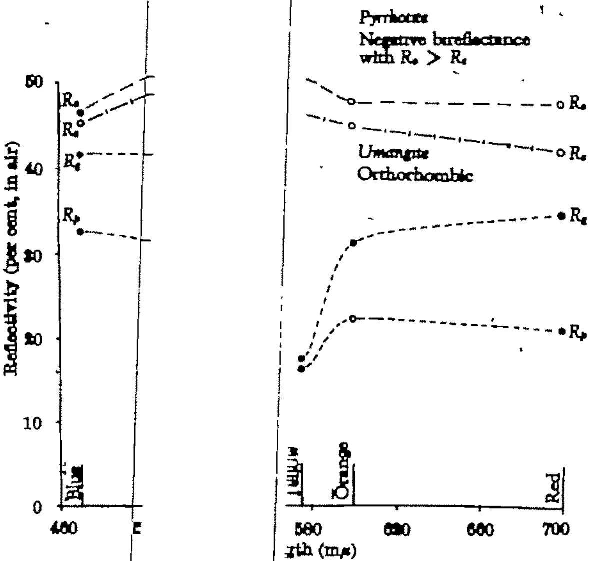


Fig. 3. Profil
the principal
gonal $Fe_{1-x}S$)
Orientation &
cent): uman

R_o and R_e against wave-length in
ted sections of pyrrhotite (hexa-
umangite (orthorhombic, Cu_3Se_2).
Fig. 2. White-light values (per
R_p 19·2; pyrrhotite R_o 46·4;
43·7

The sta
enabled acc

usions

procedure employed has
nations to be made of the

absolute reflectivity in air of oriented polished sections of opaque ore-minerals in both monochromatic- and white-light. The spectral profiles obtained from these measurements show variation in reflectivity, bireflectance magnitude and sign. The insensitivity of the human eye to wave-length intensity coupled with its inherent colour bias cause apparent anomalies in intensity change compared with photo-conductive cell measurements. This is particularly apparent with wide band-width filters using standard comparison methods (visual micro-photometer), and with selenium photo-electric cells which respond in a manner comparable to that of the eye. The fundamental data of absolute reflectivity in white light combined with the characteristics of spectral reflectivity profiles are of great significance in the interpretation of other optical phenomena in polarized light, such as natural colour, spectral dispersion, rotation of polarization plane and conoscopic isogyre effects under crossed Nicols.

The detailed results of this study of the spectral reflectivity of about 200 oriented ore-mineral oxides, sulphides and sulphosalts, and the application of the data and technique to the systematic identification of economic minerals, are to be published in full elsewhere.

---

[1] Cameron, E. N., "The Study of Opaque Minerals in Reflected Light". American Society for Testing Materials, Publication No. 257 (1959).

[2] Nakhla, F. M., *Econ. Geol.*, 51, 811 (1956).

[3] Bowie, S. H. U., and Taylor, K., *Nature*, 179, 628 (1957).

[4] Bowie, S. H. U., and Taylor, K., *Mining Mag.*, 99, 265, 337 (1958).

OBITUARIES

H. Francis

Godfrey
tragically
in the Lak
violent sto
rock, disloc
Francis
and was ed
Australia.
about the
enlisted in
nearly thre
between G
gained fir
College, Ca
petrology
Urquhart,
successful
within a sh
home.
In 1953
ment of M
History) a
officers in
Two years
scientific
death.
Cambridg
Glen Urq
much of
general kn
problems

ancis died on June 5, at the
hirty-two. While climbing
was overtaken by a sudden
he victim of a heavy fall of
ng.
India on August 11, 1927,
the War in Adelaide, South
his school-days finished at
he returned to England and
Arm, in which he served for
niversity career was divided
Oxford (1947–50), where he
urs in geology, and Clare
–53), where his work on the
morphic complex of Glen
re, formed the subject of a
ation. Glen Urquhart lay
nient distance of his mother's

ined the staff of the Depart-
he British Museum (Natural
fficer; he was one of the two
Museum's collection of rocks.
romoted to the rank of senior
tinued in that rank until his
devoted his three years at
ve and detailed study of the
x, it was only natural that
petrological work of a more
e originated in the particular
. During his six and a half

years in the British Museum he published several papers, both on the rocks of Glen Urquhart and on their metamorphism; he was especially interested in metamorphic facies boundaries, and his original contributions on the subject are worthy of note. It is a matter of regret that his unexpected death left so many of his works incomplete or unpublished; some, including a long paper on "Alkali Metasomatism and its Consequences in Glen Urquhart, Inverness-shire", will be published posthumously.

Dr. Francis was a keen field geologist, and his short career was pleasantly punctuated by three expeditions—to South Peru in 1954 and 1959, and to South Greenland in 1957. The two Peruvian expeditions (the first of which was also his honeymoon) were to study the nepheline-syenite Allincoapac massif, rising to a height of nearly 19,000 ft. in the Province of Carabaya; the purpose of the Greenland expedition was to undertake a study of the same rare rock type in a classic area and to collect specimens of other rocks. All three expeditions resulted in the production of useful topographical and geological maps and (in the case of the 1954 expedition) a paper on the general geology of the area. The Peruvian expeditions also afforded opportunities for archæological work; Dr. Francis published an account of two hitherto unrecorded pre-Columbian villages at Chichacori and Quilliquilli in the gorge of the Rio San Gaban, and he collected fine examples of artificially deformed human skulls from mummies of the period.

The little-known mountain ranges of Peru and Greenland were an even greater attraction to Dr. Francis than was the nepheline-syenite, and he made first ascents in both countries. Indeed, he was a noted climber, having been chosen to take part in another assault on Everest in the autumn of 1953 if the first assault should fail. He was a former member of the Mountaineering Clubs of both his Universities, being treasurer at Oxford, and had undertaken many Alpine climbs of the utmost severity; he sat on the committee of the Alpine Club and was secretary of the Mount Everest Foundation screening committee; his book, "Teach Yourself Mountain Climbing," is the standard work recommended by the British Mountaineering Council, and he had helped edit a guide-book to selected climbs in the Mont Blanc range.

Dr. Francis's quiet and modest manner gave no hint of those qualities which made him such an outstanding leader—initiative, loyalty, courage, perseverance and stamina. His enormous sense of fun helped him to enjoy every aspect of his happy and varied life. He will be greatly missed, both as a scientist and as a friend.

He was married to Gillian Hemens in 1954, and leaves also a son and infant daughter.

A. J. CHARIG

Dr. H. F. Barnes

DR. H. F. BARNES, senior principal scientific officer in the Entomology Department at Rothamsted Experimental Station, died suddenly on February 5, at the early age of fifty-seven. He was at the height of his scientific output, and still full of activity and ideas for the future.

Educated at Bedford School, he obtained his B.A. and M.A. at Oxford, and Ph.D. at London. His work was largely based on the group of Diptera known as gall-midges or Cecidomyidae; but his approach was a very wide one, including their economic status and natural control; their geographical and food-plant range; systematics, including a very close study of biological species and races; their parasites and phenology; and particularly the accurate study of population changes by field measurements. At Rothamsted he assessed the population-levels of two species each year for more than twenty-five years, providing a wonderful basis for the discussion of insect fluctuations and their causes. His work on the group—which covered the whole world—was published in more than fifty papers and seven (out of a contemplated eight) volumes of his "Gall Midges of Economic Importance".

His collection, now in the British Museum (Natural History), was unique in its coverage of the economic species of the whole world and in its long series of hundreds of specimens from different localities and bred from different host-plants. From this material, Barnes was able to solve many questions as to the identity of insects causing similar damage in different countries.

For some years, during the War and after, Barnes took up the study of injurious slugs in Britain, and once more tackled the question of accurate assessment of population and population changes in the field.

He was zoological secretary of the Association of Applied Biologists during 1939–44 and treasurer during 1947–60. He also edited the *Bedford Naturalist* from 1952 until his death. He paid a number of visits abroad, where his reputation was high owing to the world-wide outlook on every problem that he tackled.

On the personal side, I may add that I worked side by side with him at Rothamsted for more than twenty years, and found him a good friend, a stimulating companion and a very loyal colleague.

C. B. WILLIAMS

NEWS and VIEWS

Royal Navy Hydrographic Department: Rear Admiral K. St. B. Collins, C.B., O.B.E.

ON July 7, Rear Admiral K. St. B. Collins was succeeded by Rear Admiral E. G. Irving as hydrographer of the Navy. Admiral Collins has held office for five years in a difficult period of retrenchment and staff reduction which have been imposed upon the Hydrographic Department in common with other branches of the Royal Navy. But despite these reductions, the Department, under Admiral Collins's direction, met, during these years, increased demands for charts from the merchant navies of the world. A new record was achieved in 1957, when 1,404,450 charts were sold, and only a slight reduction in sales, attributable to a world shipping recession, has occurred since that time. As a direct result of his encouragement, Admiral Collins has seen a steadily increasing inflow of reliable oceanic sounding data from many sources so that the world-wide series of oceanic plotting sheets, introduced by his predecessor, Admiral Day, is now increasingly referred to by oceanographers and those interested in the morphology of the ocean floor. These sheets are regularly supplied to the International Hydrographic Bureau for use in the compilation of the General Bathymetric Chart of the Oceans. Admiral Collins has served as chairman of the World Geomagnetic Survey Panel and the Physical Oceanography Sub-committee of the National Committee for Geodesy and Geophysics. He was a member of the National Oceanographic Council and a member of the Executive Committee of the National Institute of Oceanography. He served on the National Committee for the International Geophysical Year. During his period of office, he was able to grant a considerable number of facilities to scientists in Her Majesty's surveying ships, this being in the best traditions of the Surveying Service, while oceanographic tasks for the National Institute of Oceanography, the Department of Geodesy and Geophysics, Cambridge, and the British Museum (Natural History) and other establishments have been increasingly included in Commanding Officers' Hydrographic Instructions. The introduction of electronic aids for fixing the ship while sounding and for base measurement of triangulation onshore have been generally introduced into the Surveying Service by Admiral Collins, and it is for his vigour in introducing these systems that he will be remembered by surveying officers. He was, however, always quick to point out the gross errors that may be introduced into electronic systems by carelessness and insisted that they should be subject to frequent check by well-tried visual methods.

RBAR ADM
grapher of th
cadet in Au
the Surveyir
been constar
work in mar
in Sicily and
wartime oper
and mention
four of Her
the posts of
superintende
Department

Biochemistr

PROF. W
chair of bioc
sity of Lor
biochemists
turned the
chemistry.
Studies in
and was ap
College in 1
of the subje
students w
Robson for
generations
medical sol
influenced
ment, Prof
rememberir
than thirt
chemistry
promising

DR. H. I
best know
human ge
techniques.
Universitie
served for
Royal Air
of human
began wor
Laborator
Leverhulm
icians. I
tialities o
genetical
biochemic
to a joint
and of E
appointed
Biochemis
Generous
from 195
Dr. Harr
developm
two bool
Genetics"
in 1959.
surveys c
great hu

The Med

THE C
establish

niral E. G. Irving, O.B.E.

who succeeds as hydro-
d *H.M.S. Royal Oak* as a
erwards volunteering for
1931. Since then he has
on hydrographic survey
world, including surveys
North-West Europe during
he was awarded the O.B.E.
nes. He has commanded
veying ships and has held
t to the hydrographer and
s in the Hydrographic

College, London :

Prof. W. Robson

, who is retiring from the
ing's College in the Univer-
of London's most senior
of King's College, he re-
lecturer in physiological
a member of the Board of
since its formation in 1929
in biochemistry at King's
he became the first professor
Besides many postgraduate
on to be grateful to Prof.
ement and guidance, many
l students in the London
d their biochemical studies
his wisdom. In his retire-
l have the satisfaction of
art he has played for more
earing and nurturing bio-
ancy in the 'twenties to the
'sixties.

Prof. H. Harris

vill succeed Prof. Robson, is
tributions to the study of
application of biochemical
ated in medicine from the
ge and Manchester and then
as a medical officer in the
came interested in problems
ng this period, and in 1947
L. S. Penrose in the Galton
ity College, London, as a
the Royal College of Phys-
quick to realize the poten-
phy and electrophoresis in
increasing requirements for
re met by his appointment
the Departments of Genetics
In 1953 Dr. Harris was
rer in the Department of
don Hospital Medical College.
the Rockefeller Foundation
to expand his field of work.
contributed notably to the
ject by the production of his
ion to Human Biochemical
Human Biochemical Genetics"
presented lucid and critical
anding research in matters of
ce.

and Steel Institute

Iron and Steel Institute has
medal award, to be known
as "The Medal of The Iron and Steel Institute". This Medal is to be presented on special occasions to societies which have, in the opinion of the Council of the Institute, rendered exceptional service to science or industry over a lengthy period. The first award of the Medal is to be made to the Royal Society, in recognition of its unique service to science over a period of three hundred years. The Medal was presented by the Hon. R. G. Lyttelton, past-president of the Iron and Steel Institute, at the Tercentenary Celebrations of the Royal Society on July 18.

Advisory Council for Research and Development in Fuel and Power

IT is announced that the Scientific Advisory Council to the Minister of Power has been reconstituted and its terms of reference amended so as to emphasize that its advisory functions cover all aspects of research and development concerned with fuel and power from the laboratory to industrial application. In order to ensure the co-ordination of the advice which the Minister receives on research and development matters, the Council will take over the functions of the Minister's Fuel Efficiency Advisory Committee. This Committee is accordingly being wound up and the Council is being invited to appoint a standing Committee on Fuel Technology. The members of the Advisory Council on Research and Development are as follows: *Chairman*, Sir Alexander Fleck; *Deputy Chairman*, Captain (E) W. Gregson; *Members*, Lieut.-Colonel S. J. M. Auld (oil industry consultant), Dr. C. M. Cawley (chief scientist, Ministry of Power), Mr. T. B. Clark (Imperial Chemical Industries, Ltd.), Sir Josiah Eccles (deputy chairman, Electricity Council), Mr. W. K. Hutchison (deputy chairman, Gas Council), Dr. W. A. Macfarlane (managing director, National Industrial Fuel Efficiency Service), Sir Harry Melville (secretary, Department of Scientific and Industrial Research), Mr. L. Rotherham (member for research, Central Electricity Generating Board), Prof. M. W. Thring (University of Sheffield), Dr. F. A. Vick (deputy director, Atomic Energy Research Establishment, Harwell), Mr. A. H. A. Wynn (scientific member, National Coal Board); *Assessors*, Mr. P. Chantler (economic adviser, Ministry of Power), Dr. E. Lee (director, Stations and Industry Divisions, Department of Scientific and Industrial Research), Mr. H. T. Ramsay (director, Safety in Mines Research Establishment, Ministry of Power); *Secretariat*, Dr. E. N. Eden and Mr. E. W. Prior (Ministry of Power).

The National Council for Technological Awards

THE report of the National Council for Technological Awards for the period April 1959–March 1960 records the agreement of the Minister of Education to an amendment of its constitution so as to ensure the inclusion of principals of colleges of advanced technology, and three such principals—Dr. E. C. Edwards, Dr. J. S. Tait and Dr. P. F. R. Venables—have been nominated by the Minister as members (Pp. 26. London: National Council for Technological Awards, 1960). During the year, thirteen courses at six colleges were recognized as leading to the Diploma in Technology, five courses rejected and seven courses referred back. Since September 1956, 100 courses in all, at twenty-three colleges, have been recognized as leading to the Diploma, and of these eighty-nine have commenced, and the number of students attending the first year of such courses is now 1,558, including forty women students: 129 students gained the Diploma during the year. The Council has set up a Panel, under Sir Walter C. Puckey as chairman, to advise them on industrial training for the Diploma in Technology and the collective responsibilities of the firm and the college in this field. A memorandum setting forth the requirements of the Council, the responsibility of the firm and the responsibility of the college has been issued for the guidance of firms and colleges (Memorandum on the Industrial Training of Students following Courses recognized as leading to the Diploma in Technology. Pp. 11). At the conclusion of a course the firm will be responsible for assessing the extent to which the student has benefitted from his industrial training and for certifying to the college that he has completed his training satisfactorily. The college is responsible for certifying to the Council, in the light of this certification, that the student has completed satisfactorily a course of industrial training in accordance with the Council's requirements, as well as for making appropriate arrangements for collaborating with firms and ensuring that where the training is received at more than one firm the complete scheme of training followed complies with the statement of the broad nature and sequence of training required for the particular course. The Council has also issued a List of ninety-five courses at twenty-three colleges which are now recognized as leading to the Diploma in Technology (List No. 11. Diploma in Technology. Pp. 5).

Polar Research in the U.S.S.R.

The first Arctic drift expedition, led by I. D. Papanin, took place in 1937–38. Six expeditions of the same type followed, and since 1954 drifting Arctic stations are a constant feature of the regular survey. Recent progress of this work is reviewed by P. A. Gordienko (*Priroda*, 6, 35; 1959), while recent progress in the oceanography studies in the Arctic is described by A. F. Treshnikov (*Priroda*, 2, 25; 1960), especially all the work done on the distribution of currents, temperature, chemistry and biology of the Arctic Ocean as influenced by the submarine Lomonosov ridge. The work of the Antarctic expedition of the Academy of Sciences is constantly under review. K. A. Brodsky, K. K. Markov and V. I. Shilnikov (*Priroda*, 7, 19; 1959) give a summary account of the geographical zonality at high latitudes of the southern hemisphere. It is provided with a map in colour and several sections illustrating the distribution of temperature and salinity in the different parts of the ocean. The glacial cover of the Antarctic, as determined by the seismic survey, is discussed by Y. M. Model and A. V. Nudelman (*Priroda*, 11, 93; 1959), who have assembled together the results of the various national expeditions. They give an outline structural map of the Antarctic continent with indications of the probable mountain ranges and rift troughs.

International Bird Preservation

In its annual report for 1959 the British Section of the International Council for Bird Preservation announces the additions of the U.S.S.R., Portugal and Malaya to the national sections of the Council, bringing the total number of subscribing countries to forty-eight. Another important event has been the setting up of a special sub-committee of the British Trust for Ornithology to investigate the injurious effects of pesticides on wild life. Reference is made to the mass destruction of small birds in Italy to be served up as savoury dishes to tourists. Individual tourists, it is claimed, can do much to eliminate this practice by expressing their displeasure and disgust when they see small birds served in restaurants. The Indonesian authorities are trying to control the clandestine traffic of birds of paradise plumes between New Guinea and Singapore. These beautiful birds face the threat of destruction while their plumes are in demand for purposes of personal adornment. The report also points out that, while Lord Ilchester was one of the first to raise the question of oil pollution of the sea in the House of Lords nearly forty years ago, the evil still persists. When the International Convention for the Prevention of the Pollution of the Sea by Oil came into force on July 26, 1958, eleven maritime countries had ratified; on March 2, 1959, Finland ratified, thus bringing the total up to twelve. It has since been announced that the United States has also accepted the International Convention, though with certain technical reservations. The report of the British Section may be obtained from the International Council for Bird Preservation, c/o British Museum (Natural History), Cromwell Road, London, S.W.7, price 3*s*.

South Australia Museum

The annual report for 1958–59 of the South Australian Museum in commenting on the field work accomplished describes the search for Tertiary mammalian records in the Lake Eyre Basin (Pp. 15. Adelaide: Government Printer, 1960). This was a joint expedition with the University of California and enabled a clearer picture to be obtained of the stratigraphy of the region than had been possible before. Several other expeditions were arranged, and such activities should be an incentive to museums in Great Britain to conduct similar work in spite of the financial position. The Cave Exploration Group has undertaken further work at the Specimen Cave, Naracoorte. An underwater research group has also been formed and is being fostered by the museum. Its activities—in which many members of the staff take part—has added many specimens to the marine collections.

Classification of Pharmaceutical Preparations

Because of the toxic or dangerous nature of many pharmaceutical preparations, special regulations are necessary to prevent risks of poisoning and other risks to which they may give rise. Trade in pharmaceutical preparations must be controlled, and for this purpose a classification of such preparations must be established. Twenty years ago it was relatively easy to establish such a classification, but since then hundreds of new preparations have been put on the market, and earlier systems of classification do not fully satisfy present requirements. The principles which inspired or still inspire such classifications vary from country to country. These regulations contain two common elements: certain pharmaceutical preparations may be supplied only against a medical prescription; and some may be sold only by pharmacists. Despite these common factors, the regulations of different countries vary considerably so that any possible attempt at obtaining uniformity is beset with difficulties. A survey of comparative health legislation based on health laws and regulations published in the *International Digest of Health Legis-*

lation, which he various systems of
classification tical preparations in ten
or more cour out the divergences in
these differen World Health Organiza-
tion. Classific maceutical Preparations :
a Survey of E ation. Pp. 56. (Geneva :
World Heal tion ; London : H.M.
Stationery O 2 Swiss francs ; 3s. 6d. ;
0.60 dollar).

Bacterial Pop e Nose and Skin

THE frequ oe of penicillin-resistant
Staphylococcu e noses of those working
in hospitals cillin factories has been
shown to be he presence of penicillin
in the envirc Villiams Smith and W. E.
Crabb of the lth Trust Farm Livestock
Research Cer ssex, decided to determine
whether the ctice of feeding pigs and
chickens con liets containing antibiotics
influenced th *us* population of the nose
and skin of t that of their attendants in
a similar ma *and Bact.*, 79, No. 2, April
1960). They ns where antibiotic feeding
was practisec here antibiotic feeding had
never been e approach was indicated to
a considerab rrent agricultural practice.
For exampl nable to examine as many
penicillin-fe would have wished because
in Great Br cillin additives in pig foods
have been ded by tetracycline addi-
tives ; on t in chickens it was possible
to study th eeding with penicillin and
chlortetracy tracycline together, for it
is customar penicillin with one or other
of the tetra est antibiotic-supplemented
poultry foo tigations showed antibiotic-
resistant str h more prevalent on animals
maintained. taining antibiotics than on
animals m diets that did not contain
antibiotics s also to their attendants.
Phage typ r tests showed that the
antibiotic-r ains isolated from the
attendants. identical with those isolated
from their

Controllin vers

LOCAL r Britain have had varying
success in to rid their sewers of rats.
Until rece ng has been growing that a
mere redu average level of infestation
was the uld be achieved, and that
this was for all the effort expended.
During th or so, the introduction of
new meth directed the way to further
progress, ing number of authorities
are report actory results, several having
achieved ances. A Technical Bulletin
prepared V. Bentley, of the Ministry
of Agricu and Food, has been written
to try to trend (No. 10: Control of
Rats in iii+22+4 plates. London:
H.M. St e, 1960. 2s. 6d. net). It
describes s of the ecology and behaviour
of rats i ns and the several ways by
which co brought about ; its main
emphasis d for effective planning.

Televisio s

THE f television services of Great
Britain i constant review by the Postmaster-General and his Television Advisory Committee. The latter in turn has a Technical Sub-Committee, which has been asked to consider the relative merits of the 405-line transmission used in Britain, and the 625-line system now in general use in Europe. Consideration has also been given to the possibilities of colour television and to the best direction in which to develop the higher frequency bands IV and V when these are available. To assist the sub-committee in its task, a working party was established to organize and conduct field trials designed to give technical data on the performance of some of the systems concerned. These trials were carried out during 1957–58, and in view of the importance of the scientific and technical results obtained, these are now made generally available in a report published by the British Broadcasting Corporation (Television Field Trials of 405-Line and 625-Line Systems in the UHF and VHF Bands, 1957–1958. Pp. 152. London : British Broadcasting Corporation, 1960. 20s.).

The first part of the report gives the results of field trials of 405-line television in bands I and V, using frequencies of about 45 and 650 Mc./sec., respectively. These show that the service area is more limited at the higher frequency, and is subject to greater irregularity in hilly terrain. It is therefore evident that a greater number of transmitters would be required for a band V service than is at present used in band I. In the second series of trials described in Part 2 of the report, a comparison was made between 405-line television in band I with 625-lines in band V. In areas where adequate field strength prevailed, the band V pictures were slightly better. The appendixes to the report contain a large number of diagrams illustrating in considerable detail the various features, subjective as well as objective, of the results obtained in these extensive trials.

New British Analogue Computer

IN a recent issue of *Nature* (186, 201 ; 1960) the first British digital-analogue computer, the *Corsair*, was described. Now a second machine of digital-analogue type has been introduced by the Redifon Company. The new Redifon machine differs completely in concept from the *Corsair*, since the actual calculations are performed exclusively by analogue techniques. Even multiplication, which is notoriously unsatisfactory using an analogue device, is treated in this way. The digital part of the machine lies in its input–output device which makes use of magnetic tape upon which information is recorded by a machine of standard keyboard and through which information can be obtained via a typing device of the sort used in adding machines. The magnetic tape store which is associated with the *Radic* system, as it is called, has a number of novel features, including the interesting one that the magnetic tape is perforated with sprocket holes and apparently moves discontinuously. This technique makes such operations as the serial correlation of recorded data particularly easy, and will undoubtedly result in the *Radic* computer filling a niche which previous analogue computers have failed to do.

Interstellar Extinction and Polarization

THE study of the particles in interstellar space is important for two reasons. First, interstellar dust produces absorption of light, and makes difficulties for astronomical distance determination. Secondly, the discovery of interstellar polarization by Hall and Hiltner indicated the existence of a general galactic magnetic field, and one would like to determine the strength and direction of this field. H. C. van de Hulst studied the scattering of light by homogeneous spheres, and from the observed extinction concluded that the interstellar grains are dielectric, and are about 1μ in size. The grains must be asymmetric in shape to produce interstellar polarization, and the relation between the observed polarization and extinction will depend on the shape of the particles. It would be an improvement if the theory could be based on scattering by long cylinders. R. Wilson (*Mon. Not. Roy. Astron. Soc.*, 120, 51; 1960) has recently published an approximate solution of this case for refractive index near unity. Extinction curves have been computed for different degrees of polarization; it is predicted that the colour excess per unit mass and the ratio of the total to selective extinction will both depend on the polarizability. The predictions are compared with observation, and confirmation is obtained of the existence of a general galactic magnetic field aligning the interstellar grains by a mechanism of paramagnetic relaxation as proposed by L. Davis and H. L. Greenstein. The new expression for the ratio of total to selective absorption may lead to substantial revisions in the distances of some of the more distant stars.

Abundance of Marine Plankton

An unusual and worthwhile statistical study of the abundance of marine plankton has been made by R. M. Cassie in the March issue of the *New Zealand Journal of Science*. He has analysed the results from a transect of sixty stations starting in the open sea and passing through a zone of mixed water into harbour water. Partial and multiple regressions were calculated, relating the abundance of each species to that of five other species, to temperature and to salinity. The regressions accounted for much of the variation, but the residuals were not randomly distributed, so that the interpretation of the results is necessarily inconclusive. It is inevitable that the results of one day's sampling should be suggestive rather than informative, but the technique which Cassie has described is likely to prove most useful in the quantitative study of the relationships of animals and plants to each other and to their physical and chemical environment.

Pelagic Polychaetes of the South Atlantic

The samples collected since 1925 during the Discovery Investigations of the southern oceans continue to provide fruitful material for studies of systematics and zoogeography. In Discovery Reports (30, April 1960), Mr. N. Tebble has made a study of the pelagic polychaetes. A systematic account is given of the twenty-nine species recorded in the South Atlantic; this is followed by a description of the distribution of these species in relation to the environment. Only three species were found to be endemic to the Antarctic zone, while sixteen were found only to the north of the Sub-Tropical Convergence. Of the remaining species, four were cosmopolitan in distribution. The results conform to the usual pattern of plankton distribution in the South Atlantic with a few species occurring in large numbers in the Antarctic zone and a great variety of species forming a small standing crop in the sub-tropical and tropical zones.

Research Committee on Archæological Field Experiments

Excavators have long had to deal with the setting up of ditches, soil creep and other similar phenomena. They also have to notice the activities of worms which have frequently considerably altered the original soil structure. Too little has been known about these matters, and at the Glasgow meeting of the British Association in 1958 a discussion on the natural processes leading to the burial of archæological remains was inaugurated. This led to the formation of a Research Committee which made preliminary investigations. The idea, now, is to start in a chalk down environment and to make there a simple earthwork which can be kept under review for a long period of time. Later similar projects in sandy and clayey situations will be undertaken as funds allow. The first site selected is near the summit of Overton Down near Marlborough, on the Fyfield Down reserve of the Nature Conservancy. After the earthwork is made a careful study at regular intervals will be undertaken so that more exact data relating to the infilling of the ditch and the weathering of different kinds of objects can be obtained. Only those with permits will be allowed on the site and no cars will be permitted anywhere near it. It is hoped in this way to learn something of the mechanics of these well-known phenomena in a chalk down milieu.

U.S. Gas Chromatography Research Center

A new Gas Chromatography Research Center, the first of its kind, has been established by the Barber-Colman Co., at Houston, Texas. The primary function of the Center will be new instrument development and evaluation of component parts and accessories. This will include the development of laboratory chromatographs, portable chromatographs, process monitors and custom instruments, as well as refinement of argon and flame ionization detectors, sample injection devices and other accessory designs. Further information can be obtained from Ad. Auriema, Inc., 85 Broad Street, New York 4, N.Y.

Analytical Chemistry and Applied Spectroscopy at Pittsburgh

The twelfth Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy will be held at the Penn-Sheraton Hotel in Pittsburgh, Pennsylvania, during February 27–March 3, 1961. About 150 papers will be presented on all phases of analytical chemistry and spectroscopy. A symposium entitled "New Frontiers in Optics and Spectroscopy" will be sponsored jointly by the Pittsburgh Conference and the Optical Society of America. Original papers are invited on all phases of analytical chemistry, spectroscopy, and nucleonics applied to analysis. The final date for receipt of abstracts is October 15. Further information can be obtained from Dr. William F. Harris, Research Laboratories, Westinghouse Electric Corporation, Pittsburgh 35, Pennsylvania.

The Night Sky in August

Full moon occurs on Aug. 7d. 02h. 41m. U.T., and new moon on Aug. 22d. 09h. 16m. The following conjunctions with the Moon take place: Aug. 3d. 18h., Jupiter 5° S.; Aug. 5d. 01h., Saturn 4° S.; Aug. 15d. 14h., Mars 4° N.; Aug. 15d. 17h., Aldebaran 0·3° S.; Aug. 31d. 01h., Jupiter 5° S. In

addition to
Mercury is in
17h., Mercury
Aug. 8d. 14h
Aldebaran of
Mercury is a
week of the
observation.
about 1h. 4C
nitude of Me
too close to
23h. 20m., 22
middle and e
Taurus, passi
its stellar ma
the Earth in
miles. Jupit
45m. on Au
Ophiuchus,
distance from
miles. Jupit
after sunset
favourable f
east of Jupi
0h. 05m. on
stellar magn
Earth on Au
of stars brig
observations
22h. 05·9m.
179 B.Tau.
R denotes
active durin
ditions are

tions with the Moon,
with Pollux on Aug. 5d.
Venus with Regulus on
g 1° N., and Mars with
12h., Mars being 5° N.
, and during the second
favourably situated for
3h. 00m. on August 13,
Sun; the stellar mag-
on this date. Venus is
servation. Mars rises at
2h. 20m. at the beginning,
ith, respectively. It is in
Aldebaran on August 17;
0·7 and its distance from
the month is 120 million
50m., 23h. 45m. and 22h.
nd 31, respectively. In
gnitude is −2·0 and its
n August 15 is 430 million
it low in the southern sky
ons are not particularly
Saturn is in Sagittarius,
2h. 15m., 1h. 10m. and
and 31, respectively. Its
and its distance from the
million miles. Occultations
agnitude 6 are as follows,
at Greenwich: Aug. 8d.
Aug. 15d. 02h. 46·2m.,
. 2h. 51·6m., 130 Tau. (*R*).
The Perseid meteors are
lf of the month, but con-
for observation.

University

California

Prof. Gr
the Biochem
mittees, D
National In
chairman c
College of A
at Berkeley
of Health,
poultry nut
Paul, Minn
at the Uni
land.

ggs, executive secretary of
armacology Training Com-
General Medical Sciences,
ealth, has been appointed
ment of Nutrition in the
the University of California
ing the National Institutes
as an associate professor of
Jniversity of Minnesota, St.
rofessor of poultry nutrition
yland, College Park, Mary-

Canberra

Prof. L.
chancellor
the end of
physics at

ry has been appointed vice-
to Sir Leslie Melville. Until
txley was Elder professor of
ersity.

Rockefeller Institute

Dr. Edw
Hirsch hav
of the Roc
pioneer in
to associat
also chair
the U.S.
recent yea
blood cell
been conc

ns, jun., and Dr. James G.
ed to professors and members
ute. Dr. Ahrens has been a
on lipids, and was promoted
the Institute in 1955. He is
Metabolism Study Section of
n Services. Dr. Hirsch in
vestigating the role of white
stance to infection, and has
e discovery of phagocytin.

Southampton

The C
received
tribution

University has gratefully
d Motor Co., Ltd., a con-
the 1962 Centenary Appeal Fund. The title of reader has been conferred upon Mr. A. T. Patterson (history) and Dr. W. H. Cockcroft (mathematics). Mr. H. C. Tottenham has been appointed to the readership in structural engineering (Department of Civil Engineering). The following new appointments have been made: H. S. Allen (lecturer in civil engineering), C. H. B. Mee (assistant lecturer in physics).

Announcements

Prof. Alexander Robertson, emeritus professor of organic chemistry in the University of Liverpool, has been appointed a member of the Agricultural Research Council arising from the appointment of Prof. E. G. Cox as secretary to the Council.

Dr. T. F. West has been appointed editor of *Chemistry and Industry*, the weekly journal of the Society of Chemical Industry. Dr. West is at present editor of *Pyrethrum Post* and the author of the standard work on DDT, of a treatise on chemical control of insects and of a book on synthetic perfumes. He was for some years a director of Drug Houses of Australia, Ltd.

Mr. G. D. Speake has been appointed deputy chief of research at Marconi's Research and Development Laboratories, Great Baddow, near Chelmsford, Essex. Mr. Speake joined Marconi's Wireless Telegraph Co., Ltd., in 1950, when he was engaged in radar systems research. In 1954 he was appointed chief of the Vacuum Physics Section of the Research Division, and two years later he became chief of the Microwave Physics Section.

The Research Study Group, which was appointed to study the need for further research into the effects of the use of toxic chemicals in agriculture and food storage, has begun its inquiries. The Group is prepared to receive written evidence of views on the subject of the inquiry from persons or organizations. Written evidence should be addressed to the secretary of the Group, Dr. E. J. Miller, Plant Pathology Laboratory, Hatching Green, Harpenden, Herts.

The British Society of Rheology will be holding a meeting on "Rheology of Polymers" at Swansea during September 8–10. Further information can be obtained from Dr. M. F. Culpin, 8 The Broadway, Pontypool, South Wales.

The 1960 International Conference on Nuclear Structure will be held at Kingston, Ontario, Canada, during August 29–September 3. Further information can be obtained from R. L. Graham, Atomic Energy of Canada, Ltd., Chalk River, Ontario.

The first International Symposium on "Cori' Ester and Phosphorylated Glucides" will be held at the Museo della Scienza e della Tecnica, Milan, during September 16–18. Further information can be obtained from the Secretary of the organizing committee of the Symposium, Via Modica 6, Milan.

An International Symposium on "Data Transmission" is being sponsored by the Benelux Section of the Institute of Radio Engineers in co-operation with Het Nederlands Radiogenootschap and the Institute of Radio Engineers Group on Communications Systems, at the Technische Hogeschool during September 19–21. Further information can be obtained from B. B. Barrow, secretary of the Benelux Section, Institute of Radio Engineers, Postbus 174, Den Haag, Nederland.

THE ROYAL SOCIETY: APPOINTMENTS AND AWARDS

THE Council of the Royal Society has appointed Dr. J. Seed, of the Department of Radiotherapeutics, University of Cambridge, to a Foulerton Gift research fellowship as from October 1, to enable him to carry out an investigation of the control mechanisms of nucleic acid and protein synthesis in normal and tumour cells, with particular reference to the actions of ionizing radiations in radiotherapy at the Department of Radiotherapeutics, University of Cambridge. The Council has also appointed Dr. D. T. Edmonds, of the Clarendon Laboratory, University of Oxford, to a Mackinnon research studentship as from October 1, to enable him to carry out magnetic investigation below 1° K. in large magnetic fields at the Clarendon Laboratory, Oxford.

The Committee representing the Royal Society and the Armourers and Brasiers' Company has appointed Dr. J. H. Brunton, of the Laboratory for the Physics and Chemistry of Solids, Cavendish Laboratory, Cambridge, to the Armourers and Brasiers' research fellowship as from October 1, to work on deformation characteristics of base metals at very high rates of strain, at the Laboratory for the Physics and Chemistry of Solids, Cavendish Laboratory, Cambridge.

Awards under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme have been made to the following: Dr. S. M. Bromfield, of the division of plant industry of the Commonwealth Scientific and Industrial Research Organization, Canberra, to assist him in visiting the Macaulay Institute for Soil Research, Aberdeenshire, for ten months from October, in order to develop his studies of processes affecting the availability of phosphorus to plants; Dr. J. A. Friend, senior lecturer in physical chemistry, University of Tasmania, to assist him in visiting the University of Reading for a year from January 1961, to enable him to study experimental techniques for the precise measurement of heats of mixing; Prof. I. Lauder, associate professor of chemistry, University of Queensland, to enable him to study 'ion-molecule' reactions by mass spectrometry at the University of Leeds, for six months from October 1960; Mr. W. V. Lewis, university lecturer in geography, Cambridge, to assist him to visit the Arctic Institute of North America, Montreal, for five months from April 1961 in order to study 'permafrost' areas, and areas once covered by large continental glaciers; Prof. H. McLennan, associate professor of physiology, University of British Columbia, to enable him to extend to invertebrate material, his studies on the chromatographic characteristics of an inhibitory principle present in mammalian brain, at University College, London, during June–July; Prof. H. B. Rycroft, director of the National Botanic Gardens of South Africa and Harold Pearson professor of botany in the University of Cape Town, to assist him in completion of study of the genus *Protea* at the Royal Botanic Gardens, Kew, and elsewhere in the United Kingdom, for six months from July.

Awards of grants by the Paul Instrument Fund Committee have been made as follows: £1,000, in supplement of a previous grant to Prof. J. D. McGee, professor of instrument technology, Imperial College of Science and Technology, London, for the construction of a television system for X-ray image intensification; £500, in supplement of a previous grant, to Dr. H. Motz, Donald Pollock reader in engineering science, University of Oxford, for the construction of a linear accelerator working at 1·6 cm. (*J*-band); £3,230, in supplement of a previous grant, to Dr. P. M. B. Walker, Royal Society research fellow, department of zoology, Ashworth Laboratory, University of Edinburgh, for the construction of a high-speed integrating microspectrophotometer, to facilitate the analysis of biological cells or liquid droplets of the order of 10^3 cubic microns volume.

AUSTRALIAN BREAD RESEARCH INSTITUTE LABORATORIES

DR. D. A. CAMERON, Minister for Health and Minister-in-Charge of the Commonwealth Scientific and Industrial Research Organization, Australia, opened the new laboratories of the Bread Research Institute at North Ryde, a suburb of Sydney, on May 16. Dr. Cameron said that it was good to see such an excellent relationship between the bread manufacturers, who had started the Institute, and the Government which contributed to its costs through the Commonwealth Scientific and Industrial Research Organization. Mr. W. Sloan, president of the Council of the Institute, remarked that the occasion was being attended by bakers from every State in Australia and from New Zealand.

The new Institute comprises laboratories covering some 14,000 sq. ft., on a three-acre site at North Ryde which was made available by the Organization. The total cost of the building was about £75,000 of which £30,000 was contributed by the Organization. During the past thirteen years the Institute has been housed in laboratories in Pacific Highway, North Sydney, which it has now outgrown. The new site will allow room for expansion, and has the advantage of being in close proximity to the laboratories of the Organization's Division of Food Preservation and Transport, now under construction.

The Bread Research Institute was established in New South Wales in 1947 following the Kinsella inquiry into the bread industry. The noted British cereal chemist, Dr. D. W. Kent-Jones, went to Australia in 1947 to advise on the establishment of the Institute. In 1950, it was recognized by the Commonwealth Scientific and Industrial Organization as an industrial research association, and now receives an annual grant from the Organization, related to its industrial income. This year the grant will be about £15,000.

With funds made available from the Wheat Industry Research Council, the Organization has recently established a small Wheat Research Unit for bio-

chemical inve
Research Ins
its new labor
will act as of
The work
effect in im
industry, an
Australia, w
provided a
materials us
demonstratio
newsletters
ledge and pr
country. It
gramme of
of wheat an

heat quality. The Bread
sed to house this unit in
e director of the Institute
of the unit.
e has had a very marked
standards of the baking
d by bakers throughout
ps in close touch. It has
for flour and other raw
ustry, and by means of
ng bakers and a series of
ns it has brought know-
o bakeries throughout the
lt up an important pro-
search in various aspects
, the properties of doughs

and other subjects. This work has been done in close association with the Organization, the State Departments of Agriculture and some of the universities.

The Institute's influence now extends strongly to the flour milling industry, where its work has been largely responsible for the establishment of standards of flour quality. This has been important to the bread industry, which is thus enabled to insist on definite quality specifications for the flour it buys and has been particularly important for building up the export trade in wheat and flour. The Department of Trade and the Australian Wheat Board have called extensively on the services of the Institute in this connexion, and officers of the Institute have visited Japan and other countries in the East and Middle East to advise on the use of Australian wheats.

U.K. ENERGY RESEARCH ESTABLISHMENT: WANTAGE RESEARCH LABORATORY

By B. S. SMITH
Head of the Isotope Research Division

AFTER
the pr
United Kin
to reorgani
so as to en
of isotopes
years. Th
continue to
reactors at
The prepar
compounds
at the Radi
on the app
of radiatio
Research I
Establishm
are at Wa
Hailsham
Authority
facilities
sources a
scientists,
variety of
As the
unlimited
available,
examine t
high cost
from fissi
use cobal
as the de
chemical
power p
considera
cobalt wh
gramme f
There
cells in
which th
radiation
pre-deter
strength
curies, a
controlle

rs successful expansion of
and use of radio isotopes,
Energy Authority decided
research and production
rther expansion of the use
expected in the next few
of the raw materials will
in the Authority's nuclear
der Hall and Chapelcross.
es, the synthesis of labelled
sting are being concentrated
re at Amersham. Research
dio isotopes and on the use
oncentrated in the Isotope
e Atomic Energy Research
laboratories of this Division
e formally opened by Lord
In these laboratories the
focal point where extensive
h isotopes and radiation
d by about two hundred
n are graduates in a wide

programme develops, almost
radiocaesium will become
e tasks of the Division is to
sive radiation sources. The
extract and encase caesium
akes it more economical to
ation source until such time
the construction of a large
nt. Fortunately, the nuclear
provide as a by-product
of radiocobalt, and it is this
e basis of the radiation pro-

ee large versatile irradiation
concrete shielded rooms in
apparatus can be set up under
s, and then irradiated by a
ation of sources. The source
use range from 100 to 10,000
the cells are temperature

In the radiation chemistry field, investigations have been concentrated on such chain processes as polymerization, oxidation and halogenation. The effects of radiation on catalysts are also being studied. In the food and medical applications section, the use of radiation for sterilization of equipment is giving encouraging results, particularly in expanding the use of plastic materials which are unsuitable for heat sterilization. A study is being made on the use of radiation for the control of *Salmonella* in frozen eggs, desiccated coconut, and imported cattle feed with a high protein content. The plant genetics section has been studying the external factors which influence the radio-sensitivity of plants and the conditions under which radiation can be used to break down the interspecific incompatibility.

The Laboratories have a small animal house for testing food and pharmaceuticals for possible toxicity, glass houses and trial beds for the plant genetics work, and constant temperature rooms for insect culture.

To gain experience at the pilot stage of projects, and to allow manufacturers to carry out extensive trials, a package irradiation plant has been built in conjunction with the Owen Organization and is at present undergoing proving trials. The plant permits the automatic handling of standard packages (14 × 12 × 9 in.) through an irradiation field providing a dose of 10,000 rads to 5 megarads, according to the rate of traverse. The capacity of the plant is about 100 cu. ft. a day at a sterilizing dose of 2·5 megarads, and larger quantities at lower total doses. The plant is initially loaded with 150,000 curies of cobalt-60 and the cost of giving 1 cu. ft. of material a dose of 2·5 megarads is about 15*s*. This cost will be considerably reduced in plants designed for a special purpose. It is planned to rent four-fifths of the capacity of this plant to industrial concerns, and although it is not yet in operation its capacity has already been oversubscribed.

The Laboratory also operates an irradiation pond at Harwell. This uses the high gamma flux available from the spent fuel elements from the *Dido* and *Pluto* research reactors. It consists essentially of a water pond 20 ft. deep with facilities for mounting the freshly discharged fuel elements in a lattice containing a number of irradiation positions. The material to be irradiated is placed in watertight cylinders (3¾ or 7¼ in. diam. and 30 or 48 in. long) which are then lowered through the water shield to the irradiation position. The pond usually contains more than a megacurie of fuel element activity and will give up to 4 megarads/hr. in the small irradiation cans. The present charges for irradiation in this unit work out at about 10s. per megarad to a cubic foot of material.

In addition to the cobalt and fuel element sources, there is a 4-MeV. linear accelerator with a 2-kW. electron beam output. It is used principally for treating small samples to high dose-levels of the order of 10^8 rads and also to study dose-rate effects. It gives dose-rates a hundred times higher than those available from the gamma cells.

The Division has medium-level and tracer-level chemical laboratories. The fields covered are wide and include the incorporation of isotopes in colloids for medical studies, improved methods of synthesis of labelled compounds, the use of autoradiography as an analytical tool in metallurgy, and the operation of an activation analysis service for other laboratories.

In the physics laboratory a section works in close collaboration with the National Physical Laboratory and other national laboratories on the absolute measurement of radioactivity. It has established standards of radioactivity and issues standards for many isotopes not yet covered by the standards service of the Radiochemical Centre. The work on instruments and radiation detection is largely directed towards widening the fields of application of gauges using radioactive sources and increasing the sensitivity and discriminating powers of detectors so that tracer uses of isotopes can be extended without increasing the quantity of isotope used.

An essential feature of the work of the Research Laboratory is to discover those industrial processes and fields of industrial and academic research where advantages can be gained by the introduction of instruments or techniques using radioactive materials. An experimental and advisory service is operated which will visit firms and discuss general and particular problems, and on a payment basis will make special investigations either on the firm's premises or back in the laboratories. To further this objective, exchange visits are made with the research associations of many trades, and the Department of Scientific and Industrial Research has attached a small group which uses the facilities of the laboratories and acts as a further contact with research and industry.

For a fixed capitation fee, firms can attach a scientist to the laboratory to work on a problem of either general or commercial interest. In this way a satisfactory blending of the skills of the firm in its own field with the facilities and experience of the Laboratory is achieved.

No outline of the facilities of the Laboratory would be complete without mention of the Isotope School. It was first set up at Harwell in 1951 to give basic training in the uses of radioisotopes in research, industry, and medicine. It is open to students from all countries, and provides a basic four-weeks' course several times a year, together with a number of courses on specialized subjects such as medical applications, radiological protection and autoradiography.

PROTECTION AGAINST TIDAL FLOODING IN LONDON

MEMORIES of the effects on the east coast of Britain of the disastrous storm surge of January 31–February 1, 1953, are beginning to dim. A Government report[1], which has recently been published, is therefore a timely reminder that in the vitally important London area there is no justification for complacency concerning the present degree of protection against tidal flooding.

It is true that in 1953 the low-lying areas of London escaped flooding, but the water lapped the top of the defences at many points so that the margin of safety must have been very small. Thus the question might well be asked as to how it is that seven years afterwards the defences of London are still virtually the same, whereas at almost all other vulnerable points on the east coast of Britain they have been greatly strengthened. As will be seen, the explanation lies in the complexity of the problem and the high capital cost of a solution.

In 1953 the maximum level of the surge-cum-tide at London Bridge was 6 ft. above predicted high water. When considering the possibility of a future even higher maximum level, there are four significant features of the 1953 event which should be borne in mind: (*a*) the river discharge was low—only 2,600 cu. ft./sec.; (*b*) the normal tide on which the surge was superimposed was a spring tide, but not a particularly high one; (*c*) the peak of the surge did not coincide with the time of predicted high water, but preceded it by about 2 hr.; (*d*) considerable breaching and overspill into low-lying areas occurred farther down the estuary.

Any of these features could have been more adverse, in addition to which the magnitude of the surge itself might have been slightly greater. In order to investigate these possibilities, tests were carried out on a hydraulic model[2] of the Thames estuary. It was deduced that a major river flood of 20,000 cu. ft./sec. would have raised the 1953 level by 6 in.; also that an increase of 1·5 ft. in the surge height at Southend (or a correspondingly less favourable phasing with tide) would have added about 1·7 ft. at London Bridge, while a 3 ft. increase would have added about 3 ft. at the same point. The relief due to storage in low-lying areas was shown to be quite small—not more than 3 in. Owing to raising of the banks this should be discounted in the future.

Thus it appears that a surge 1·5 ft. higher, coinciding with a freshwater flood, would raise water-levels by about 2·7 ft. above those of 1953. If the extreme, though exceedingly remote, case be considered of the highest possible surge coinciding with a peak spring tide and a freshwater flood, then the resultant water-levels might be expected to be about 6 ft. above 1953.

Also, it shor
consideration
relative rise i
is about 1 ft.
The Waver
position at L
submitted in
the problems
tive schemes
direct raising
struction of a
latter would c
taking, invol
and unusual
that the best
Purfleet and
In accorda
tions, a tech
the purpose
recently pub
follows, is a
together wit
who were aft
technical rep

The cost o
2–3 ft. abov
region of £1
added a cons
compensatio
The locati
satisfy both
From each o
was acknowl
regard to de
navigational
were that tv
should be pr
ance of abou
would be r
except whe
imminent, t
passage of s
Under the
in operation
a potentiall
would enabl
levels were r
would build
consequent
be allowed
riverine side
sufficient to
of closure.
to be of suf
tide 6 ft. hi
wave should
lying areas.
With the
ing consulte
that there
could be re
(*a*) the ver
bridge type
The liftin
piers each 7
Between th
suspended r
hinged gate

d out that a long-term
to take into account the
uch in south-east England

)[3] was very mindful of the
pecial section of its report,
oted to a consideration of
It suggested two alterna-
further investigation: a
an defences, or the con-
rier across the river. The
nidable engineering under-
l problems of a difficult
peared to the Committee
e in Long Reach between

Committee's recommenda-
as constituted in 1954 for
oth these proposals. The
briefly outlined in what
the findings of the Panel,
e engineering consultants
ated to make a preliminary
rier scheme.

Measures

parian defences to a height
ter-levels would be in the
which would have to be
unknown sum in respect of
s.
of a barrier would have to
on and shipping interests.
of view the Long Reach site
he most favourable. With
, the stipulations made on
particularly severe. These
ngs of about 500 ft. width
a minimum vertical clear-
ditional smaller waterways
ght craft. At all times,
is surge was present or
ould be open to the free

system, which is at present
oast, about 6 hr. notice of
surge is received and this
o be closed when the water-
After closure, water-levels
ntly on either side and the
essure head would have to
sign of the gates. On the
capacity would have to be
water flood for the duration
he side the gates would have
to withstand a surge-cum-
3. Also the reflected tidal
erspill into important low-

of reference, the engineer-
the problem and decided
o types of barrier which
s being suitable, namely:
idge type; (*b*) the swing

would consist of three main
porting towers 320 ft. high.
ng bridge spans would be
wer side these would carry
rrier open the bridges would

be in the fully raised position. When closure was necessary, the bridges would be lowered to just above flood-level and the hinged gates then swung downwards to come to rest in the vertical position against the concrete sill at the bed of the river. A somewhat similar, but much smaller barrier, has recently been constructed on the River IJssel, Holland. Experience gained in its operation should prove invaluable.

The swing bridge type would have a similar foundation design to that just described, but the three central piers would have a much greater length in the direction of flow. Three lattice girder swing spans would be pivoted on the piers and these would carry the hinged gates in the same manner as in the first type. On closure, the spans would swing on their pivots, meeting in the centre of the two main waterways.

The lifting type would be better for navigation, owing to the shorter piers, whereas the swing bridge type would be easier to maintain. The estimated cost of the swing bridge type is lower—between £13 and £15 million as compared with between £15 and £17 million. Further experiments and investigations would be required before a final choice could be made.

From the flood protection aspect, the barrier scheme is decidedly preferable to the raising of the riparian defences, since the former would provide a standard of protection 6 ft. above 1953 levels whereas the latter could only reasonably be raised by about 3 ft.

The next stage is that consultations between interested parties will take place with the view of establishing the degree of support for the proposals and considering the arrangements for putting them into effect.

Flood Economics

It is often found with flood protection works, and the case of London is no exception, that the capital cost is high and the need only patently demonstrated at infrequent occasions. In these circumstances, there is an understandable tendency for the urgency accorded to a particular scheme to diminish progressively with the time which has elapsed since the last flood. A gamble with fate is tempting when the odds are long, but it is generally advisable to be cognizant of the stakes.

The worthwhileness of a protection scheme may be assessed on an economic basis. This entails a comparison between the cost of protecting against a particular flood, and the cost of the damage which would otherwise result. It is of course necessary to take into account the likely interval of recurrence of the flood, and this may be estimated by statistical methods.

The danger to public safety and the damage which would be associated with various degrees of overspill in London have not been generally made known. It is significant, however, that the Dutch are planning the Delta scheme on the basis of a flood with a 10,000-year recurrence interval. This standard may be compared with the estimated 400-year interval of the 1953 flood.

N. B. WEBBER

[1] "Technical Possibilities of a Thames Flood Barrier". Pp. 30+3 plates. (Cmnd. 956.) (London: H.M. Stationery Office, 1960.) 3*s*. 6*d*. net.

[2] Allen, F. H., Price, W. A., and Inglis, C. C., *Proc. Inst. Civ. Eng.*, 4, Pt. 3, 48 (1955).

[3] "Report of the Departmental Committee on Coastal Flooding". (Cmnd. 9165.) (London: H.M. Stationery Office, 1954.)

ARID ZONE PROBLEMS

A GENERAL symposium on the "Problems of the Arid Zones" was held at Unesco Headquarters in Paris during May 11–18. It was attended by more than two hundred delegates, representing twenty scientific disciplines, from thirty-four countries, the latter including all the major arid areas of the world; the U.S.S.R., the United States, France and the United Kingdom were all well represented.

The symposium was opened by Mr. Vittorino Veronese, director-general of Unesco, who warmly welcomed the distinguished delegates from so many countries. He directed attention to the importance of the arid zones, which cover one-third of the Earth's surface, in relation to the need for increasing the food resources of the rapidly increasing world population, which has already reached the 2,000 million mark, and is expected to double itself within the next fifty years. The universal character of the results of research in the arid lands and the importance of employing them to the common good make this research a suitable field for international action, particularly through Unesco, which is charged by its constitution to promote scientific research with the view of improving the living conditions of mankind.

The director-general introduced the president of the symposium, M. P. Piganiol, delegate-general for scientific research of the Government of France, whose responsibilities cover the organization of scientific research in that country; he addressed the delegates on the main problems to be faced by the symposium, the principal object of which was to evaluate the results already achieved and to make recommendations regarding the future course of arid zone research.

The general arrangements for the symposium, which followed the recommendations of the Unesco Advisory Committee for Arid Zone Research at its meeting in Madrid in September 1959, were carried out with great care and efficiency by the Arid Zone Unit of the Unesco staff. Review papers covering the principal scientific disciplines were requested from acknowledged leaders in their particular fields, and the discussions that followed added considerably to the value of the papers. The Proceedings of the symposium, which should be of considerable scientific interest and value, will be published in English and in French by Unesco in its Arid Zone Research Series.

In 1951 Unesco was given the task of promoting research in the arid zones, which for this purpose are taken as including also the semi-arid areas; by an extension of stock raising and the building of great new irrigation schemes in suitable areas, these zones are capable of augmenting considerably world food supplies. This basic research led to such interesting and useful results that in 1957 the activities were raised to the rank of a major project, whereby increased funds were made available for it with special reference to the arid belt extending across northern Africa from Morocco to Egypt and thence through the Middle East to Pakistan and India. Following eight years of activity on the many facets of arid zone research, including three years devoted to the major project, the general symposium has been held with the object of reviewing the results of this research and to suggest new directions of useful activity.

Also, since the major project is due to be terminated at the end of 1962, this review had to be made now in order to provide in good time for the continuation of arid zone research after 1962. The General Conference of Unesco in 1958, in approving the holding of the general symposium, had directed the director-general to submit to it in November, 1960, a report on the past effectiveness, and recommendations for the future course, of the major project, on the basis of the study and recommendations of the symposium.

In order to achieve this purpose, the symposium was divided into four parts.

(1) Critical Appraisal of the State and Perspectives of Knowledge in the Various Scientific Disciplines Involved

For this part of the symposium, review papers were presented in the following fields of science, most of which have formed the subjects of symposia or research reviews organized under the Unesco Arid Zone Programme:

(i) Surface hydrology (including sedimentation)—Dr. W. B. Langbein, U.S. Geological Survey, Washington.

(ii) Geology, geomorphology and ground-water hydrology—Dr. F. Dixey, former director of Overseas Geological Surveys, London.

(iii) Climatology (including hydro-meteorology)—Dr. C. C. Wallen, Swedish Hydrological and Meteorological Service, Stockholm.

(iv) Microclimatology (physical and biological)—Prof. W. R. Van Wyk and Prof. J. de Wilde, Agricultural University, Wageningen.

(v) Soil science (including soil conservation)—Dr. Georges Aubert, Chef du Service des Sols de l'Office de la Recherche Scientifique et Technique Outre-Mer, Paris.

(vi) Salinity problems of plants and soils—Dr. H. E. Hayward and Dr. L. Bernstein, U.S. Salinity Laboratory, Riverside, California.

(vii) Plant physiology—Prof. M. Evanari, Hebrew University, Jerusalem.

(viii) Plant ecology—Prof. G. Lemée, Faculté des Sciences, Paris, and Prof. L. Emberger, Institut de Botanique, Montpellier.

(ix) Human and animal physiology and ecology (including human and animal population problems)—Dr. D. H. K. Lee, Quartermaster Research and Engineering Command, Natick. Development of arid lands and its ecological effect on the insect fauna—Dr. B. P. Uvarov, former director, Anti-Locust Research Centre, London.

(x) Local energy sources—Mr. E. W. Golding, Electrical Research Association, London, and Dr. Tabor, National Physical Laboratory, Jerusalem.

(xi) Saline water conversion—Dr. E. D. Howe, College of Engineering, University of California, Berkeley.

(2) Appraisal of Unesco's Activities in Promoting Research and Training related to Arid Zones

This was supplemented by reports on related activities of international governmental organizations and by reports from Member States in the major project areas.

Under this heading was presented a comprehensive report by the Secretariat describing Unesco's activities under the major project and the preceding arid zone programme in organizing the symposia and research reviews already referred to, the financial and technical assistance given to a number of research institutes within the arid zone, as in Egypt, Israel, India and Pakistan, the organization of training courses in hydrology, plant ecology, microclimatology, etc., required by the scientific staff of arid lands, and the granting of fellowships in such subjects; the report also underlined the results achieved and the difficulties encountered. The United Nations Water Development Centre, the United Nations Special Agencies, including the Food and Agriculture Organization, the World Health Organization, and the World Meteorological Organization, the international scientific organizations, including the International Union of Geodesy and Geophysics, the International Geographical Union, and the International Commission on Irrigation and Drainage, and the Commission for Technical Co-operation in Africa South of the Sahara, also submitted reports of their activities and plans in relation to the arid zone. Finally, most of the Member States of the region of the major project submitted similar reports.

These various reports demonstrated the close collaboration that exists between Unesco and the Special Agencies, and certain international scientific bodies, in the joint attack on the problems of the arid zones; for example, Unesco co-operated with the Food and Agriculture Organization on a desert locust ecological survey, on an ecological map of the Mediterranean area, and on forest and grazing policies in arid and semi-arid areas, with the World Meteorological Organization on the measurement of solar radiation and on a climatological survey of solar radiation, with both Organizations on an agro-climatological study in arid and semi-arid areas of the Mediterranean region, with the International Association of Scientific Hydrology in certain hydrological and hydrogeological problems, and with the International Commission of Irrigation and Drainage on the prevention of evaporation losses from irrigation systems.

(3) Studies on Selected Problems Illustrating Difficulties in Translating Knowledge into Action in Arid Zone Research, Training and Development

Since it had become increasingly clear with widening experience that a considerable gap tends to develop between the accumulating scientific knowledge of the problems of the arid zone and its application in daily life by the pastoral, agricultural and other inhabitants of the lands concerned, papers were called for devoted essentially to the difficulties of translating knowledge into action in certain typical situations; accordingly papers were presented under three main headings as follows:

(i) *Nomadism in relation to grazing resources.* The Sahara and the Sahel—Prof. R. E. Capot-Rey.

Moving of flocks in the Sahelian zone—O. Bremand and J. Pagot (Prohuza).

The Near East Arab countries—Dr. Mohammed Awad, Cairo.

The mountain and plateau areas of South-West Asia—Dr. F. Barth, Norway.

Nomadic pastoralism—Food and Agriculture Organization, Rome.

(ii) *Alternative uses of limited water supplies.* Studies were presented underlining approaches in four distinctive regions as follows:

United States. Water and the arid zone—Dr. L. Leopold, U.S. Geological Survey, Washington.

Algeria. Possibility of using minor water resources—Mr. G. Drouhin, Director de l'Hydraulique et de l'Equipement Rural, Algiers.

United Arabic Republic. Egyptian region—Dr. Youssef Simaika, technical adviser, Ministry of Public Works, Cairo.

U.S.S.R. Basic trends and methods of water control—Prof. A. N. Askoschensky, member of Lenin's Academy of Agricultural Sciences, Moscow. Also, Prof. Gilbert White, University of Chicago, considered these regional aspects in a review paper on alternative uses of limited water supplies.

(iii) *Public awareness and the educational problem.* Under this heading were submitted papers related to certain special problems in arid zones as follows:

Agriculture (Israel)—Prof. D. Weintraub, Hebrew University, Israel.

Irrigation and land use (Pakistan)—Dr. A. G. Ashgar, Pakistan.

Mineral resources (Sahara)—J. Petit, Prohuza, French Research and Information Centre on Human Problems in Arid Zones.

Agriculture: extension work in the Near East—Z. Behravesh, Food and Agriculture Organization.

(4) Study of the Perspectives for Future International and National Action in Arid Zone Research, Training and Development

The discussion at this concluding session of the symposium was based on the previous papers and discussions, and on a paper prepared by Unesco showing the administrative, financial and other considerations to be taken into account in submitting proposals for an extension of Unesco's arid zone research programme.

From this discussion it was clear that the symposium was unanimously of the opinion that the Unesco arid zone research programme should be continued for some years at not less than the present level, and that it should be extended particularly to cover the Latin-American countries; it was considered also that the organization of training courses and fellowships should be expanded. In addition, it was recommended that the Advisory Committee should continue to function on its present lines. Finally, many new projects and lines of research were suggested, including particularly an international study of the artesian basins of northern Africa; the extension of integrated surveys, including surveys relating to geology, geomorphology, water supplies, pedology, plant ecology and microclimate; the study of plant response to environmental factors; soil biology; insect pests and plant diseases; diseases linked with irrigation systems; and human environmental physiology.

The suggestions and comments made at the symposium were examined by the Unesco Advisory Committee on Arid Zone Research in a special review session held immediately afterwards, and they will be taken carefully into account when the Unesco governing bodies come to consider the future of arid zone research. The Advisory Committee met also during the two days prior to the symposium, and the Sub-Committees on Cartographic Problems in the Arid Zones, and on the Socio-Economic Problems of the Arid Zones, also held meetings at this time.

During the symposium there was an exhibition of maps, photographs and publications illustrating the activities of Unesco, the member States and other bodies; two excellent films were also shown—the Unesco film, "Arid Lands", produced by World Wide Pictures, Ltd., based mainly on scenes and research activities in Pakistan, Israel and Morocco, and a Russian film depicting arid zone development, in respect of irrigation, dry farming and stock raising, in the Karakum and other deserts of the U.S.S.R. Also, a party of delegates visited the phytotron being set up at Gif-sur-Yvette by the Centre National de la Recherche Scientifique; the studies in plant physiology at the phytotron, with special reference to growth under varying conditions of light and temperature, were demonstrated by the director, Prof. P. Chouard.

In respect of the high standard of the papers presented, of the many countries of the arid zone represented, and of the free discussions that followed the papers, the symposium marked an important stage in the study of the arid zones; moreover, it afforded a valuable review of present knowledge and of the scope and nature of future research, and it clearly achieved its objective in presenting, for the consideration of the governing bodies of Unesco, a unanimous and broadly based opinion on the importance of maintaining arid zone research and training at a high level.

Whatever may be the final decision, Unesco's achievements to date will rank high as a contribution to science in making known the problems of the arid zones, and in assisting in their scientific investigation, thereby leading also to the increased economic and social development of these lands. F. Dixey

SELF-REGULATION IN LIVING SYSTEMS

THE Ottawa symposia on "Self-regulation in Living Systems" organized by Dr. D. K. C. MacDonald of the National Research Council shows signs of becoming an annual series (*Nature*, 184, 239; 1959, and 183, 370; 1959). The third meeting was held on March 4, in Montreal, with the Montreal Neurological Institute and McGill University as joint hosts. The attendance exceeded thirty people, representing most medical branches, physics and engineering. The theme was "Tremor", and on this occasion the topics of discussion were introduced by clinicians and illustrated with the willing co-operation of patients. Discussion during the day was general and spirited.

Dr. F. L. MacNaughton (Montreal Neurological Institute) introduced the subject of 'clonus' (alternating contractions and relaxations of muscle). A patient with ankle clonus was introduced and subsequent discussion on the mechanism of oscillation was therefore restricted to this example. The oscillation could be initiated by a sharp application of force to the ball of the foot, and was sustained as long as the force remained. Simultaneous but asynchronous oscillation of both feet could be produced. The oscillation frequency was about 4 c.p.s. and increased only slightly with pressure. The disease had been caused by a spinal tumour pressing on the spinal cord; the tumour had recently been removed and there was some slight improvement in the patient's condition. She was paralysed from the waist down and could not feel the clonus directly. MacNaughton explained that the disease was known to be caused at the spinal cord level, rather than higher in the central nervous system. Ankle clonus was produced mechanically by involuntary contractions of the leg's rear lower muscle (gastrocnemius) followed by relaxation under action of the external force. Clonus was not produced by a coupled oscillation between the rear and front leg muscles, and disappeared if the afferent stretch receptors in the gastrocnemius were cut. Any healthy person can produce clonus, for example, by trying to lift an unliftable weight.

After this discussion Dr. MacDonald (National Research Council) exhibited a simple closed-loop system as an illustration of the instability features discussed above. In this demonstration a galvanometer mirror deflected a light beam so as to follow the physical movement of a photo-cell. Normal stable following was produced by negative feedback at some gain. Sufficiently increased gain, however, drove the light spot into a tremor, as did increase of the controllable time-delay in the circuit.

Dr. Burns (McGill) discussed the physiology of the basic causal loop; that is, muscle-stretch receptor—multiple afferent nerves—spinal cord—multiple motor neurons-muscle. With nerve propagation speed of order 10^2 m./sec. and nerve-length of order 1 m., the propagation time of the nerve in the loop is 20 msec. (2 nerves); other lag-times in the circuit are negligible. This loop delay-time would produce an oscillation of 25 c.p.s. if it were the direct cause of clonus, but this provides poor correlation with the observed 4–10 c.p.s., and of course this closed-loop action is the same in normal healthy voluntary actions.

The situation is complicated by the fact that the components of a multiple-nerve system do not fire simultaneously, but rather in a statistical pattern approaching a Gaussian distribution of frequency, and propagation velocities are also distributed about a mean in the range 70–120 m./sec. Furthermore, the excitability of a nerve follows a time pattern after firing as indicated in Fig. 1.

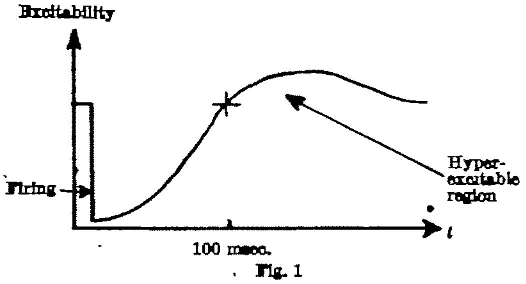


Fig. 1

In discussion, Dr. Burns wondered whether the nerves in clonus might fire almost simultaneously due to hyperexcitability. The observed oscillation frequency corresponds well to a closed-loop oscillation based on the 100-msec. time-delay to hyperexcitability in a nerve after firing.

In the afternoon, Dr. MacNaughton introduced a patient with Parkinson's disease. The particular symptom studied was a tremor of the thumb and forefinger, in the frequency range 3–5 c.p.s. Amplitude increased with concentration, excitement and fatigue, but disappeared during sleep. Application of a heavy weight to the hand only reduced the amplitude. Purposeful action of the hand was quite possible and tremor decreased during a 'slewing' action, but increased, for example, as the hand approached the pen it was going to pick up.

Dr. Blundell (Montreal Neurological Institute) discussed the tremor problem from the point of view of the surgeon, particularly in relation to Parkinson's disease. Surgical possibilities are: (1) To cut the motor nerves; but then no movement is possible. (2) To cut the afferent nerves. This removal of feedback would be justified in extreme cases if it overcame incapacitating tremor. This is true of clonus, but in one known operation on a Parkinsonian case, tremor remained, although at a different amplitude. (3) To cut in the area of the central nervous system. This is the current field of research. Results so far are rather conflicting, and there is insufficient knowledge for confident surgery. Dr. Blundell then detailed the following possibilities as tremor producers: (1) servo-loop oscillations; (2) rhythmic oscillations, for example, by a steady driving mechanism in the brain; (3) hyperexcitability of cells, due to disease.

Dr. Burns also developed the physiology of muscle action somewhat further. Recently a second loop (the 'gamma' loop) has been identified by which 'small' motor neurons are fired from the spinal cord to contract the fibre which is measured by the length receptor. In addition, the afferent nerves from the stretch receptors communicate with the central nervous system. In turn the central nervous system communicates with both the 'big' and 'small' motor neurons. Several more loops are thus added, and much remains to be learned of the combined control action.

Dr. Jasper (University of Montreal) described extensive experimental measurements on tremor, being carried out at the University of Montreal, using micro-electrodes. Frequency measurements of the action potential of muscles in clonus and Parkinson's disease look exactly alike. On the other hand, the cortical phenomena seem different. Some 15–20 per cent of the cortex cells seem to show activity correlated with tremor, but not enough is yet known. In monkeys, tremor has been produced by a small cut in the brain in the appropriate area; a 'large' cut can then remove the tremor.

Finally, Dr. J. A. Tanner (National Research Council) reported the work being done by Massachusetts Institute of Technology and Yale University on measuring the impedance of the wrist and finger extremities when subjected to sinusoidal or stochastic vibrations. The impedance falls with frequency as might be expected for an inertial load, except that in healthy people there are resonant peaks in the 7 and 17 c.p.s. regions. These are as yet unexplained. In patients with tremor the major resonance is due to the tremor, but at a different frequency than the tremor itself, lying between the 7–17 c.p.s. peaks. This overshadows the other resonances, naturally enough.

A spirited discussion followed concerning the relative usefulness of the 'black box' technique as illustrated by the impedance measurements just described, and the classic analysis-techniques in which individual elements are isolated and their characteristics learned before they are combined together. Everyone agreed that the latter method is ideal if it can be used. Opinion was divided as to whether the 'black box' techniques could be useful, since the 'black box' may often be altogether too complex. I myself feel that both approaches are useful and must be pursued in parallel. This in fact is done of necessity in both engineering and medicine at least.

J. H. MILSUM

SCHIZOPHRENIA AND LOW-GRADE MENTAL DEFICIENCY IN SWEDEN

A CLINICAL and genetico-statistical analysis of schizophrenia and low-grade mental deficiency of a large rural population of 25,000 people in Sweden indicated that altogether 1,790 individuals belonging to 231 families were suffering from schizophrenia, and 1,541 individuals belonging to 215 families were low-grade mental defectives*.

Of the cases of schizophrenia, 50 per cent were classified as hebephrenic, 33 per cent as catatonic, 10 per cent as paranoic and 7 per cent as atypical. 70 per cent of the cases had symptoms generally described as catatonic, but only 20 per cent had them in connexion with the onset of the psychosis.

The mean age at onset of schizophrenia among females, 32 years, is significantly higher than that, 28 years, among males. The psychosis had an acute onset in approximately 40 per cent of the cases and a periodical course in many cases, there being no sex difference. There is thus a positive relationship between acute onset of schizophrenia and periodical course of the psychosis.

There was a statistically significant association between schizophrenia and mental deficiency. Such an association has not been statistically established previously. The morbidity-rate for mental deficiency—including high-grade defectives—among the schizophrenic propositi is 10·5 ± 1·9 per cent as against a risk of 3 per cent estimated for the general population. The morbidity-rate for mental deficiency among the sibs of propositi was no higher than the risk in the general population of the area studied, nor was the rate of schizophrenia among the sibs of propositi affected with low-grade mental deficiency increased.

---

* A Clinical and Genetico-Statistical Study of Schizophrenia and Low-Grade Mental Deficiency in a Large Swedish Rural Population. By Bertil Hallgren and Torsten Sjogren. (*Acta Psychiatrica et Neurologica Scandinavica*, Supplementum 140, Volumen 35, 1959.) Pp. 65. (Copenhagen: Ejnar Munksgaard, 1959.)

The genetico-statistical analysis confirms the conclusions of previous investigations that specific genetic factors are of importance for the manifestation of schizophrenia. The morbidity-rate for schizophrenia as well as that for non-psychotic mental abnormalities among the sibs of propositi was significantly higher in the families where one of the parents was affected with psychosis or non-psychotic mental abnormality (mainly severe personality deviations) than in those where both parents were unaffected.

Of the mental defectives 88 per cent belonged to the group of uncomplicated, undifferentiated mental deficiency. In 4·1 per cent of the cases the mental defect was combined with epilepsy, in 3·3 per cent with deaf-mutism and in 2·6 per cent with spastic paresis. These figures are considerably higher than corresponding frequencies of epilepsy, deaf mutism and spastic paresis in the general population.

The genetico-statistical analysis confirms the findings of previous investigations that specific genetic factors are of importance for the manifestation of undifferentiated low-grade mental deficiency. In the unclassified material, the morbidity-rate for the low-grade mental deficiency among the sibs of propositi with uncomplicated undifferentiated mental deficiency is 8·4 ± 0·9 per cent. This rate is significantly higher than the corresponding risk, 0·9 per cent in the general population. The rate among brothers, 11·3 ± 1·5 per cent, is significantly higher than that among sisters, 5·6 ± 1·1 per cent.

RADIOACTIVE FALL-OUT IN GHANA

By Dr. A. H. WARD and J. D. MARR*

Physics Department, University College, Legon, Ghana

ROUTINE radioactive survey measurements were started in Ghana in October 1959, after the announcement of French atomic testing plans at Reggan in the northern Sahara. The measurements were extended in January 1960, and the first atomic explosion at Reggan was on February 13. It gave a peculiarly simple variation of radioactive fall-out in Ghana, as it was a single isolated test, after all other fall-out levels had fallen considerably following the cessation of atom bomb tests in 1958. The unexpected relatively large increase in radioactivity of samples of dust, crops, soil and water is summarized; most of the measurements were by gross β- or γ-counting, and no chemical separation has yet been made.

Radioactivity-levels were very low in Ghana before February 13; there is little natural uranium or thorium in the country, and because of Ghana's position near the equator, world-wide fall-out from earlier atomic tests had produced only very slight contamination. Daily measurements since January of activity in air-borne dust, deposited dust, and milk have been made at two laboratories, and the main results are shown in the two graphs. Tamale is in the Northern Region of Ghana, 1,000 miles south of Reggan, and the Accra laboratory is at Legon, 8 miles from the coast and 1,400 miles south of Reggan.

The graphs show the daily measurements of radioactivity in air-borne dust per cu. m., and in deposited dust per sq. m. per day. Air-borne dust is collected by filtration under forced flow, using the method developed by the Radiation Protection Division of the Canadian Department of Health and Welfare; an air pump is fitted with a glass-fibre filter paper and with the average loading of dust has a capacity of about 720 m.^{3} a day. Each pump and filter is in a Stevenson screen, that at Tamale being 3 ft. above ground-level, that at Accra being on a flat roof 21 ft. above ground-level. Deposited dust was swept up daily from a measured area of flat concrete roof, 21 ft. above ground-level at both Tamale and Accra; during peak periods the same area was swept each day until any remaining activity was negligible.

The contamination reaching Ghana was dust-borne, and from the graphs the bulk of the contamination appears to arrive between the third and tenth days after the explosion. Thereafter, the daily arrival of contamination is seen to fall off slowly; some of the delayed arrival may be 'secondary' in origin, as dust was blowing up freely from all soil and sand surfaces in Ghana and in the Sahara at this time, due to the extremely dry weather conditions. The fall-off in daily arrival of contamination is, however, more rapid than the radioactive decay of mixed fission products, indicating that the total radioactivity carried by this 'secondary' dust is very much less than in the original bulk of contaminated dust direct from Reggan.

The decay of each sample is complicated. All air filters collect natural radium and thorium daughter products as well as fall-out radioactivity. The radium and thorium daughter products decay rapidly, and their effective $\mu\mu$c./m.^{3} content is shown on the graph up to February 16. After this date, the fall-out alone is shown; from repeated counts the contribution of the longer-lived fall-out can be separated from the rapid decay of the radium and thorium daughter products. On the other hand, for deposited dust the total radioactivity content is shown in all cases. Each sample of fall-out has been stored and counted repeatedly to establish its own decay scheme. Apart from some of the 'peak' samples which initially decayed more rapidly, all samples gave a rate of decay fitting closely to the curve:

$$I_t = I_4 t^{-1.2} \text{ (from } t = 4 \text{ days onwards)}$$

Dust particles varied in size, and it seemed likely that the larger particles were more local in origin than the smaller ones. Specimens of collected dust were therefore passed through a 50-μ sieve, and it was found that the specific activity of the transmitted

---

* Technical adviser loaned to Ghana by Canadian Government.

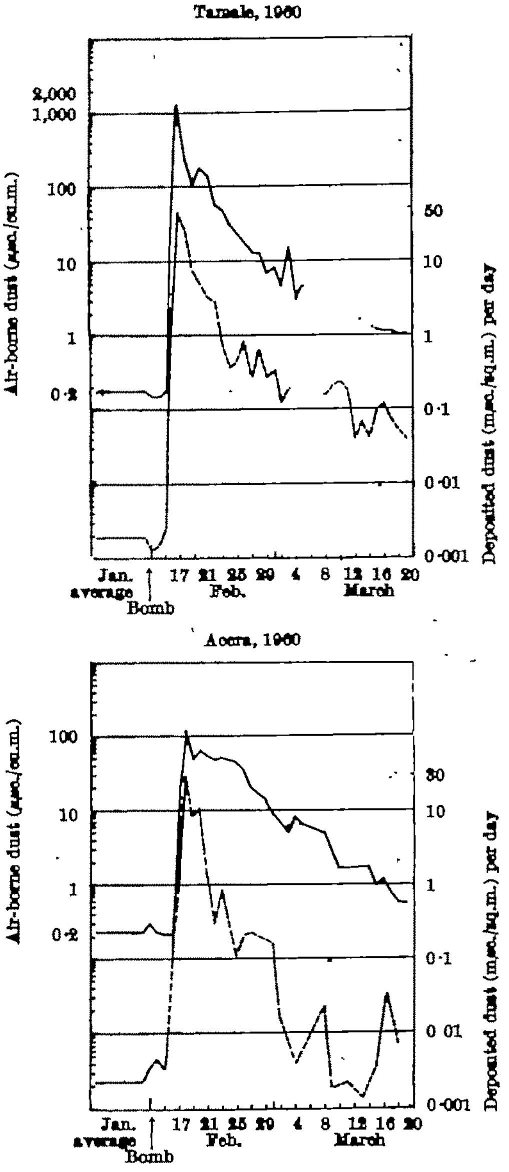


Fig. 1. Air-borne dust (full line) and deposited dust per day (dashed line) showing the January average, and the rise after the bomb test of February 13

particles was forty times greater than that of the retained particles.

Rain fell at the Legon laboratories, Accra, on March 2 and 6, with an average activity of 60 mμc./l. The average pre-bomb activity was 0·013 mμc./l. Little rain fell at Tamale until mid-March; but milk from two local grazing herds of cows showed a small increase on February 18, from a pre-bomb average of 1·8 counts/min. per 10 ml., to counts of 3·7, 2·8, 2·6, 3·6 and 4·0 for the days February 18–22.

From the other thirty stations in Ghana, samples of dust deposited over weekly periods, of exposed leaves and top soil, were sent to the main laboratory at Legon for β and γ analysis. In addition, transistorized equipment was taken by 'Landrover' on a survey of northern Ghana. The results give a simple area and time variation which is consistent with the detailed analyses from the Tamale and Legon laboratories.

The γ counting of top soil probably gives the best measure of cumulative fall-out, but β- and γ-counting of exposed leaves and of dust swept from measured areas of flat concrete surface provides useful confirmatory figures. The average of all measurements for the cumulative fall-out up to the three dates shown is given below, in units of $m\mu c./m.^2$. The high, medium and low counts correlate well with the 'north' (nine stations), 'central' (thirteen stations) and 'south' (eight stations) of Ghana (Table 1).

Table 1

	Pre-bomb average	Cumulative to Feb. 20	Cumulative to Feb. 27	Cumulative to March 18
North	11	126	55	13
Central	13	42	16	5
South	12	17	6	3

The first column refers to soil samples only, for a 2-in. deep section of top soil; these pre-bomb figures, or equivalent 'deep soil' samples after the test, have been subtracted from top soil counts to give the cumulative fall-out figures of the last three columns. Pre-bomb leaf measurements gave negligible counts even with a Philips-type low-background counter; pre-bomb dust figures are very small, and have been subtracted in the graphs and table above. The separate station figures on which the averages in Table 1 are based vary considerably; the highest level found in Ghana was 4·6 times the average 'north' figure.

On leaf samples of February 20, most of the radioactivity could be washed off, and so was attributed to surface dust; in later leaf samples more of the contamination was 'fixed' in the leaves.

The amount of dust radioactivity makes γ-spectroscopy very easy, even with a single-channel pulse analyser. γ-spectra taken from specimens of different ages after February 13 were found to be typical of mixed fission products of those ages, and these results were confirmed and extended by courtesy of two health physics laboratories in the United Kingdom.

The increased radioactivity-levels described above are much higher than those generally predicted for Ghana before the February 13 test at Reggan. Those familiar with local conditions had, however, anticipated that direct fall-out was a possibility, on account of the wind circulation which occurs for the period December–March, and its occasional unusual variations. Detailed wind trajectories from data taken during February 13–18 agree well with the observed times of arrival of the main increases of radioactivity, both in Ghana and Nigeria. The röntgen doses from these increases, however, are still low. Calculations from the $m\mu c./m.^2$ figures, together with a few direct dose-rate readings, assuming a $t^{-1\cdot 2}$ decay, indicate a total gonad dose for the maximum 'north' fall-out of less than 1 millirad for the year from the first French bomb test. It is considered by many authorities that an additional dose to a whole population of 500 millirads is acceptable genetically.

We wish to thank the Ministry of Defence of Ghana for financing the work and for permission to publish these results, and to acknowledge the valuable assistance of the professor of physics, members of his Department, and the Director of Meteorological Services in Ghana.

RADIOACTIVE LABELLING OF LEPIDOPTEROUS LARVÆ: A METHOD OF ESTIMATING LATE LARVAL AND PUPAL MORTALITY IN THE WILD

By L. M. COOK
Department of Zoology, University of Oxford

AND

DR. H. B. D. KETTLEWELL
Genetic Laboratories, Department of Zoology, University of Oxford

THE special advantages of marking insects by means of radioactive tracers have been explained in a previous communication by one of us[1]. It was pointed out that the technique allows even holometabolous species to be detected through successive instars and between stages in metamorphosis. A method was described for calculating pupal mortality using individuals marked as larvæ. Phosphorus-32 was employed for species with a rapid metamorphosis (*Locusta migratoria* L. and *L. pardalina* Walk.), and sulphur-35 for those with a longer life-history (*Panaxia dominula* L.)[2]. This work was conducted under laboratory conditions, and no field releases were undertaken at the time. The marking of adults by feeding a radioactive tracer to the larvæ has been carried out on a number of occasions[3-5], but the unique advantages of this method of recording individuals in studies of population dynamics have not so far been fully utilized. We present here the results of two estimations of late larval and pupal mortality under natural conditions in colonies of the moth *Panaxia dominula* (L.).

I. 1953 (H. B. D. Kettlewell)

The colony of *P. dominula* at Sheepstead Hurst, Berkshire, was studied for some years by Dr. P. M. Sheppard[6]. He estimated the total size of the adult population in each season using Fisher's multiple recapture method[7]. In 1953 a sample of larvæ was taken from this colony and fed on deadnettle (*Lamium* spp.) which had been grown in water culture containing sulphur-35. 1,227 larvæ were returned to the colony, each giving 20 counts per minute or more above the background when scanned under a Geiger counter. Larvæ with counts as low as this can be used because the earlier work had shown that the recorded activity in the imagines is always two to six times greater than that in the same individual when scored as a larva more than two months earlier. Sulphur is present in the wings of the adults, but in the larvæ it is principally internal, and the low larval count is due to the low penetrating power of the isotope.

The larvæ were extremely abundant in 1953, and in view of the heavy predation by cuckoos (they are probably the main visual predators of the species), it was decided to shoot one some days after the release. The remains of about 25 *P. dominula* larvæ were present in the gizzard, but none gave radioactive counts, nor did the intestine, liver, heart or any other part of the cuckoo. I did, however, note that there was a complete absence of larval hairs and skins in the small intestine, which suggests that the cuckoos regurgitate the larval roughage, probably in the form of small pellets.

In July 1953 the total adult population in the colony was estimated by Sheppard[6] to be between 20,000 and 26,000. In the course of the sampling from which this estimate was obtained, each captured insect was taken to the laboratory and scanned before being released again into the colony. The labelled insects were clearly distinguishable from non-radioactive ones, the lowest count recorded being 76 c.p.m. above background. The results are given in Table 1.

Table 1. NUMBERS OF RADIOACTIVE INDIVIDUALS IN RANDOM SAMPLES OF IMAGINES

Date	Number of radioactive insects	Total sample
1.7.53	—	80
2.7.53	—	99
3.7.53	—	125
4.7.53	—	207
5.7.53	—	127
6.7.53	2	119
7.7.53	4	229
8.7.53	5	160
9.7.53	3	285
11.7.53	0	164
12.7.53	0	251
13.7.53	1	259
14.7.53	0	276
15.7.53	2	141
16.7.53	0	316
17.7.53	0	211
18.7.53	0	180
19.7.53	1	210
21.7.53	0	197
22.7.53	0	143
23.7.53	0	148
24.7.53	0	111
	18	3,400 + 638 = 4,038

$$\text{Total larval population} = \frac{\text{radioactive larvæ released} \times \text{total imagines caught}}{\text{radioactive imagines caught}}$$

The imagines were not scanned on the first five days of collection; but using the ratio of the number of labelled insects to the total number in the sample from which they are recorded as an estimate of the frequency of radioactive individuals in the population, the mean number of larvæ is calculated to be 231,767. The data suggest that marked individuals emerged slightly in advance of the rest of the population, however, so they may have been present at a higher frequency in the first few days. This is possibly because they were kept at a slightly higher temperature than the rest of the population during the 48-hr. feeding period. Inspection of the scatter of their distribution in the later samples suggests that 5 or 6 may have been present, and to recalculate the larval population size the figures 4 and 7 have been used. Assuming the number of marked insects in the total sample of 4,038 to lie between 25 and 22, the mean number of larvæ is estimated to be between 198,185 and 225,210. With a total adult population of approximately 23,000 this gives an estimate of mortality over the intervening period of 88–90 per cent.

It was apparent that the marked larvæ could be recognized clearly when recaptured as adults; and no difference was observed between the viability of radioactive and non-radioactive controls. It was therefore decided to employ the same technique again to assess late pre-adult mortality, this time in a very small colony which had thrived for some years in a wild state in the vicinity of Oxford, following its original introduction from a laboratory stock.

2. 1959 (L. M. Cook)

The larvæ were marked in the same way as before. When nearly full grown they were fed on radioactive *Lamium* for 24 hr., care being taken to ensure that the temperature was as near that prevailing in the colony as possible. 165 larvæ were returned to the population immediately after feeding. At the same time four containers were set up with mixed batches of radioactive and non-radioactive larvæ as controls. The moths from them were scored as they emerged, and despite the fact that there was heavy over-all mortality during pupation there is no evidence that it is distributed differentially between active and non-active larvæ (Table 2). The marked moths showed no tendency to emerge earlier than those which were not radioactive.

Table 2. SURVIVAL OF CONTROLS

	Radioactive	Non-radioactive
Total number of larvæ used	30	30
Number of adults which emerged	4 4 3 4	7 3 8 1
Total adult emergence	15	19

$\chi^2_{(1)} = 0·27, P > 0·5$

Because of the small size of the colony environmental conditions in it were relatively uniform and emergence of adults took place over a very short period of time. A close watch was kept from the beginning of June onwards, and sampling was carried out every day throughout the season. As the moths in the colony emerged they were captured, scanned, marked with a spot of cellulose paint (receiving a distinct mark each time they were caught), and then released. The larval population size has been calculated from the single capture-recapture equation using Bailey's correction[8] and the adult population size by Fisher's method[7]. A summary of the data is given in Table 3. The mean number of larvæ present when the labelled sample was released is estimated as 1,210, and the mean number of adults as 77. The mean value for the mortality over the period between the two estimates is 94 per cent.

The estimation in two different colonies at different times suggests figures for late larval and pupal mortality which are between 85 and 95 per cent. The adults lay about 200 eggs, or approximately 100 per individual. The population at Sheepstead Hurst comprised 6,000–8,000 individuals in 1952 (ref. 9), so that the number of larvæ which remained of the 1952–53 generation at the time when they were sampled was only about one-quarter of the total number of eggs produced. Thus, there is heavy mortality in the late stages of development after an appreciable drop in numbers has already taken place. The implications of this situation will be discussed elsewhere. The work presented here demonstrates for the first time that estimates can be made in wild populations, using a radioactive labelling technique, which are of sufficient accuracy to stand as the basis for such a discussion. The method is capable of very wide application to studies of natural populations of insects.

Table 3. POPULATION DATA FOR 1959

Days from first release	June 21	22	23	24	25	26	27	28	29	30	July 1	2	3
1		3	8	5	2	2	1	1	2	2	4	4	3
2			2	2	3	2	2	0	1	2	3	4	0
3				0	1	2	0	1	2	1	2	2	1
4					0	2	0	0	1	0	0	1	0
5						1	0	0	0	1	1	1	0
6							0	0	0	0	1	0	0
7								0	0	0	0	1	0
8									0	0	0	1	1
9										0	0	0	1
Captures	5	11	13	7	8	9	4	3	6	6	9	7	2
Releases	4	11	13	7	8	9	4	3	6	6	7	6	2
Radioactive	1	1	1	0	0	1	0	0	0	1	0	0	0
Estimated daily adult population size		15	18	21	23	21	22	27	14	15	12	8	8

Estimated mean adult survival per day	62·4 per cent
Number of tagged larvæ released	165
Total number of moths captured	48
Number of radioactive moths captured	5
Estimated seasonal adult population size	77

We wish to thank Prof. G. E. Blackman for the use of facilities in the Department of Agriculture. We are very grateful to Dr. R. P. Martin and members of the staff for the help they gave us throughout the course of the work, to Dr. A. J. Cain, Dr. E. B. Ford and Dr. P. M. Sheppard, who read and criticized the paper in manuscript, and to Drs. N. T. J. Bailey, Dennis Chitty and P. H. Leslie, who gave us helpful advice on statistical matters. One of us (L. M. C.) received support from a Nature Conservancy Research Studentship, for which grateful acknowledgment is made.

[1] Kettlewell, H. B. D., *Nature*, 170, 584 (1952).
[2] Kettlewell, H. B. D., *Nature*, 175, 821 (1955).
[3] Bugher, J. C., and Taylor, M., *Science*, 110, 146 (1949).
[4] Fredeen, F. J. H., Spinks, J. W. T., Anderson, J. R., Arnason, A. P., and Rempel, J. G., *Canad. J. Zool.*, 31, 1 (1953).
[5] Shemanchuk, J. A., Spinks, J. W. T., and Fredeen, F. J. H., *Canad. Ent.*, 85, 269 (1953).
[6] Sheppard, P. M., *Proc. Roy. Soc.*, B, 145, 308 (1956).
[7] Fisher, R. A., and Ford, E. B., *Heredity*, 1, 143 (1947).
[8] Bailey, N. T. J., *J. Anim. Ecol.*, 21, 120 (1952).
[9] Sheppard, P. M., Symp. Soc. Exp. Biol., 7 (1953).

ZINC CONTENT OF ERYTHROCYTES AND LEUCOCYTES OF BLOOD OF NORMAL AND LEUKÆMIC SUBJECTS

By E. DENNES, R. TUPPER and PROF. A. WORMALL, F.R.S.

Department of Biochemistry, Medical College of St. Bartholomew's Hospital, London, E.C.1

MANY studies have been made on the significance of zinc in the eye, pancreas, the male genital tract, and other tissues of the animal body[1,2]. Since the recognition that carbonic anhydrase is a zinc enzyme, with the metal as an integral part of the enzyme molecule[3,4], considerable progress has been made, largely by Vallee and his colleagues[5], in characterizing the alcohol dehydrogenase, glutamic acid dehydrogenase, lactic dehydrogenase, and carboxypeptidase, as zinc metalloenzymes. Also, zinc ions increase the activity of many enzymes, and there appears to be little doubt that this metal has important biological functions relating to cellular oxidation and possibly other aspects of metabolism.

Zinc is present in blood plasma, in which the metal is largely bound to the β-globulins (ref. 6 and unpublished work by us), and in erythrocytes and leucocytes, and although the last-named cells contain only about 3 per cent of the whole-blood zinc[7], the individual leucocyte is relatively rich in this metal, and "probably contains more zinc than does any other cell in the body"[8]. A protein which contains 0·3 per cent of zinc and which accounts for about 80 per cent of the leucocytic zinc has been isolated from normal human leucocytes[8,9], but as yet there is no information about the function of this protein. In work on the zinc content of the blood of five individuals suffering from myeloid leukæmia and three from lymphatic leukæmia, Vallee and his colleagues found that the zinc contents of the leukæmic leucocytes (expressed as µgm. zinc/10^8 cells) were exceptionally low, ranging from 10 to 40 per cent of the normal values, and they suggested[10] that "one characteristic of the blood dyscrasias known as leukæmia is an inability of the leucocytes to attain a normal zinc content". Wolff[11] has also obtained relatively low values for the serum zinc and the leucocyte zinc of leukæmic patients.

During recent years we have studied the uptake of zinc by normal and tumour tissues of mice, and we have measured the zinc content of the blood cells of normal subjects and individuals suffering from various types of leukæmia. The determination of the zinc in human leucocytes presents many problems. It is necessary to prepare leucocyte suspensions which are practically free from erythrocytes, and erythrocytes free from leucocytes, and an ultra-micro method of assay for zinc is required. For the separation of leucocytes, we have found dextran the most satisfactory substance to add to the blood to increase the rate of sedimentation of erythrocytes, as advocated by Wildy and Ridley[12]. We have estimated the amount of nitrogen in small samples of leucocytes or erythrocytes by Russell's colorimetric phenol–hypochlorite method[13]. For the zinc determinations, we developed a method of neutron activation analysis[14] which allows duplicate zinc determinations to be made on two or three drops of blood, or the leucocytes separated from 4 or 5 ml. or the red cells from about 0·2 ml. of human blood. The leucocyte samples used for each zinc determination contained 10^7–10^8 leucocytes and about 0·2–0·6 µgm. zinc.

We have made determinations on blood samples from 27 normal subjects and 22 leukæmic patients (15 subjects with chronic lymphatic leukæmia and 7 with chronic myeloid leukæmia), and we have found that the leukæmic leucocytes contained much less zinc (a mean value of 7·7 µgm. (*S.E.*, ± 1·3) of zinc, per 10^9 leucocytes) than did the normal leucocytes, the latter showing a mean zinc content of 14·2 ± 2·1 µgm. per 10^9 leucocytes. This difference between the leukæmic and normal leucocytes is statistically highly significant ($P = 0·02$).

Since leucocytes show considerable variation in size, measurement of the average zinc content per cell may not give the most satisfactory values for comparing the zinc contents of normal and pathological bloods, and we decided to calculate, in addition, the amount of zinc in the red and white cells in terms of µgm. zinc per mgm. of total nitrogen, in order to have a measure of the zinc/protein ratio. With these ratios also, the leukæmic leucocytes showed a very much lower zinc content than did normal leucocytes. The mean values (as µgm. zinc/mgm. total nitrogen) being 0·91 (± 0·08) and 1·97 (± 0·37) for the leukæmic and normal leucocytes respectively. Statistical analysis showed that this difference is highly significant (*P* between 0·01 and 0·02).

The amount of zinc in the erythrocytes shows a difference in the opposite direction, with the leukæmic erythrocytes giving a mean value of 1·13 (± 0·06) µgm. of zinc per 10^9 cells as compared with 0·96 (± 0·03) for the normal erythrocytes. The corresponding values for the erythrocyte zinc calculated as µgm. zinc per mgm. nitrogen were 0·26 ± 0·01 and 0·21 ± 0·01 for the leukæmic and normal bloods respectively. Statistically, this difference is highly significant (*P* between 0·02 and 0·05 for the zinc contents measured on a cellular basis, and between 0·001 and 0·01 for the ratios calculated on a nitrogen basis).

The whole-blood samples showed no significant difference between the values for normal and leukæmic subjects, and the relatively low zinc contents of the leucocytes, and the higher zinc content of the erythrocytes, in leukæmic blood as compared with normal human blood, did not appear to be related in any way to abnormally low or high levels of total blood zinc.

The relatively low zinc content of leukæmic leucocytes is of special interest to us at present, and we are making further investigations of this phenomenon. It is possible that the difference is due simply to the relative immaturity of the leukæmic leucocytes, and we are at present studying the zinc content of leucocytes associated with other types of leucocytosis. On the other hand, there is the possibility, as has been postulated by others, that the synthetic processes concerned with the formation of a zinc-protein or some other zinc compound associated with leucocytes, may be deficient in the leukæmic subject. In this connexion, it may be significant that our total nitrogen determinations have shown no significant difference between the amount of nitrogen (and presumably the amount of protein) present in the leukæmic leucocytes and that in normal leucocytes. A full account of these investigations will be published elsewhere.

This work was carried out with the aid of grants from the British Empire Cancer Campaign, and we are also indebted to Dr. T. E. Banks, of the Physics Department of this College, for continued valuable help with the maintenance of our equipment used for radioactivity measurements.

[1] Vallee, B. L., *J. Amer. Med. Assoc.*, 162, 1053 (1956).

[2] Vallee, B. L., *Physiol. Rev.*, 39, 443 (1959).

[3] Keilin, D., and Mann, T., *Biochem. J.*, 34, 1163 (1940).

[4] Keilin, D., and Mann, T., *Nature*, 153, 107 (1944).

[5] See reviews by Vallee (refs. 1 and 2).

[6] Vikbladh, I., *Scand. J. Clin. Lab. Invest.*, 3, Supp. 2, 9 (1951).

[7] Vallee, B. L., and Gibson, J. G., *J. Biol. Chem.*, 176, 445 (1948).

[8] Hoch, F. L., and Vallee, B. L., *J. Biol. Chem.*, 195, 531 (1952).

[9] Vallee, B. L., Hoch, F. L., and Hughes, W. L., *Arch. Biochem. Biophys.*, 48, 347 (1954).

[10] Gibson, J. G., Vallee, B. L., Fluharty, R. G., and Nelson, J. E., *Acta Unio Internat. Contra Cancrum*, 6, 1102 (1950).

[11] Wolff, H. P., *Klin. Woch.*, 34, 409 (1956).

[12] Wildy, P., and Ridley, M., *Nature*, 182, 1801 (1958).

[13] Russell, J., *J. Biol. Chem.*, 156, 457 (1944).

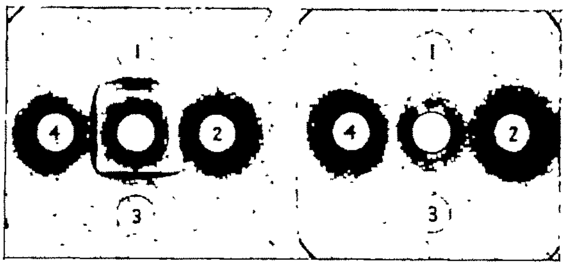
[14] Banks, T. E., Tupper, R., White, E. M. A., and Wormall, A., *Int. J. App. Rad. Isotopes*, 4, 221 (1959).

SERUM ALBUMIN CONCENTRATION IN ANALBUMINÆMIA AND ITS IMMUNOLOGICAL SIGNIFICANCE

By Dr. J. H. HUMPHREY
National Institute for Medical Research, London, N.W.7

BENNHOLD, Peters and Roth[1] recently described a brother and sister whose sera contained no albumin detectable by electrophoresis. If these persons completely lack human serum albumin, and their last contact with it resulted from transplacental transfer from their mother some 30–35 years ago, it might have been expected that they would treat human serum albumin as a foreign protein and react to transfusion by developing antibodies. In fact, extensive investigations[2] have shown that one of the subjects, who received repeated transfusions of human serum albumin, not only showed no signs of the increased elimination-rate which would have been expected had she formed antibodies, but actually catabolized transfused human serum albumin at about half the rate of normal persons. This raises the question whether albumin might have been present in the plasma in trace amounts even before transfusion, or whether the failure to develop antibodies was due to long persistence of immunological tolerance. The presence of traces of human serum albumin was therefore investigated by other techniques.

Through the kindness of Dr. Kallee a sample of serum was obtained, which was taken from the brother (Karl Br.) before any transfusions had been given. Using a rabbit antiserum specific for human serum albumin, and employing the quantitative precipitin technique, the serum was found to contain a substance reacting immunologically as human serum albumin in concentration 1·6 mgm./100 ml. The identity of this material with human serum albumin was confirmed by the agar-gel diffusion technique, in which the subject's undiluted serum gave a line continuous with that produced by albumin in normal human serum, and equivalent in concentration to that given by normal serum diluted 1/2000 (Fig. 1). Removal of antibodies to human serum albumin from the serum by adding a small excess of crystallized human serum albumin (Behring) prevented the formation of the line. Further confirmation was obtained by fractionation of the subject's serum with 22 per cent w/v sodium sulphate. The supernatant, after concentration by pressure dialysis to 1/3 the original volume, was subjected to paper electrophoresis. Most of the protein was α- and β-globulin, but there was a very faint trace of material with the electrophoretic mobility of human serum albumin.



Unabsorbed

Absorbed

Fig. 1. Agar-gel diffusion patterns with rabbit antiserum, before and after removing specific anti-human serum albumin by addition of a small excess of authentic human serum albumin
1, normal human serum 1/1,000 ; 2, 'analbuminæmic' serum 1/1 ; 3, normal human serum 1/100 ; 4, 'analbuminæmic' serum 1/1 containing normal human serum 1/100

Lohss and Kallee[3] have reported that 'analbuminæmic' serum may contain material behaving serologically as serum albumin, but differing from authentic serum albumin in its behaviour after extraction with a trichloroacetic acid-acetone mixture. To decide whether authentic serum albumin was present in the serum under study, the general method used by Lohss and Kallee was modified and extended. The proteins in the serum fraction where albumin might be present were radio-iodinated ; they were then precipitated with anti-human serum albumin in the presence of unlabelled carrier human serum albumin ; the antigen–antibody precipitate was dissociated with trichloro-acetic acid–ethanol ; and the protein so obtained was subjected to electrophoresis in starch gel.

The 22 per cent w/v sodium sulphate supernatant from 1·85 ml. serum was iodinated with iodine-131 by the iodine chloride method of McFarlane[4], after preoxidation of any free —SH groups with non-radioactive iodine. An authentic sample of crystallized human serum albumin was iodinated in the same way for use in parallel control tests. Although the preparation from the 'analbuminæmic' serum contained 23 mgm. protein, less than 0·1 mgm. was expected to be albumin. In order to diminish losses due to adsorption, 2 mgm. of unlabelled carrier human serum albumin was added to the labelled 'analbuminæmic' material and to 0·1 mgm. of the control human serum albumin labelled with iodine-131. The albumin in each was precipitated with 26 mgm. rabbit anti-human serum albumin in the presence of 5 mgm. potassium iodine. As is shown in Table 1, the precipitate contained only 1·1 per cent of the radioactive proteins in the test material. Even this could be partly due to co-precipitation of a part of the other labelled proteins present.

After washing the test and control precipitates twice with 0·9 per cent sodium chloride at 2°, they were stirred with 6 ml. 1 per cent w/v trichloracetic acid in 96 per cent v/v ethanol at 0°, to extract the albumin. After 2 hr. the residual precipitate was spun down at 0°, and the supernatant fluid was treated with 2 volumes of cold dry ether to precipitate the extracted protein. The recovered protein was dissolved in 1 ml. water at 0°. In this way 75 per cent of the radioactivity was recovered from the antigen–antibody precipitate prepared with authentic human serum albumin, but only 19 per cent from that prepared with the 'analbuminæmic' material. Since the bulk of the precipitate in each case was due to unlabelled carrier human serum albumin, and each sample was subjected to identical procedures, the low recovery of radioactivity from the 'analbuminæmic' material must have been due to the presence of

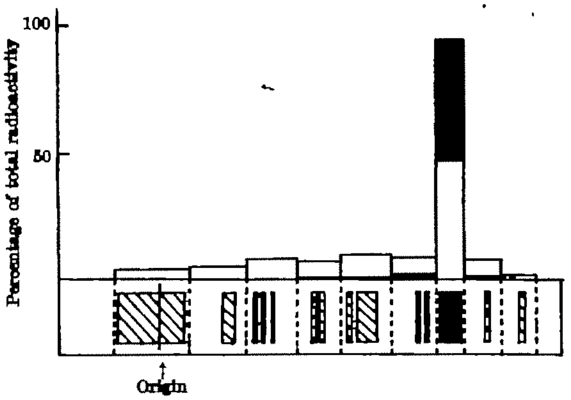


Fig. 2. Distribution of radioactivity after electrophoresis in starch gel of material recovered from analbuminaemic serum and from authentic human serum albumin. The abscissa is a diagrammatic representation of the stained gel, illustrating the position of the cuts
☐ – radioactivity in analbuminaemic material; ■ – radioactivity in authentic human serum albumin

labelled contaminants other than albumin in the precipitate.

In order to identify the recovered labelled materials definitely as human serum albumin, 0·1 ml. of unlabelled human serum was added to each, the solutions were concentrated 5–10-fold by dialysis against 'Carbowax' in the cold, and 50 µl. of each was then subjected to electrophoresis in starch gel, according to Smithies[5]. The gels were fixed and stained; the albumin had travelled 10–11 cm. from the origin and was well separated from pre- and post-albumins. The gel was photographed, and then cut into segments corresponding to each protein peak. Radioactivity in each segment was measured in a well-type scintillation counter, care being taken to ensure that conditions of counting were similar. The distribution of radioactivity along the gels is shown in Fig. 2. Whereas 94 per cent of the authentic radioactive human serum albumin was recovered in the albumin band, only 47 per cent of the radioactive protein recovered from the 'analbuminaemic' serum was located in this position, the remainder being distributed throughout the serum proteins.

It is not certain whether the non-albumin radioactivity was associated with denatured material or with traces of labelled globulins which had survived intact the earlier stages of purification, and which would not have been present in the authentic human serum albumin.

Table 1

Experimental stages	Per cent of original radioactivity recovered HSA	'Albumin' fraction of serum
Precipitated with antibody	99	1·1
Extracted with TCA-ethanol and re-precipitated with ether	75	0·208
Present in albumin peak after starch gel electrophoresis	70·5	0·098

When compared with the authentic human serum albumin labelled with iodine-131, only 0·098 per cent of the original iodinated protein in the 22 per cent sodium sulphate supernatant behaved as human serum albumin throughout the successive stages of precipitation with anti-human serum albumin, extraction in trichloracetic-acid ethanol (TCA), and starch gel electrophoresis (Table 1). On the assumption that all the proteins in the 22 per cent sodium sulphate supernatant were iodinated to the same extent, this would imply that the original serum contained 1·23 mgm. authentic human serum albumin/100 ml.—a value quite close to the 1·6 mgm./100 ml. obtained by immunochemical methods. It is not clear why these results differ from those of Lohss and Kallee[3], but the explanation may lie in pre-oxidation of —SH groups before iodination with iodine-131 or in the use of carrier human serum albumin. The results certainly underline their warning that no single technique should be relied on to identify and measure unequivocally a material constituting so small a proportion of a mixture, unless it possesses some readily identifiable specific property such as enzyme activity.

The evidence seems sufficient, however, to permit the conclusion that traces of human serum albumin were present, and that the failure of these subjects to develop antibodies in response to albumin administration does not require postulation of prolonged persistence of a state of immunological tolerance. Furthermore, it seems possible that 'analbuminaemia' may resemble 'agammaglobulinaemia' in being a condition in which there is a very great, rather than an absolute, deficiency of the particular plasma protein. This work was made on serum from a single subject, and it is clearly desirable—though impossible in this instance—to examine by similar techniques the sera from other such subjects before any transfusions have been given.

---

[1] Bennhold, H., Peters, H., and Roth, E., *Verhandl. Deutsch. Ges. Inn. Med.*, 60, 630 (1954).

[2] Freeman, T., Matthews, C. M. E., McFarlane, A. S., Bennhold, H., and Kallee, E., *Nature*, 183, 606 (1959).

[3] Lohss, F., and Kallee, E., *Clin. Chim. Acta*, 4, 127 (1959).

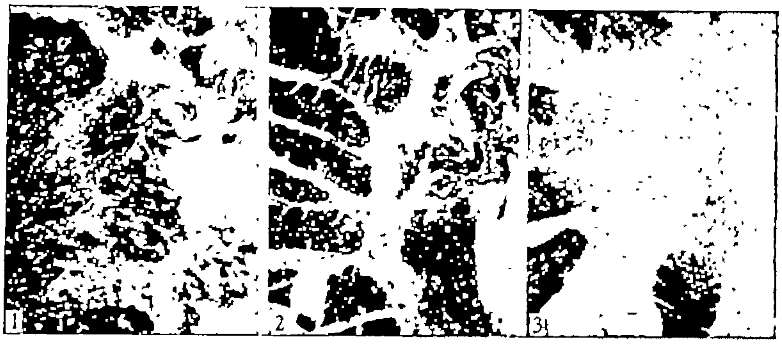
[4] McFarlane, A. S., *Nature*, 182, 53 (1958).

[5] Smithies, O., *Biochem. J.*, 61, 629 (1955).

ACTION OF SOME SURFACE-ACTIVE COMPOUNDS ON THE GASTRO-INTESTINAL MUCOSA

By Dr. J. A. NISSIM
Pharmacology Department, Guy's Hospital Medical School, London, S.E.1

IN a previous article[1], the actions of trimethylhexadecylammonium stearate (cetyltrimethylammonium stearate) on the gastro-intestinal mucosa were described. These actions included: (1) damage to gastro-duodeno-jejunal mucosa after large oral and parenteral doses; (2) loss of weight, presumed to be due to functional inhibition of the gastro-intestinal mucosa, after smaller oral doses; and (3) occasional hypertrophy of the gastro-duodeno-jejunal mucosa after prolonged administration of doses that are just



Figs. 1–3. Damage with hæmorrhage in gastric and intestinal mucosa of mouse 16 hr. after a subcutaneous injection of 0·1 gm. cetrimide per kgm. body-weight. (× 86) (1) Pyloric mucosa. (2) and (3) Intestinal mucosa. Note dense altered hæmoglobin pigment at tips of villi in (2)

too small to cause loss of weight. In a preliminary investigation of the mode of action, a number of related compounds have been studied and an attempt made to relate structure and activity.

Trimethylhexadecylammonium stearate is a cationic surface-active quaternary ammonium compound practically insoluble in water. The present investigation includes the study of (1) sodium stearate and cetyltrimethylammonium bromide or cetrimide, two compounds which represent the acidic and basic parts of the molecule; (2) domiphen bromide, sodium lauryl sulphate, sorbitan monostearate ('Span 60') and polyoxyethylene sorbitan mono-oleate ('Tween 80'), of which the first two are cationic and anionic and the last two non-ionic surfactants; and (3) tetraethylammonium bromide and hexamethonium chloride, two simple quaternary ammonium compounds. In preliminary screening tests, these compounds were given by subcutaneous or intraperitoneal injection to adult male mice in order to find out which of them possessed the selective activity exhibited by trimethylhexadecylammonium stearate on the gastro-intestinal mucosa. Afterwards, some of these substances were incorporated in diet 41 in various concentrations and fed to mice, each of the animals receiving 5 gm. of diet a day. All the mice used were from non-interbred albino C stock. Tissues for histological study were only taken from animals killed when moribund.

Cationic Compounds

Cetrimide. Some of the results obtained after subcutaneous injections of cetrimide are given in Table 1. The *LD*50 of the bromide ester administered by this route was some ten times smaller than that of the stearate. There was always brown staining at the site of injection. After the smaller doses, mice died in 1–5 days and invariably showed reddish brown or coffee-ground hæmorrhages in the pyloric part or the whole of the stomach, in the duodenum, jejunum and sometimes the ileum, but not in the cæcum or colon (Figs. 1–3). Mice receiving the larger doses of cetrimide died in a matter of minutes or hours and failed to show gastro-intestinal hæmorrhage; but the duodenum was intensely stained with bile and the intestines contracted.

These findings, noted after doses of 0·25–1·0 gm./kgm., and the occasional occurrence of convulsions with varying degrees of auriculo-ventricular block, were considered compatible with an acetylcholine effect. This was confirmed by studies on the blood pressure of the cat and on the motility of strips of rat intestine. In both biological tests the potency of cetrimide was about 10^{-3} or 10^{-4} of that of acetylcholine, but the drug seemed to block itself rapidly.

Surviving animals were killed some 2–3 months after the injection and carefully examined, but no abnormality was ever detected.

When cetrimide was given intraperitoneally in doses of 0·075 gm./kgm., death occurred with convulsions within 3–5 min., but even doses of 2 mgm./kgm. caused 100 per cent mortality in about 12–15 hr. The largest doses which mice survived were 1·5 and 1 mgm./kgm., and thus cetrimide was some 50 times more toxic by the intraperitoneal than by the subcutaneous route. For the stearate ester the corresponding factor was about 10.

When cetrimide was administered orally in diet 41, however, it proved no more toxic than trimethylhexadecylammonium stearate (Table 2). It seemed unlikely that this result was due entirely to poor absorption of the cetrimide from the alimentary canal, so that inactivation of the compound by gastro-intestinal juices and/or food was presumed to occur. The ratio of intraperitoneal to oral activity was of the order of 2,000 : 1.

Domiphen bromide. This substance was administered by subcutaneous injection only (Table 1). Its *LD*50 was about 0·125 gm./kgm., or 5/3 that of cetrimide. All postmortem findings, including the histological changes in the gastro-intestinal mucosa, were similar to those after cetrimide.

Anionic Compounds

Sodium stearate. Given both subcutaneously and intraperitoneally in single doses of 0·5 and 1·0 gm./kgm., this compound was distinctly devoid of

Table 1. EFFECT OF SOME SURFACE-ACTIVE SUBSTANCES ADMINISTERED TO MICE BY SUBCUTANEOUS INJECTION

Drug	Dose (gm./kgm.)	No. of mice	Percentage mortality	Percentage incidence of hæmorrhage in intestine
Trimethylhexadecylammonium stearate	0·50	10	20	—
	0·75	20	60	40
	1·00	30	92·5	100
Cetrimide	0·075	10	50	100
	0·100	10	70	100
	0·150	10	100	100
	0·188	12	100	67
	0·250	2	100	0
	0·500	2	100	0
	1·000	2	100	0
Domiphen bromide	0·100	10	30	100
	0·150	10	70	100
	0·200	10	90	—
	0·250	2	100	50
	0·500	6	100	33
	1·000	2	100	0
Sodium lauryl sulphate	0·100	2	0	0
	0·200	2	0	0
	0·500	2	0	0
	1·000	2	0	0
	2·000	2	0	0

Table 2. Loss of Weight and Period of Survival of Mice on Different Concentrations of Some Surface-active Substances in the Diet

Drug	Conc. of drug in diet (gm. per cent)	No. of mice	Average original weight (gm.)	Average weight at 1 month (gm.)	Average change in weight (gm.)	Survival period in days
Trimethylhexadecyl-ammonium stearate	0·00	24	23·5	23·1	− 0·4	indefinite
	0·05	20	23·7	23·6	− 0·1	90 or more
	0·10	24	23·5	21·7	− 1·8	60 or more
	0·20	24	23·4	20·0	− 3·4	17–25
	0·40	12	23·3	18·4	− 4·9	11–20
Cetrimide	0·00	6	26·7	27·3	+ 0·6	indefinite
	0·05	6	26·1	26·5	+ 0·4	indefinite
	0·10	6	26·1	25·5	− 0·6	indefinite
	0·20	6	26·5	22·5	− 4·0	35–63
	0·40	6	26·8	20·3	− 6·5	9–12
Sodium stearate	0·00	4	29·8	28·5	− 1·3	indefinite
	0·50	4	29·9	29·5	− 0·4	indefinite
Sodium lauryl sulphate	0·50	6	28·0	28·0	0·0	indefinite
	1·00	6	27·9	25·9	− 2·0	indefinite
	2·00	6	27·4	19·5	− 7·9	3–4

any adverse effect on the thirteen animals used, and no loss of weight was noted. When killed 1–2 months after the injection, these mice differed in no way from the controls. The substance was also given to 16 animals in a concentration of 0·5, 1, and 5 per cent in diet 41. The results leave no doubt that for all practical purposes the gastro-intestinal activity of trimethylhexadecylammonium stearate is invested entirely in the cationic part of the molecule.

Sodium lauryl sulphate. Subcutaneous doses of 0·1, 0·2, 0·5, 1 and 2 gm./kgm. of this compound were each given to two mice. Large skin ulcers, at first surrounded by oedema, appeared in the same day after the injection of the largest three doses. The ulcers did not perforate to the peritoneum, which was evidently resistant to this action, and there was no evidence of systemic disturbance after the injection. The animals remained alive and well and the ulcers healed in about six weeks. Intraperitoneal injections of 0·2 and 0·4 gm./kgm. were each given to four mice. The animals receiving the larger dose died within 1–3 days, but postmortem revealed no consistent pathological abnormality to indicate the cause of death.

The results obtained with oral feeding of sodium lauryl sulphate in concentrations of 0·5, 1 and 2 per cent are of fundamental importance. Death supervened within four days in the group receiving the highest concentration, and all six animals showed typical gastro-intestinal hæmorrhage associated with marked loss of weight, just as in the case of cetrimide and domiphen. However, the toxic dose was critical, as no adverse effects were noted after the two smaller concentrations of 0·5 and 1 per cent even in experiments lasting some three months. Animals receiving 1 gm./kgm. of this drug showed a transient loss of weight averaging 2 gm. per mouse at five weeks.

Non-Ionic Compounds

Both sorbitan monostearate ('Span 60') and polyoxyethylene sorbitan mono-oleate ('Tween 80') were given as a 10 per cent aqueous suspension and solution respectively by subcutaneous injection to mice in doses of 1, 4 and 8 gm./kgm. No loss of weight followed, the animals remained healthy, and nothing abnormal was found when the animals were killed four weeks later. Doses of 1 gm./kgm. of 'Tween 80' given by stomach tube to three mice did not cause gastro-intestinal hæmorrhage.

Simpler Quaternary Ammonium Compounds

Tetraethylammonium bromide and hexamethonium chloride were tested in subcutaneous doses ranging from 20 to 200 mgm./kgm. The animals either died in 10–60 min. and failed to show any injury to the gastro-intestinal mucosa or survived the dose and showed nothing abnormal when killed a week later.

Discussion

The above results indicate clearly that the activity of trimethylhexadecylammonium stearate with regard to the gastro-intestinal mucosa is invested mainly, and may be entirely, in the cationic part of the molecule. The related substance domiphen bromide possesses the same effect. If the side-chain of the quaternary ammonium compounds is shortened or removed, this activity is abolished. It is possible, however, that such an effect is still invested in the quaternary ammonium structure and may be revealed by investigating less-soluble esters of the compounds, for example, tetraethylammonium stearate. The fact that this action on the gastro-intestinal mucosa may also result from the administration of the non-quaternary-ammonium anionic sodium lauryl sulphate strongly suggests that the activity is a feature of an ionic (cationic or anionic) long-chain structure, particularly as the non-ionic compounds tested gave entirely negative results.

A point of great interest is that in the case of sodium lauryl sulphate the gastro-intestinal effect disappeared completely when the dose was reduced from 2 to 1 gm./kgm. In other words, with this compound the effect appears abruptly and maximally at a critical dose. In the case of the cationic quaternary ammonium surfactants, the range of activity was at least 2–3 times that of sodium lauryl sulphate, so that halving a maximally toxic dose twice did not abolish the effect. The fact that such gradation in activity is possible is a useful indicator for future research, since an even greater grading of response may be expected to be associated with decreased toxicity.

[1] Nissim, J. A., *Nature*, 186, 222 (1960).

REDUCTION OF THE INTESTINAL ABSORPTION OF GLUCOSE, METHIONINE AND SODIUM BUTYRATE BY THE CATION TRIMETHYLHEXADECYLAMMONIUM

By Dr. J. A. NISSIM

Pharmacology Department, Guy's Hospital Medical School, London, S.E.1

IN two preceding publications[1] it was shown that some ionic surface-active compounds, including the stearate and bromide of trimethylhexadecylammonium, have definite structural effects on the gastro-intestinal mucosa. Interference with the absorptive function of the intestine was also presumed. In this article an account is given of the effect of these compounds on the intestinal absorption of glucose, methionine, sodium butyrate and water, as studied in more direct experiments.

The methods used in the study of the effect of the trimethylhexadecylammonium cation on intestinal absorption are convenient modifications of the method described by Jervis *et al.*[2]. The different nutrient substances were perfused in normal saline, with or without the drug, through the intestine of rabbits or albino rats and circulated by a flow of moist oxygen from a cylinder. The animals were anæsthetized with sodium pentobarbitone, the gut washed with warm saline and emptied. A length of small intestine consisting of the duodenum plus a piece of jejunum, about 2 ft. long in the rat and 3 ft. long in the rabbit as measured from the duodeno-jejunal flexure, was perfused with a known volume of the fluid under study. At the end of each experiment the perfusate was drained into a flask, its volume measured, and the amount of fluid absorbed or secreted per hour calculated. The length of the perfused intestine was then removed and measured accurately. From the difference between the initial quantity of each of the substances perfused and the final amount recovered, the percentage absorption was calculated.

The different solutions used were approximately neutral, their *p*H values ranging from 6·7 to 7·7.

Glucose was estimated by the modified Schaffer–Hartman method of King[3], methionine by the method of McCarthy and Sullivan[4], and sodium butyrate by the method of Smyth and Taylor[5]. Perfused and non-perfused duodenum and jejunum were fixed either in formol-saline or in ice-cold 80 per cent alcohol at the end of the experiment for histological study.

The experiments may be divided into two groups according to duration of perfusion: 2-hr. perfusion experiments, and half-hour perfusion experiments.

Two-hour Perfusion Experiments

The control perfusion fluid consisted of normal saline containing either 0·3 per cent glucose and 0·3 per cent methionine together or 0·3 per cent sodium butyrate alone. 250 and 125 ml. of fluid were perfused in the case of rabbits and rats respectively. Trimethylhexadecylammonium stearate was added to the perfusion fluid to give concentrations of 0·1 and 0·5 per cent, while cetrimide was used in concentrations of 0·01 and 0·1 per cent. Samples of perfusate for glucose and methionine, or butyrate estimations, and samples of blood for glucose estimations were taken at 0, 1 and 2 hr. Perfusion pressure was 10–12 cm. at the duodenal end, but only just above zero at the distal end. The rate of flow was kept at 20–40 ml./min. by adjusting the oxygen flow. The bile duct was included in some experiments and excluded in others.

Rats. This group comprised four control rats and eight rats perfused with the control solution containing the drug in the form of the stearate ester. Four of the latter received 0·1 per cent and four received 0·5 per cent of the drug, but since the results obtained with the two concentrations did not differ significantly, they have been grouped together for simplicity (Table 1, Fig. 1). The absorption of glucose and of methionine fell to one-half and one-third respectively with the addition of the drug, and the absorption of water was likewise diminished. Furthermore, in spite of wide variations in the levels of blood sugar under the conditions of the experiment, there was a net rise of 32 mgm./100 ml. in the control group and a net fall of 6 mgm./100 ml. in the treated group, a result compatible with the more rapid rate of absorption of glucose in the former. To counter the suggestion that the decreased rate of disappearance of glucose from the perfusate under the influence of the drug was due to decreased utilization by intestinal bacteria, a suspension of some 15–20 per cent of the intestinal contents of a rat in 125 ml. of the control solution was circulated in the apparatus for 2 hr.,

Table 1. ABSORPTION OF GLUCOSE, METHIONINE, BUTYRATE AND WATER AND RISE IN BLOOD GLUCOSE IN 2-HR. PERFUSION EXPERIMENTS. FIGURES REPRESENT MEAN ± *S.E.*

	Rats		Rabbits	
	Control (4 exp.)	0·1 and 0·5 per cent TAS* (8 exp.)	Control (19 exp.)	0·1 per cent centrimide (6 exp.)
Percentage absorption of glucose	61·6±3·2	30·5±1·8 $P < 10^{-4}$	53·0±2·6	−6·0±7·8 $P < 10^{-4}$
Rise in blood glucose (mgm./100 ml.)	31·9±7·8	−5·9±8·5 $P < 0·02$	62·4±6·3	20·8±10·9 $P \simeq 0·002$
Percentage absorption of methionine	59·1±2·9	18·7±2·9 $P < 10^{-4}$	54·9±2·8	54·1±5·1
Fluid absorption (ml./hr.)	6·5±0·5	1·0±0·8 $P \simeq 10^{-4}$	5·8±2·5	−5·9±8·1 $P \simeq 0·02$
Length of perfused intestine (cm.)	74·8±3·5	73·8±2·4	140·0	150·8
Percentage absorption of butyrate			33·1±2·8 (3 exp. only)	34·9±11·0 (3 exp. only)

* TAS = Trimethylhexadecylammonium stearate.

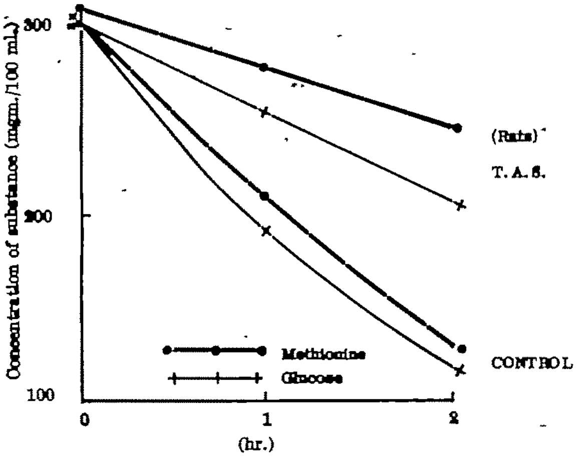


Fig. 1. Curves showing rate of disappearance of glucose and of methionine from perfusate in four control rats and eight rats receiving 0·1 or 0·5 per cent trimethylhexadecylammonium stearate in 2-hr. perfusion experiments

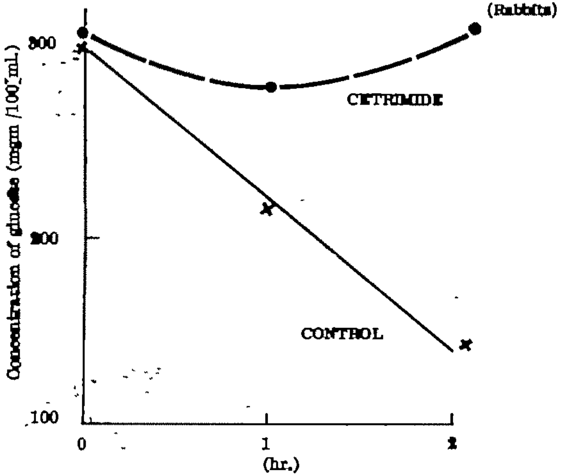


Fig. 2. Curves showing rate of disappearance of glucose from perfusate in nineteen control rabbits and six rabbits receiving 0·1 per cent cetrimide in 2-hr. perfusion experiments

but no measurable change was noted in the glucose concentration at the end of the experiment.

Rabbits. This group comprised initially nine control rabbits. The perfusion of 0·1 per cent trimethylhexadecylammonium stearate in seven rabbits, with and without 0·06 per cent hydrochloric acid or bile, did not inhibit the absorption of either glucose or methionine. Similarly, the perfusion of 0·01 per cent cetrimide in three rabbits had no effect. These 10 rabbits were therefore included in the final control group, which now comprised 19 experiments. Six rabbits were then given 0·1 per cent cetrimide in the perfusion fluid, and here the results as regards glucose absorption were striking, but the absorption of methionine remained unaffected. In three of the six rabbits the glucose titration readings were in fact greater for the final sample than for the first, and if the reducing material is accepted as wholly glucose, the excess sugar recovered in the perfusate equalled 125, 159 and 212 mgm. respectively, so that in the last hour the direction of net flow of glucose was from the blood to the intestine (Table 1, Fig. 2).

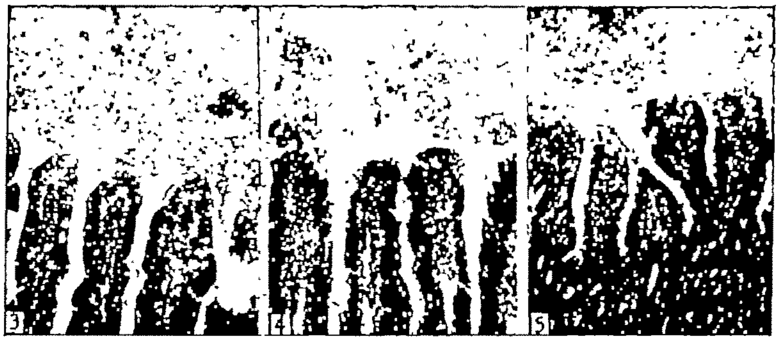
Three control rabbits were given 0·3 per cent sodium butyrate in normal saline but no glucose, and three were given the same solution containing 0·1 per cent cetrimide. There was no inhibition of the absorption of the short-chain fatty acid as is evident from Table 1, but although no glucose could be demonstrated in the perfusate of the control rabbits at any time, reducing material began to appear at 1 hr. in the perfusate of the rabbits receiving cetrimide and the total recovered at 2 hr. for the three rabbits was equivalent to 220, 306 and 391 mgm. glucose.

Finally, in one experiment, 0·1 per cent glucose-free solution of cetrimide in normal saline was perfused in a rabbit for 6 hr. Titration readings for glucose on the perfusate gave the values of 0, 23, 75, 104, 116, 122 and 133 mgm./100 ml. at 0–6 hr. The 2-, 4- and 6-hr. values of 75, 116 and 133 mgm./100 ml. were checked by the specific glucose oxidase method of Huggett and Nixon[8], and the respective values 80, 108 and 127 mgm./100 ml. were obtained. The close agreement between the two sets of figures identifies the reducing substance as mainly if not entirely glucose.

125 and 250 mgm. cetrimide given subcutaneously to two rabbits, both weighing 2 kgm., did not cause glycosuria, so that in comparable doses this substance does not appear to possess the obvious blocking effect of phloridzin on the absorption of glucose by the renal tubules. Conversely, a perfusion experiment in which 0·1 per cent phloridzin was used reduced the intestinal absorption of glucose only to 25 per cent and had no effect either on methionine or on butyrate absorption.

Half-hour Perfusion Experiments

Only rats were used here, and the perfusion fluid consisted of 50 ml. of normal saline containing 0·2 per cent each of glucose, methionine and sodium butyrate, which were studied together. The drug concentrations were the same as in the 2-hr. experiments. Blood samples were collected from the tail at the beginning and end of each experiment, and the change in blood sugar noted; but perfusate samples were estimated for sugar, amino-acid and fatty acid only at the end. The hydrostatic pressure was kept at 7–10 cm. at the duodenal end, and the rate of flow at 10–20 ml./min. The bile duct was included in all experiments.



Figs. 3–5. Intestinal mucosa of rats after perfusion for 2 hr. (× 75)
(3) Control solution. (4) 0·1 per cent trimethylhexadecylammonium stearate.
(5) 0·1 per cent cetrimide

Table 2. ABSORPTION OF GLUCOSE, METHIONINE, BUTYRATE AND WATER AND RISE IN BLOOD GLUCOSE IN ½-HR. PERFUSION EXPERIMENTS IN RATS. FIGURES REPRESENT MEAN ± *S.E.* OF FOUR EXPERIMENTS

	Control	0·1 per cent TAS	0·5 per cent TAS	0·01 per cent cetrimide	0·1 per cent cetrimide
Percentage absorption of glucose	39·4 ± 2·5	30·1 ± 2·6 $P < 0·05$	24·7 ± 1·0 $P \simeq 10^{-4}$	29·3 ± 3·3 $P = 0·05$	5·4 ± 2·4 $P < 10^{-4}$
Rise in blood glucose (mgm./100 ml.)	117·5 ± 22·3	72·3 ± 20·0 $P \simeq 0·1$	56·2 ± 22·8 $P \simeq 0·1$	83·9 ± 8·1 $P \simeq 0·4$	33·3 ± 13·1 $P < 0·02$
Percentage absorption of methionine	43·9 ± 1·8	32·3 ± 1·9 $P < 0·01$	18·2 ± 2·1 $P < 10^{-4}$	30·4 ± 2·5 $P < 0·01$	13·3 ± 2·5 $P < 10^{-4}$
Percentage absorption of butyrate	58·9 ± 2·7	37·1 ± 4·3 $P < 0·01$	22·9 ± 1·7 $P < 10^{-4}$	33·8 ± 1·2 $P < 10^{-4}$	17·3 ± 1·5 $P < 10^{-4}$
Fluid absorption (ml./hr.)	5·9 ± 0·8	1·8 ± 1·0 $P < 0·02$	2·7 ± 0·6 $P < 0·02$	1·3 ± 0·5 $P < 0·01$	−1·8 ± 0·9 $P < 10^{-4}$
Length of perfused intestine (cm.)	62·5 ± 0·7	65·3 ± 2·8	62·3 ± 2·9	65·3 ± 3·4	66·0 ± 3·2

TAS = Trimethylhexadecylammonium stearate.

The results obtained in five groups of four rats are given in Table 2. The five groups comprised a control group and four others in which the animals received in addition 0·1 and 0·5 per cent of the stearate ester and 0·01 and 0·1 per cent of the bromide ester in the perfusion fluid. The effect of the cationic trimethylhexadecylammonium of both esters on the absorption of water, glucose, methionine and butyrate can scarcely be questioned.

In all experiments with this cation the secretion of mucus by the intestine was increased as compared with the control, and the effect seemed proportional to the activity and concentration of the drug.

Histological Results

In 2-hr. perfusion experiments, both in control and treated animals, large numbers of cells appeared in the lumen of the gut and consisted chiefly of leucocytes and shed epithelial and mucus cells; but, in addition, rabbits perfused with 0·1 per cent cetrimide showed definite damage to the intestinal villi. In half-hour perfusion experiments, the number of cells in the lumen was markedly less and scarcely differed from non-perfused control intestine. Similarly, rats perfused with 0·1 per cent trimethylhexadecylammonium stearate did not differ significantly from either, but those perfused with 0·5 per cent of the stearate ester and with 0·01 per cent of the bromide ester showed a significant increase in cells shed and those receiving 0·1 per cent cetrimide showed frank damage to the intestinal mucosa (Figs. 1–3).

Discussion

The most striking and consistent effect of trimethylhexadecylammonium was on the absorption of glucose, which at a concentration of 0·1 per cent of the bromide ester appeared to be completely inhibited. At this concentration cetrimide is described as non-irritant to tissues[7]; however, the injury to the intestinal villi in these experiments was unmistakable. An interesting feature was the marked differences in species with regard to their sensitivity to the inhibitory action on glucose absorption. There was, in addition, the interesting absence of an inhibitory effect on the absorption of methionine and sodium butyrate in the rabbit, though the effect on the absorption of glucose was more or less as pronounced as in the rat. Furthermore, it is evident that the inhibitory effect on absorption was not related to the degree of injury caused by high concentrations of this cation, as the absorption of methionine and butyrate continued at high concentrations in the rabbit, but failed at low concentration in the rat. This is an important finding, and in the search for new compounds the aim should be to widen this gap still further.

The results of perfusion experiments reported here support the earlier conclusion[1] that large doses lead to structural damage, while small doses "appear to reduce the functional efficiency of the mucosal cell". The functions of the mucosal cells are presumed to be mainly enzymic in nature. In the present investigation, the marked species differences point clearly to specific enzyme actions being involved in the functional inhibition of activity.

The concentrations of the stearate ester used in the perfusion experiments have been of the same order as those used in feeding experiments, but in assessing the significance of histological injury to the intestinal mucosa it should not be assumed that the same conditions prevail for the action of the drugs in both cases. It is quite clear, for example, that cetrimide in the rat is at least ten times and probably a hundred times as active in perfusion as in feeding experiments in which the drug is incorporated with diet 41. It is possible that the inhibition of absorption, which in all probability depends on the uptake of the cation by specific enzymes, can be achieved slowly in a feeding experiment as the ester is gradually solubilized in the intestine to inactivate more and more enzyme molecules. On the other hand, structural damage of villus cells, which evidently differs in its mechanism from that of inhibition of absorption, may be more directly related to the actual concentration of the cation present in the bathing fluid.

I should like to thank Mrs. Miriam Thurlow and Miss Myra Jones for their expert and willing technical assistance, Mr. L. Westwood for invaluable help, particularly in the preparation of the histological sections, and Prof. W. J. H. Butterfield and Miss Margaret Wichelow for carrying out check glucose estimations by the oxidase method.

[1] Nissim, J. A., *Nature*, 185, 222 (1960); also preceding article.
[2] Jervis, E. L., Johnson, F. R., Sheff, M. F., and Smyth, D. H., *J. Physiol.*, 134, 675 (1956).
[3] King, E. J., Haslewood, G. A. D., and Delory, G. E., *Lancet*, 1, 886 (1937).
[4] McCarthy, T. E., and Sullivan, M. X., *J. Biol. Chem.*, 141, 871 (1941).
[5] Smyth, D. H., and Taylor, C. B., *J. Physiol.*, 141, 73 (1958).
[6] Huggett, A. St. G., and Nixon, D. A., *Lancet*, 2, 368 (1957).
[7] Martindale, "The Extra Pharmacopoeia", 365 (The Pharmaceutical Press, 1958).

LETTERS TO THE EDITORS

PHYSICS

Effect of a Resisting Couple on the Rotational Motion of a Rigid Body

THE examination of the effect of external couples upon the rotational motion of artificial Earth satellites has been of interest, in view of the rapidity with which their instantaneous axes of rotation have been observed to approach the axis of greatest moment, even when they have been initially spun about the axis of least moment. In this particular problem the role of internal energy dissipation due to non-rigidity may in fact be important, but, setting this aside, the theorem set out below appears relevant. This states a well-known principle and many of its corollaries have been proved; however, I have been unable to trace any direct reference to the proposition, or its converse, and would be grateful if any reader could do so.

The proposition is as follows. An external couple applied for a discrete time to a rigid body about its instantaneous axis of rotation in the sense opposing its rotation tends to cause that axis to approach the axis of greatest moment (provided that the instantaneous axis is not initially that of a permanent rotation).

In regard to the proof, we note that if **h** is the vector moment of momentum, and **w** the angular velocity, then the kinetic energy of the rotation is:

$$T = \tfrac{1}{2}\mathbf{h}.\mathbf{w} \qquad (1)$$

and in the free motion following the application of the couple, the invariable line intersects the surface of the ellipsoid of gyration at points distant $(h^2/2MT)^{1/2}$ from its centre (M being the body mass). Thus the value of $(h^2/2T)$ is bounded above and below by the greatest and least moments of inertia, and such limit values denote respectively a permanent rotation of the body about the axes of greatest and least moment in the free motion. Further, within these bounds, an increase in $(h^2/2T)$ would imply a change in the free motion consisting of an expansion of the invariable cone about the axis of least moment, and/or a contraction about that of greatest moment. The corresponding change in configuration of the polhode cone is analogous, as it is an affine transformation of the invariable cone.

Interpreting such a change in the motion to be that implied in the theorem, its proof is as follows. From the equations of motion we deduce that, if G is the couple, then during its action:

$$\mathbf{w}.\mathrm{G} = \frac{\mathrm{d}T}{\mathrm{d}t} \qquad (2)$$

$$2\mathbf{h}.\mathrm{G} = \frac{\mathrm{d}h^2}{\mathrm{d}t} \qquad (3)$$

Consequently it follows from (2) and (3) that:

$$T^2 \frac{\mathrm{d}}{\mathrm{d}t}(h^2/T) = 2T(\mathbf{h}.\mathrm{G}.) - h^2(\mathbf{w}.\mathrm{G}.)$$

or using equation (1), the right-hand side may be rearranged to give:

$$\left.\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}t}(h^2/2T) &= \tfrac{1}{2}(\mathrm{G}\times\mathbf{h}).(\mathbf{h}\times\mathbf{w})/T^2\\ &= \tfrac{1}{2}[\mathrm{G},\mathbf{h},\mathbf{h}\times\mathbf{w}]/T^2\end{aligned}\right\} \qquad (4)$$

If, as in the proposition, G is opposite to **w**, then $(h^2/2T)$ is increased while the couple acts and remains constant thereafter, unless $\mathbf{h}\times\mathbf{w} = 0$, which would indicate a rotation about a permanent axis. It may further be shown that the value of $(h^2/2T)$ increases asymptotically to its upper bound as the total applied wrench is indefinitely increased.

The converse of the theorem may be stated as follows. If the instantaneous axis, not being initially permanent, is caused to approach the axis of greatest moment by the action of an external couple, then for some discrete time the resolved component of that couple about the instantaneous axis opposes the motion.

For we may, without loss in generality, compound the couple of three non-planar components, one in the direction of the vector $\mathbf{h}\times\mathbf{w}$ (which exists if the instantaneous axis is non-permanent), another in the direction of the moment of momentum and one in the direction of the instantaneous axis. By (4), only the last-named component affects the rate of change of $(h^2/2T)$, and since $(h^2/2T)$ is increased, this component must be sensed in opposition to **w**.

Thus, the instantaneous axis of rotation of a rigid body, not being initially a permanent axis, approaches the axis of greatest moment if, and only if, the body is acted on for some discrete time by a resisting couple about the instantaneous axis. A body subjected to a continuous resisting couple about the instantaneous axis is unstable in an initial motion about the permanent axis of least moment, but stable about that of greatest moment.

An exactly analogous proposition and converse exists in relation to an accelerating couple, the body then tending to rotate about the axis of least moment.

T. NONWEILER

The Queen's University,
Belfast.

A Relation between Ultra-sonic Velocity and Latent Heat of Vaporization

SEVERAL attempts have been made by different investigators to find the relation between ultra-sonic velocity in liquids and the physical properties. One such relation has been obtained by Rao[1] empirically. Recently, Kishimoto and Nomoto[2] have obtained a relation between temperature coefficient of ultra-sonic velocity and boiling point of a liquid. In this communication we present a new relation between ultra-sonic velocity and latent heat of vaporization.

For this investigation we have used ultra-sonic velocity data taken from the literature for about

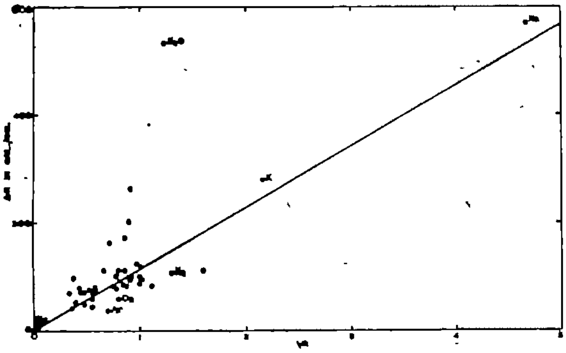


Fig. 1. Relation between ultra-sonic velocity and heat of vaporization

forty-five liquids in addition to some measurements which we have made on liquids not included in the literature. We have included a few liquefied gases and molten metals. In the first instance the values of the latent heats of vaporization L_v were plotted against the ultra-sonic velocities at 30° C., but as there was no sign of linearity in the graph, the values of L_v were replotted against the square of the ultra-sonic velocity V. It was found that the observations gave a fairly linear graph. To see if the linearity of the plot of points improves, the values of the latent heats at boiling point are again plotted against the extrapolated ultra-sonic velocities at temperatures where the molar volume of the saturated vapour of the liquid is 22·4 l., and this plot (Fig. 1) shows a better degree of linearity. A smooth line is drawn so as to pass through the maximum number of points, and using the gradient of this straight line the following empirical relation is obtained:

$$L_v = 133\,V^2$$

where L_v is in cal./gm. and V in km./sec. If L_v is expressed in ergs/gm. and V in cm./sec., this relation reduces to the simple form $L_v \approx \frac{1}{2}V^2$.

It may be noted that significant deviations from the linear graph are observed only in the case of highly associating liquids like water, alcohols and organic acids. It is in any event expected that these liquids would not show such a simple relation in view of the molecular associations and complexes formed. It is significant that these deviations are always on the higher side of L_v as expected, and the excess over the value from the linear graph may be regarded as giving some idea of the association energy.

We have been able to deduce this relation theoretically by using the equation of state of a liquid obtained by Wentorf, Buehler, Hirschfelder and Curtiss[3] based on Lennard-Jones and Devonshire's liquid model[4], and utilizing also Trouton's rule modified by Hildebrand and the relations deduced by Kishimoto and Nomoto[2]. A detailed paper embodying these results will shortly be published elsewhere.

We are indebted to the Council of Scientific and Industrial Research for financial assistance in this research work.

B. RAMACHANDRA RAO
P. R. K. L. PADMINI

Andhra University,
Visakhapatnam 3.

---

[1] Rama Rao, M., *Ind. J. Phys.*, 14, 109 (1940).

[2] Kishimoto, T., and Nomoto, O., *J. Phys. Soc. Japan*, 9, 66 (1954).

[3] Wentorf, R. H., Buehler, R. J., Hirschfelder, J. O., and Curtiss, C. F., *J. Chem. Phys.*, 18, 1424 (1950).

[4] Lennard-Jones, J. E., and Devonshire, A. F., *Proc. Roy. Soc.*, A, 163, 53 (1937); A, 165, 1 (1938); A, 169, 317 (1939); A, 170, 464 (1939).

CRYSTALLOGRAPHY

Macroscopic Swelling of Vermiculite Crystals in Water

EXPANDING lattice-layer silicates belonging to the smectite and vermiculite groups form complexes with organic cations by replacement of the inorganic cations normally present in interlayer positions in these minerals[1-4]. The formation of a complex, and sometimes also the orientation of the organic ions within the lattice, can be inferred from changes in the basal spacing of the mineral as shown by X-ray diffraction.

During studies of a series of vermiculite-organic complexes, it was observed that single crystals of vermiculite containing interlayer butylammonium ions swell macroscopically when placed in water. Swelling is anisotropic and occurs in a direction perpendicular to the plane of the silicate layers, leading to an increase in volume of the order of 3,000 per cent. The swollen crystals are coherent and gel-like. Their shape and homogeneous appearance suggest that the 10-Å. thick silicate layers remain effectively parallel to one another on swelling, and the observed increase in thickness indicates a mean interlayer distance of several hundred angstroms. Low-angle X-ray diffraction examination of several swollen crystals, for which I am indebted to Drs. K. Norrish and J. A. Rausell-Colom, indicates that individual interlayer distances probably do not deviate markedly from the mean value.

In view of these results, it seems justifiable to derive the interlayer distance in swollen crystals directly from measurements of the change in thickness of a crystal before and after swelling. The data in Fig. 1 were calculated on this basis using a vermiculite from Kenya[7], and show that the swelling, which is reversible, can be controlled by varying the concentration of butylammonium ions in the external solution. At high concentrations, the interlayer distance is 9–10 Å. (d_{001} = 19·2 Å.), suggesting that the butylammonium ions are oriented at right angles to the silicate layers. When the external concentration is reduced to about 0·06 N, marked swelling develops rather suddenly, and spacings in the region of 170 Å. are found. Further dilution results in continuous swelling to a maximum of about 530 Å. at infinite dilution. In this latter region, the interlayer distance appears to be related linearly to the reciprocal of the square root of solution concentration.

The ability of single crystals of lithium-vermiculite to swell when immersed in water has been mentioned briefly on previous occasions[8,9]. Tests show that the

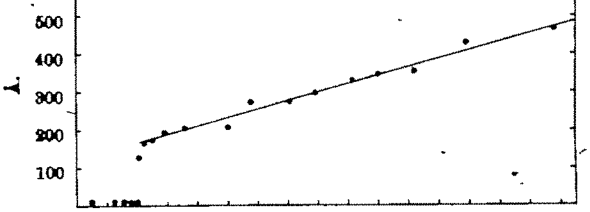


Fig. 1. Relationship between interlayer distance of butylammonium-vermiculite and concentration of butylammonium chloride in external solution (C = moles/litre)

degree of swelling in this system is also related to electrolyte concentration, but a tendency for the lithium-vermiculite crystals to exfoliate and break along cleavage planes during swelling makes measurements of changes in crystal thickness less reliable as an index of interlayer distance. Nevertheless, the indications are that, while the maximum amount of swelling is of the same order as that observed with butylammonium-vermiculite, the discontinuity in the curve, which occurs at about 0·15 *N* in this instance, leads to a relatively small 'step' of a few tens of angstroms. Apart from lithium and butylammonium, no other inter-layer ions tested so far cause extensive macroscopic swelling with water, although propylammonium ions produce limited swelling in certain vermiculites.

The swelling process in lithium-vermiculite recalls the swelling of aggregates of hydrogen-, lithium- and sodium-montmorillonites as studied by Norrish[9], and ascribed to the development of diffuse electrical double layers following upon the hydration and dissociation of the cations from the negative sites on the silicate layer surfaces. One may speculate that a similar mechanism operates in the butylammonium-vermiculite system, and that the sudden large expansion to an interlayer distance of 170 Å. at 0·06 *N* electrolyte concentration corresponds with the formation of 'icebergs'[10] around the butylammonium ions.

The highly oriented structure of these swollen crystals appears to offer a unique opportunity for examining the properties of water films of variable and known thickness associated with silicate layer surfaces, and further work on this and other aspects of these systems is in progress.

G. F. WALKER

Chemical Research Laboratories,
Commonwealth Scientific and Industrial Research
Organization,
Melbourne.

[1] Ensminger, L. E., and Gieseking, J. E., *Soil Sci.*, 48, 467 (1939).
[2] Jordan, J. W., *Min. Mag.*, 28, 598 (1949).
[3] Walker, G. F., *Nature*, 166, 695 (1950).
[4] Weiss, A., and Hofmann, U., *Z. Naturforsch.*, 6b, 405 (1951).
[5] Weiss, A., Mehler, A., and Hofmann, U., *Z. Naturforsch.*, 11, b 431 (1956).
[6] Weiss, A., *Chem. Ber.*, 91, 487 (1958).
[7] Mathieson, A. McL., and Walker, G. F., *Amer. Min.*, 39, 231 (1954).
[8] Walker, G. F., and Milne, A. A., Trans. Fourth Int. Cong. Soil Sci., Amsterdam, 2, 62 (1950).
[9] Norrish, K., *Disc. Faraday Soc.*, 18, 120 (1954).
[10] Frank, H. S., and Evans, M. W., *J. Chem. Phys.*, 13, 507 (1945).

Dislocations in Layer Structures

Amelinckx and Delavignette[1] have recently studied non-metallic substances with layer structures, including talc and graphite, by transmission electron microscopy. They observed nets of widely dissociated dislocations particularly in talc. Splitting into more than two partial dislocations in such hexagonal layer substances had been forecast by Kronberg[2]. Grenall[3] has observed dislocations in graphite previously, but did not observe dissociation into partials.

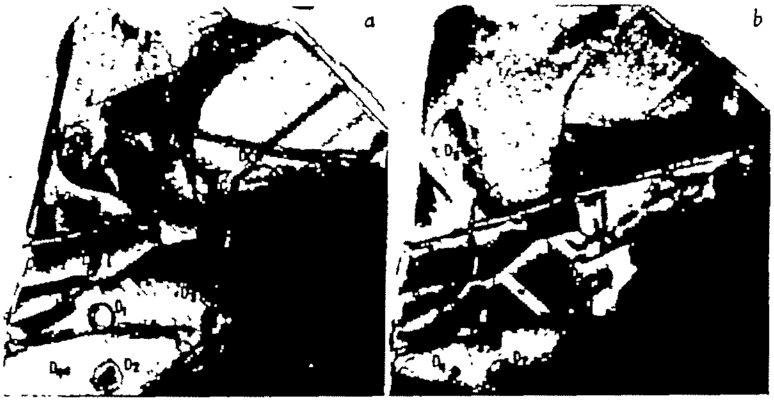


Fig. 1(*a*). Transmission electron micrograph of molybdenite flake. (*b*) As (*a*), but sample tilted about 1°. (× 62,000)

We have examined cleavage fragments of graphite and molybdenite for evidence of dislocations and have found that the interpretation of electron micrographs from such materials is rendered difficult by the presence of contrast effects due to extraneous surface detail such as steps and irregularities and by the presence of sub-grain boundaries. However, if a massive specimen is split in two, very thin and quite uniform leaflets can usually be found on the cleavage surfaces. Suitable leaflets of molybdenite which transmit in the red can be selected under the microscope using indirect illumination, and freed from the bulk with a fine needle. These specimens (about 1 cm. × 1 cm. × 1μ) are adequate for optical transmission studies[4], but are found still to consist of somewhat misoriented aggregations of sub-grains. When such specimens are exposed to ammonia vapour at − 78° C., a rapid absorption takes place, which results in a considerable weakening of the solid, so that these already thin pieces disintegrate easily into thinner fragments without undue mechanical damage. Fragments obtained in this way give reasonably interpretable results when submitted to transmission microscopy at high resolution in a Siemens 'Elmiskop I' electron microscope using 100 kV. Figs. 1*a* and *b* are an electron stereopair (tilt angle, 1–2°), obtained on molybdenite, which show a number of interesting features. A network of dislocations running vertically and spaced about 100 Å. is visible at *A* in Fig. 1*a* and disappears on tilting (Fig. 1*b*). A number of dislocations are visible at *B* (Fig. 1*b*). The prominent looped line feature at *C* in Fig. 1*a*, the contrast of which decreases in Fig. 1*b*, is probably also a dislocation. A number of interesting closed loops are visible at *D* in Figs. 1*a* and *b*. On tilting, some of the loops tend to change from single to double loops as at D_1; others show contrast reversal within the loop, as at D_2 and D_3. Loops with a dark centre spot are also observed at D_4 and D_5. The loops showing contrast reversal are thought to be dislocation loops enclosing stacking faults, although the details await further elucidation. Cleavage steps are visible at *E* (Fig. 1*a*).

Graphite flakes prepared by the above technique have not so far yielded results of similar interest, but recently we obtained a spectrographic graphite powder of high purity and a remarkable degree of order (grade *SP1*, National Carbon Co., New York, N.Y.). This material can be packed under moderate compression to give compacts of the density anticipated for a graphite single crystal, which is somewhat

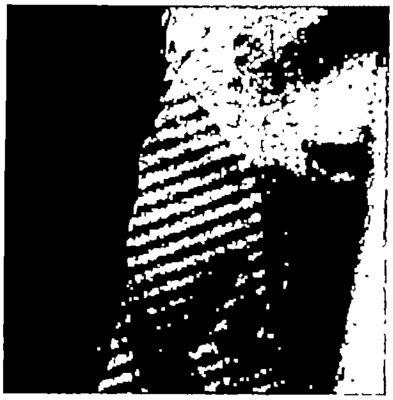


Fig. 2. Transmission electron micrograph of graphite particle. (× 62,000)

unusual. The powder consists of well-defined hexagonal particles, about 10μ wide, the edges of which are sufficiently transparent to 100-kV. electrons to permit examination at high magnification. The plate-like particles frequently show moiré fringes indicating a rotational misfit between adjacent layers, which are presumably each some hundred angstroms thick. The perfection of the moiré patterns over distances of ½–1μ (Fig. 2) indicates that regions of the layers up to this size are free from imperfection. A fourfold line detail some 600 Å. wide, which is probably a set of dislocations lying in the basal plane, may be seen running from *A* to *B* (Fig. 2), acutely inclined to the moiré fringes. A similar band of four lines can be seen running from *C* to *D*, increasing in width to a maximum of about 500 Å. as *C* is approached. Since graphite is a material of exceptionally low stacking fault energy, wide dissociation of dislocations into partials connected by stacking fault is to be expected. The two bands *AB* and *CD* are thought to consist of partial dislocations. The observation of four partial dislocations in graphite accords with the number expected from atomic considerations of the possible steps in the shear process.

A number of other features in Fig. 2 are worthy of note. *EF* is a dislocation which is roughly parallel to the band *CD* discussed above. *G* is a hexagonal loop which is about 1400 Å. long by 850 Å. wide. This is probably a dislocation loop. One pair of sides of this loop is parallel to the moiré fringes, another pair is parallel to the crystal edge *HJ*. The existence of hexagonal dislocation loops may be related to the observation by R. H. Savage (private communication) that thermal etching of graphite produces shallow hexagonal holes, and to the observation by one of us (P. C.) that chemical etching produces similar holes. Above *H*, a number of further dislocations are visible.

It appears to us that the search for dislocations in materials of this type is rewarding, but in the softer materials is very dependent on method of preparation of the sample.

V. A. Phillips
P. Cannon

General Electric Research Laboratory,
Schenectady,
New York.

---

[1] Amelinckx, S., and Delavignette, P., *Nature*, 185, 603 (1960).

[2] Kronberg, M., *Acta Met.*, 5, 507 (1957).

[3] Grenall, A., *Nature*, 182, 448 (1958).

[4] Cannon P., Graphite Meeting of the Soc. Chim. Phys., Paris (1960).

CHEMISTRY

Cage Effect in the Liquid-Phase Photolysis of Fluorinated Ketones

In a previous communication[1], the products of photolysis of 1 : 3 dichlorotetrafluoroacetone were described, and the absence of compounds which could arise from the reactions of the chlorodifluoroacetyl radical noted. It is assumed that in this behaviour the ketone is similar to hexafluoroacetone, which has been shown to dissociate on photolysis into two trifluoromethyl radicals and a molecule of carbon monoxide[2]. Acetone, on the other hand, has been shown to dissociate into an acetyl and a methyl radical when photolysed at room temperature[3].

It seems probable that the primary act in the photolysis of 1 : 3 dichlorotetrafluoroacetone is the production of two chlorodifluoromethyl radicals and a molecule of carbon monoxide, although the results do not rule out the possibility of the intervention of a short-lived chlorodifluoroacetyl radical.

This work has now been extended to two more fluorinated ketones, 1 : 1 : 3 : 3 tetrachlorodifluoroacetone and 1 : 1 : 3 trichlorotrifluoroacetone, and once again no trace of products which could arise from reactions of halogenated acetyl radicals was found among the photolysis products. It is assumed that either the primary act is dissociation into two radicals and a molecule of carbon monoxide or else the life-time of the halogenated acetyl radical formed is very short.

$$CF_2ClCOCCl_2F \xrightarrow{h\nu} .CF_2Cl + .CCl_2F + CO$$

$$CFCl_2COCCl_2F \xrightarrow{h\nu} 2.CCl_2F + CO$$

The ultra-violet absorption spectra are similar to that of 1 : 3 dichlorotetrafluoroacetone.

(Trichlorotrifluoroacetone $\lambda_{max.}$ 2950–3050 Å. $\varepsilon_{max.}$ 58
Tetrachlorodifluoroacetone $\lambda_{max.}$ 2900–3050 Å. $\varepsilon_{max.}$ 48)

The photolysis products of 1 : 1 : 3 : 3 tetrachlorodifluoroacetone have been shown to contain 1 : 1 : 2 : 2 tetrachlorodifluoroethane, which arises by the combination of the two dichlorofluoromethyl radicals.

The photolysis products of 1 : 1 : 3 trichlorotrifluoroacetone, on the other hand, were shown to contain three different halogenated ethanes arising from combinations of the two different radicals formed in the primary step.

$$2.CF_2Cl \rightarrow CF_2ClCF_2Cl\,(R_1R_1) \qquad (1)$$

$$.CF_2Cl + .CCl_2F \rightarrow CF_2ClCCl_2F\,(R_1R_2) \qquad (2)$$

$$2.CCl_2F \rightarrow CCl_2FCCl_2F\,(R_2R_2) \qquad (3)$$

As in the case of 1 : 3 dichlorotetrafluoroacetone it has been found that the radicals produced in the primary act are capable of abstracting chlorine atoms from the unphotolysed ketone to yield the corresponding halogenated methanes.

$$.CCl_2F + CCl_2FCOCCl_2F \rightarrow CCl_3F + .CClFCOCCl_2F$$

$$.CCl_2F + CCl_2FCOCF_2Cl \rightarrow CCl_3F + [.CClFCOCF_2Cl \text{ or } CCl_2FCOCF_2]$$

$$.CF_2Cl + CCl_2FCOCF_2Cl \rightarrow CCl_2F_2 + [.CClFCOCF_2Cl \text{ or } CCl_2FCOCF_2]$$

With 1 : 1 : 3 : 3 tetrachlorodifluoroacetone the products of this secondary reaction are trichlorofluoromethane and a halogenated acetonyl radical, which can undergo further combination reactions.

The secondary reactions of chlorine abstraction are much more complex in the case of 1 : 1 : 3 trichlorotrifluoroacetone, for the two dissimilar radicals produced may each abstract chlorine from either end of the halogenated acetone to give dichlorodifluoromethane (R_1Cl), trichlorofluoromethane (R_2Cl) and two isomeric halogenated acetonyl radicals. The further reactions of these radicals lead to the formation of a complex mixture of halogenated ketones, propanes and butanes, most of them too involatile to be identified with the present analytical procedure. One of the propanes, 1 : 3 dichlorohexafluoropropane, however, was sufficiently volatile to be isolated and identified by a combination of gas chromatography and mass spectrometry. It has already been identified among the photolysis products of 1 : 3 dichlorotetrafluoroacetone. The mechanism of its formation is uncertain, but it may arise either as a product of the combination of difluorochloromethyl and tetrafluorochloroethyl radicals or through the intervention of a CF_2 radical.

Trotman-Dickenson[4] has pointed out that even when two radicals R_1 and R_2 are very dissimilar the ratio of their product is such that :

$$\frac{[R_1R_2]}{([R_1R_1][R_2R_2])^{1/2}} \simeq 2 \cdot 0$$

where R_1R_1, R_2R_2, and R_1R_2 are the products of reaction.

When 1 : 1 : 3 trifluorotrichloroacetone was photolysed in the gas phase the proportions of the three halogenated ethanes formed were such that this ratio was 1·9.

The irradiation with light from a high-pressure mercury vapour lamp of 1 : 1 : 3 trichlorotrifluoroacetone in the liquid phase at room temperature resulted, however, in the formation of the three halogenated ethanes in proportions such that :

$$\frac{[R_1R_2]}{([R_1R_1][R_2R_2])^{1/2}} = 2 \cdot 6$$

This result is explained on the assumption that the two unlike radicals are formed within a 'cage' of unphotolysed ketone molecules which restrict their free diffusion apart. This concept of the 'solvent cage' was first put forward by Franck and Rabinowitch[5] and has usually been invoked to explain low quantum yields on the basis of recombination within a cage. This work has been extended by Lampe and Noyes[6], who studied the recombination of iodine atoms. The kinetics of photolysis of these three ketones provide direct evidence for the existence of such an effect. In the photolysis of 1 : 1 : 3 trichlorotrifluoroacetone the radicals escaping from the cage may either combine with each other or abstract chlorine from the unphotolysed ketone. Thus the ketone provides both a physical and a chemical cage. The effect of chlorine abstraction is reduced if the ketone is diluted with a solvent from which no abstraction can take place. Thus when the ketone is mixed with an equal volume of perfluoro-2-ethylcyclohexane and photolysed, the proportions of halogenated ethanes are such that :

$$\frac{[R_1R_2]}{([R_1R_1][R_2R_2])^{1/2}} = 2 \cdot 2$$

The effect of the chemical cage is demonstrated by the addition of 1 : 1 : 3 : 3 tetrachlorodifluoroacetone, which, providing more dichlorofluoromethyl radicals, should lower the ratio. In fact, because of the greater efficiency of the symmetrical ketone as a radical scavenger, the ratio of halogenated ethanes produced is such that :

$$\frac{[R_1R_2]}{([R_1R_1][R_2R_2])^{1/2}} = 3 \cdot 9$$

The effect of the physical cage is demonstrated by the use of perfluoro*cyclo*hexane as a solvent. Solutions of 1 : 1 : 3 trichlorotrifluoroacetone in this solvent have a high viscosity and, when photolysed, smaller amounts of the symmetrical ethanes are formed so that :

$$\frac{[R_1R_2]}{([R_1R_1][R_2R_2])^{1/2}} = 2 \cdot 8$$

These results are supported by studies of the photolysis of mixtures of 1 : 3 dichlorotetrafluoroacetone and 1 : 1 : 3 : 3 tetrachlorodifluoroacetone in the liquid phase, although the situation is complicated by the fact that the rates of production of radicals are now different. After 30 min. irradiation of such a mixture no unsymmetrical ethane was formed and on prolonged photolysis the ratio gradually rose to 0·4. When the mixture was diluted with perfluoroethyl*cyclo*hexane the ratio rose to a value of unity. In these cases it is the like radicals which are confined to the cage, thus reducing the amount of unsymmetrical ethane formed. If the assumption is made that, in the liquid phase, once a radical has escaped from the cage its combination reactions are governed by statistical factors alone, then an estimate of the proportion of the radicals escaping from the cage may be made. Thus if the number of radicals involved in the formation of the unsymmetrical ethane $[R_1R_2]'$ (1 : 1 : 2 trichlorotrifluoroethane) outside the cage is calculated from the equation :

$$[R_1R_2]' = 2.([R_1R_1][R_2R_2])^{1/2}$$

and this is added to the number required to produce the two symmetrical ethanes R_1R_1 and R_2R_2 and the methanes R_1Cl and R_2Cl, this sum is the total number of radicals reacting outside the cage. The number reacting inside the cage is given by the difference between the number required to produce the total 1 : 1 : 3 trichlorotrifluoroethane and those required to produce the amount formed outside the cage. That is :

$$[R_1R_2]-[R_1R_2]' \text{ or } [R_1R_2]-2([R_1R_1][R_2R_2])^{1/2}$$

Thus the percentage of radicals escaping from the cage is given by :

$$\frac{[R_1Cl] + 2[R_1R_1] + 2([R_1R_1][R_2R_2])^{1/2}}{[R_1Cl] + 2[R_1R_1] + [R_1R_2]} \times 100$$

and

$$\frac{[R_2Cl] + 2[R_2R_2] + 2([R_1R_1][R_2R_2])^{1/2}}{[R_2Cl] + 2[R_2R_2] + [R_1R_2]} \times 100$$

The values quoted below are in good agreement with theoretical expectations and show that for two similar radicals the combination of which is not diffusion-controlled a direct measure of the efficiency of a solvent cage may be made.

Solvent	Percentage R_1 escaping	Percentage R_2 escaping
1 : 1 : 3 Trichlorotrifluoroacetone	91	89
Perfluoro*cyclo*hexane	89	85
1 . 1 : 3 : 3 Tetrachlorodifluoroacetone	68	76

A complete account of the kinetics of the photolysis of these three ketones is published elsewhere.

R. Bowles
J. R. Majer
J. C. Robb

Chemistry Department,
University of Birmingham,
Birmingham, 15.

[1] Bowles, R., Derbyshire, H., Majer, J. R., and Patrick, C. R., *Nature*, 185, 688 (1960).

[2] Ayscough, P. B., and Steacie, E. W. R., *Proc. Roy. Soc.*, A, 234, 476 (1956).

[3] Davis, N., *Chem. Revs.*, 40, 201 (1947).

[4] Trotman-Dickenson, A. F., Ann. Rep. Chem. Soc., 55, 39 (1959).

[5] Franck, J., and Rabinowitch, E., *Trans. Farad. Soc.*, 30, 120 (1934).

[6] Lampe, F. W., and Noyes, R. M., *J. Amer. Chem. Soc.*, 76, 2140 (1954).

Photochemical Formation and Stability of the CF_2 Radical

Ten years ago, Barrow and co-workers observed the ultra-violet absorption bands due to the CF_2 radical, produced during an electrical discharge through fluorocarbon vapour, and commented on its probable stability[1]. Using high-intensity flash photolysis techniques, we have been able to photograph the transient formation and slow decay of the same absorption bands produced from some halogenated ketones. Under our experimental conditions, the strongest absorption bands can be detected as long as 20 msec. after the photolysis flash, confirming the great stability of CF_2 as compared with its analogue CH_2 (ref. 2).

The ketones, which included sym-tetrafluorodichloro-acetone, and 1 : 1 : 3-trichloro-trifluoro-acetone, were photolysed in the vapour phase with the full radiation from a silica discharge lamp; the addition of excess nitrogen ensured the maintenance of isothermal conditions. The manner in which CF_2 radicals could arise in these systems is intriguing, since CF_2 formation would not have been anticipated by analogy with hydrogenated ketones. Certainly, the primary process:

$$R_1COR_2 + h\nu \rightarrow R_1 + CO + R_2$$

occurs, since all the possible ethanes were detected by vapour phase chromatography and mass-spectrometric analysis of the reaction mixture following flash photolysis. However, the simultaneous occurrence of alternative primary steps, of the type:

$$CF_2ClCOCF_2Cl + h\nu \rightarrow CF_2ClCOCF_2\cdot + Cl\cdot$$

yielding substituted acetonyl radicals, has been verified by introducing oxygen as the coolant gas; with each ketone the well-known absorption bands of $ClO\cdot$ were detected immediately following the flash, confirming the primary production of $Cl\cdot$ atoms. (The formation of $ClO\cdot$ via substituted methyl radicals may be discounted, since it has been observed that the flash photolysis of brominated chloromethanes in the presence of oxygen gives rise to $BrO\cdot$, but not $ClO\cdot$, radicals[3].) It may be anticipated that the acetonyl radicals would be unstable, dissociating as:

$$CF_2ClCOCF_2\cdot \rightarrow CF_2Cl\cdot + CO + CF_2$$

thus accounting for the production of CF_2. In this respect, it is significant that no di-acetonyl has been detected among the reaction products. Furthermore, in view of the evident stability of CF_2 it is not unreasonable to suppose that the perfluoroketone molecule would rapidly dissociate.

Preliminary measurements on the decay of the CF_2 absorption suggest that it is zero order, supporting Barrow's suggestion that CF_2 radicals are removed by diffusion to the walls of the reaction vessel[1]. The gradual appearance of a permanent continuous background absorption after several flashes points to the accumulation of a polymeric layer of $(CF_2)_n$ on the reaction vessel windows. No tetra-fluoro-ethylene or volatile CF_2-telomers could be detected among the reaction products, and it would appear that CF_2 is extremely unreactive (compare the marked unreactivity of NF_2 as compared with NH_2).

A fuller account of this and related work in progress will be published at a later date.

We wish to thank Dr. J. R. Majer for the vapour phase chromatography and mass-spectrometric analyses, and Prof. J. C. Robb for his interest in, and encouragement of, this work. A. J. Y. thanks the Department of Scientific and Industrial Research for a maintenance award, and J. P. S. thanks the University of Birmingham for the award of an Imperial Chemical Industries fellowship.

J. P. Simons
A. J. Yarwood

Chemistry Department,
University of Birmingham,
Birmingham, 15.

[1] Laird, Andrews and Barrow, *Trans. Farad. Soc*, 46, 803 (1950).

[2] Herzberg and Shoosmith, *Nature*, 183, 1801 (1959).

[3] Zeelenberg, *Nature*, 181, 42 (1958).

Dependence on Temperature of the Electrical Resistivity of Thermosetting Polymers

To-day's great usage of thermosetting polymers has served to emphasize the lack of fundamental data on the electrical and physical properties of these materials. With the exception of the data published by us[1,2], there is almost none available on the dependence on temperature of the electrical volume resistivity and on the activation energy for the electrical conduction process, E_c, in cross-linked polymers. Data of this type are of great importance not only in technological applications but also in the study of the physics and chemistry of these polymers. For example, it has recently been shown[1,2] that the dependence on temperature of the resistivity is a convenient index of the extent of polymerization. Also, recent work has shown that electrical resistivity measurements can be successfully employed in the study of the reactions and the determination of the extent of polymerization of composite solid propellants[3]. These experimental techniques can likewise be used to investigate the properties of organic semiconductors. It is the purpose of this communication to indicate briefly how these measurements can be accurately and rapidly made and to present typical results.

A continuous current monitoring device[4] is used to determine the dependence on temperature of the resistivity of the polymer. This instrument consists of a Keithley model 210 electrometer, a Keithley model 2008 decade shunt and a cell. The cell consists of two brass parallel plate electrodes separated by two small polytetrafluoroethylene spacers. With this instrumentation it is possible to monitor continuously the large change in resistivity (10^{6}–10^{16} ohm.-cm.) which may occur on heating a polymer. To assure optimum electrical contact, the liquid

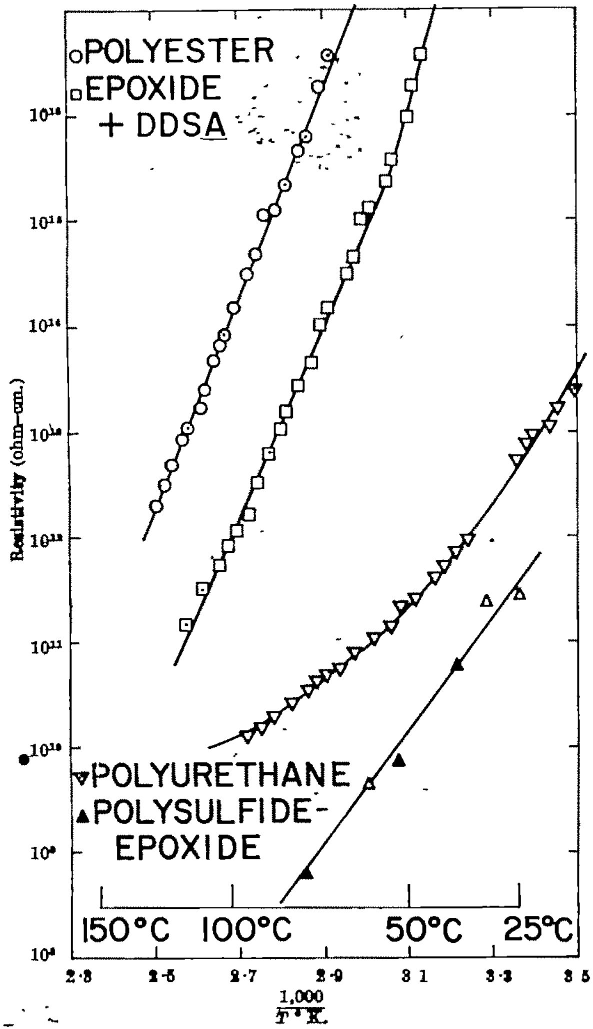


Fig. 1

polymer is polymerized directly to the electrodes which are encapsulated by the polymer. The dependence on temperature of the resistivity of the completely polymerized sample is determined by monitoring the resistivity and the temperature of the sample as it is heated at a rate of about 15° C. per hr. Measurements are made at a field-strength of about 200 V. per cm.

Polymers considered in this communication are typical of the thermosetting types in use. The epoxide was 'Epon 828' (Shell Chemical Co.), a reaction product of 2 moles of epichlorohydrin and 1 mole of *bis*(4-hydroxyphenyl) dimethylmethane[5], and had an epoxide value of 0·54 per 100 gm. It was polymerized with 59·5 per cent of dodecenyl succinic anhydride. The polyester was 'Paraplex *P*-43' (Rohm and Haas Co.), which is reported to consist of 30 per cent styrene and 70 per cent of a linear condensation polymer of maleic and phthalic acids with propylene glycol. This was polymerized using 1 per cent methyl ethyl ketone peroxide as a catalyst. The polysulphide-epoxide copolymer was a 50 : 50 mixture of a mercaptan terminated saturated elastomer and 'Epon 828'. The polysulphide was a reaction product of *bis*(2-chloroethyl) formal and sodium polysulphide[6]. Diethylaminopropylamine at a concentration of 3 per cent was used as a hardener. The polyurethane was a reaction product of a polyester glycol and 2,4-tolylene di*iso*cyanate which is cross-linked with 40 per cent castor oil.

It will be noted in Fig. 1 that in three of the polymers considered, the electrical volume resistivity, ρ, changes with the absolute temperature, *T*, in accordance with the general relationship:

$$\rho = \rho_0 \exp[E_c/RT]$$

where ρ_0 is a temperature-independent constant, *R* is the gas constant in cal./deg. mole, and E_c is the activation energy for the electrical conduction process. This activation energy was found to be 70 kcal./mole for the epoxide + dodecenyl succinic anhydride at temperatures below 54° C. and 43 kcal./mole above this temperature. The change in the slope of the resistivity versus temperature plot at 54° C. can be attributed to a glass transition within the polymer[3]. For the polyester polymer, E_c was 46 kcal./mole and for the polysulphide-epoxide copolymer 24 kcal./mole. A nonlinear temperature dependence of the resistivity is exhibited by the polyurethane which may be due to the internal plasticization of this polymer, probably by the excess castor oil.

All the resistivity versus temperature plots shown in Fig. 1 have the maximum slopes that can be obtained for these polymers. These plots, therefore, represent the greatest extent of polymerization possible.

It has been previously shown[1,2] that during polymerization the dependence on temperature of the resistivity increases as a function of the extent of polymerization. Thus, the dependence on temperature, or more conveniently E_c, is an index of the extent of polymerization. Prolonged heating at high temperatures or pyrolysis of these polymers will result in degradation, which is evidenced by a decrease in the slope of the resistivity versus temperature plot. It has been observed that thermosetting polymers generally exhibit a greater dependence on temperature and magnitude of the resistivity at 25° C. than linear polymers. The polysulphide-epoxide copolymer is an exception to this generalization.

Work is continuing in an effort to develop additional data and to broaden the use of the continuous current monitoring device to relate fundamental electrical properties to the structure and physical properties of thermosetting polymers. Additional data on thermosetting polymers, the experimental technique, and a discussion of the nature of the electrical conduction process in polymers will be published at a later date.

R. W. WARFIELD
M. C. PETREE

Non-Metallic Materials Division,
Chemistry Research Department,
Naval Ordnance Laboratory,
White Oak, Silver Spring, Maryland.

---

[1] Warfield, R. W., and Petree, M. C., *J. Polymer Sci.*, 37, 305 (1959).

[2] Warfield, R. W., and Petree, M. C., paper presented at the 136th National Meeting of the American Chemical Society, Atlantic City, New Jersey, September 15, 1959.

[3] Warfield, R. W., *J. Amer. Rocket Soc.*, 30 (1960).

[4] Aukward, J. A., and Warfield, R. W., *Rev. Sci. Instr.*, 27, 413 (1956).

[5] Lee, H., and Neville, K., "Epoxy Resins", 173 (McGraw-Hill, London, 1957).

[6] Warfield, R. W., *Soc. Plastics Eng. J.*, 15, 625 (1959).

'Enthalpy Titrations' and Thermochemistry in Molten Salts

AUTOMATIC instrumentation for recording 'thermometric titration' curves has been described in recent papers[1,2] from these laboratories, which represent the first report of a continuous titration procedure successfully carried out in a molten salt solvent. This approach is capable of yielding a wealth of quantitative information on the chemistry of fused salts. Significant thermochemical results, involving the precipitation of silver halides and of silver chromate, are summarized in this communication. A typical titration curve (of chromate with silver), obtained under essentially adiabatic conditions, is illustrated in Fig. 1. Methodologically this is a differential thermometric titration curve, because temperature has been recorded as a function of the amount of titrant. From a phenomenological point of view, however, Fig. 1 represents an 'enthalpy titration', the shape of the curve reflecting the heat evolved in the reaction as a function of added silver.

The following types of data can be inferred from a judicious interpretation of the titration curves: (*a*) The stoichiometry of the reaction occurring in the fused solvent, if concentrations of the reactants are known (the abscissa projection $B'C'$ represents a measure of the mole ratio of titrant to 'titrate' (Fig. 1) at the extrapolated end-point C). (*b*) The amount of reactant in a titrate of unknown concentration, provided the stoichiometry is known, and a standard solution of titrant is used. (*c*) The heat of the titration reaction, $\Delta H°$, calculated from the extrapolated change in temperature BB'. (*d*) The solubility product, K_{sp}, and the corresponding free energy of precipitation, $\Delta F° = RT \ln K_{sp}$, computed from the curvature in the vicinity of the end-point. (*e*) The entropy of the reaction, $\Delta S° = \dfrac{\Delta H° - \Delta F°}{T}$. Ideal thermodynamic parameters were obtained, because effective reactant concentrations in the titration cell were maintained in a range between 10^{-4} and 10^{-2} molal, where heats of dilution were found to be negligible. The change in temperature, BB', in a titration was of the order of 0·01–0·5° C., at mean temperatures of 500–800° K. The corresponding variability of the thermodynamic functions is negligible, yielding virtually isothermal enthalpies, free energies, and entropies, corresponding to the 'median temperature' of the titration curve, T (Fig. 1). The change in temperature during the titration was monitored in the titrated melt by means of a thermistor bridge having a sensitivity threshold of 0·0003° C. Random temperature fluctuations were minimized to ±0·0005° C. with the aid of a special adiabatic titration cell in a supernatant argon atmosphere. The titrant was delivered by remote control, via a motor-driven syringe-burette. Titrant and titrate were dissolved in identical fused salt solvents[2].

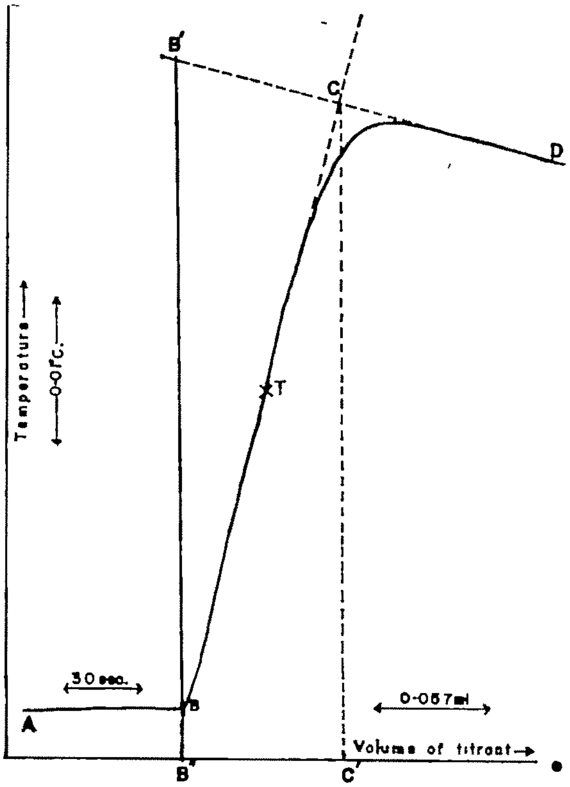


Fig. 1. Thermometric titration of 5·556 × 10^{-2} m. K_2CrO_4 titrate with 12·78 m. $AgNO_3$ titrant in fused $LiNO_3$—KNO_3 at 431° K. Amount of titrate melt, 99·3 gm. *AB*, Temperature–time blank, prior to start of titration; *B*, start of titration; *C*, end-point, $2Ag^+/1CrO_4^{--}$; *CD*, excess reagent line; *T*, median temperature

A representative set of results is shown in Table 1. As is evident from column 3, thermometric titrations are applicable to quantitative volumetric analysis with a precision and accuracy of the order of 2 per cent, at concentration-levels as low as 10^{-3} molal. Extensive applications are anticipated to the determination of halides and silver, *in situ* in molten salts at elevated temperatures. Of the thermodynamic parameters, the entropies offer interesting possibilities for direct qualitative interpretation as a measure of order–disorder situations. For example, the fact that the precipitation of silver chromate at 431° K. was virtually anentropic in a fused alkali nitrate solvent suggests that chromate existed in the melt as an associated 'polychromate' species. In contra-

Table 1. SYNOPSIS OF INFORMATION OBTAINED FROM THERMOMETRIC TITRATIONS AT 431° K.*
Titrant: Silver nitrate

Titrate	Titrate concentration (moles/1,000 gm. solvent melt)	End point stoichiometry† (silver/anion mole ratio)	Inferred reaction	Thermodynamic functions‡		
				$\Delta H°$ (kcal./mole)	$\Delta F°$ (kcal./mole)	$\Delta S°$ (cal./mole-deg.)
KCl	9×10^{-4} to 2×10^{-2}	1·01 ± 0·04	$Ag^+ + Cl^- \rightleftharpoons AgCl(s)$	−18·9 ± 0·9	−14·9 ± 0·2	− 9·2 ± 2
KBr	1×10^{-3} to 2×10^{-2}	0·996 ± 0·03	$Ag^+ + Br^- \rightleftharpoons AgBr(s)$	−26·1 ± 0·7	−17·7§	−19·5
KI	3×10^{-4} to 2×10^{-2}	0·990 ± 0·03	$Ag^+ + I^- \rightleftharpoons AgI(s)$	−32·1 ± 1	−24·2§	−18·3
K_2CrO_4	2×10^{-3} to 6×10^{-2}	1·96 ± 0·03	$2Ag^+ + CrO_4^{--} \rightleftharpoons Ag_2CrO_4(s)$	−16·7 ± 0·5	−15·7 ± 0·4	− 2 ± 2

* Solvent: 43·1 mole per cent $LiNO_3$—56·9 mole per cent KNO_3 eutectic melt.
† Precision expressed in terms of standard deviation of a single measurement.
‡ For precipitation processes indicated in column 4.
§ Data from ref. 3.

distinction, the entropy of precipitation of silver halides was normal, that is, corresponded to a loss of entropy upon precipitation, indicating that silver halide ions existed in the fused salt solution in a less-ordered state than in the solid phase.

Acknowledgment is made to the United States Atomic Energy Commission for financial support, under contract AT(30–1)–2133 with the Pennsylvania State University.

JOSEPH JORDAN
JURG MEIER
EDWARD J. BILLINGHAM, JUN.
JAMES PENDERGRAST

Department of Chemistry,
Pennsylvania State University,
University Park, Pennsylvania.

---

[1] Jordan, J., Meier, J., Billingham, jun., E. J., and Pendergrast, J., *Anal. Chem.*, 31, 1439 (1959).

[2] Jordan, J., Meier, J., Billingham, jun., E. J., and Pendergrast, J., *Anal Chem.* (in the press).

[3] Flengas, S., and Rideal, E., *Proc. Roy. Soc.*, A, 233, 443 (1956).

RADIATION CHEMISTRY

Chemical Effects of Ionizing Radiations on Nucleic Acids and Nucleoproteins

RECENT work[1] on the effects of ionizing radiations on nucleic acids (deoxyribonucleic and ribonucleic acids) in aqueous systems has shown quite clearly that the reactive species produced from the water attack mainly the constituent purine and pyrimidine bases and, to a lesser extent, the sugar moieties of these polynucleotide molecules. The extents of destruction of the individual bases on irradiation of deoxyribonucleic solutions (0·005 per cent) in the presence of oxygen (1 atm.) were measured and found to be as follows (G = molecules/100 eV.): $G(-\Delta\text{thymine}) = 0{\cdot}33$; $G(-\Delta\text{adenine}) = 0{\cdot}25$; $G(-\Delta\text{cytosine}) = 0{\cdot}23$; $G(-\Delta\text{guanine}) = 0{\cdot}18$. Breakage of the strands in the deoxyribonucleic acid helix is apparently mainly due to an attack of the radicals produced by irradiation on the sugar moieties, which leads to a splitting of the phosphate ester linkages along the chains. The extent of attack which leads to breakage of internucleotide bonds, leading to the production of phosphomonoester groups, has been determined directly with monophosphoesterase; the number of end-groups formed on irradiation with 200 kV. X-rays gives a yield of $G \simeq 0{\cdot}5$. Rupture of hydrogen bonds within the helix is a consequence of chemical changes in the polynucleotide chains; several hydrogen bonds can be broken following a single chemical event.

The hyperchromic effect which is observed in the action of the radiations on nucleic acids in solutions has been investigated in some detail. It has been concluded that this effect is caused, in general, by environmental changes of the chromophoric groups of the purine and pyrimidine bases of deoxyribonucleic acid, and is due to the change from the hydrogen bonding of the bases within the intact helix (where the bases of one strand are bonded to the bases of the complementary strand), to hydrogen bonding with water molecules when the latter have penetrated between the strands of the helix.

The chemical nature of the reactions induced by irradiation of nucleic acid has been studied in some detail by investigating solutions of the purine and pyrimidine bases and of the corresponding nucleosides and nucleotides[1].

Since deoxyribonucleic acid is generally found in biological systems in the form of nucleohistones or nucleoprotamines, a point of particular interest appeared to be a study of the changes induced by irradiation in deoxyribonucleic acid when combined with protein in the nucleoproteins.

Aqueous solutions of calf thymus nucleoprotein were prepared from fresh calf thymus glands by Doty and Zubay's method[2] using a Dounce homogenizer. Solutions (~ 0·02 per cent) were saturated with oxygen (1 atm.) for 15 min. prior to irradiation. The deoxyribonucleic acid used was kindly supplied by Prof. J. A. V. Butler. Calf thymus histone was obtained from the Mann Research Laboratories.

The irradiations were carried out with X-rays from a Victor 'Maximar' therapy tube operating at 200 kV. and 15 m.amp. Solutions were irradiated in 'Pyrex' glass vessels of the type previously described[3]. The dose-rate as determined by the Fricke dosimeter was 2,900 rads/min.

Experiments were carried out in which the total individual base compositions of irradiated and unirradiated nucleoprotein solutions were determined. For this purpose, samples were hydrolysed with formic acid and this was followed by chromatographic separation, using a butanol–ammonia system[4], and spectrophotometric estimation of the individual purines and pyrimidines. The results show quite clearly that up to doses of about $1{\cdot}3 \times 10^5$ rads, the bases of the nucleic acid were not detectably attacked by the radiation.

Another way of detecting any chemical modifications of the nucleic acid component involves determination of the rate of release of inorganic phosphate on hydrolysis at elevated temperatures[5]; this is rather a sensitive method, and has been successfully employed in irradiations of solutions of deoxyribonucleic acid. Solutions of nucleoprotein were irradiated, treated with catalase (to decompose hydrogen peroxide) and with chymotrypsin (to degrade protein) and then hydrolysed at 90° at pH 7·5. The rate of release of inorganic phosphate was almost exactly the same in the irradiated as in the unirradiated blank solutions. This latter result would therefore confirm that in the intact nucleoprotein no detectable attack on the polynucleotide takes place.

In contrast to these findings, it was found that on irradiation of solutions of synthetic mixtures of calf thymus deoxyribonucleic acid and histone, there was some degradation of the deoxyribonucleic acid component, but much less than in pure deoxyribonucleic acid solutions. In the synthetic mixtures, the protein protected the deoxyribonucleic acid to some extent, as would be expected from the fact that the free radicals produced by irradiation can distribute themselves between the nucleic acid and the protein.

We must conclude, therefore, that in the intact nucleoprotein as isolated from calf thymus glands, the active species produced by irradiation are unable to penetrate the protein sheath; apparently, up to doses as high as 10^5 rads practically all of them react with the protein and the deoxyribonucleic acid remains substantially undamaged. This chemical evidence is in agreement with the observation of Kaufmann *et al.*[6] that irradiation of nucleoprotein did not appreciably alter the viscosity of the deoxyribonucleic acid component.

These findings may explain the high radiosensitivity of the nucleus during certain stages of the mitotic cycle, when the protein is shed from the deoxyribonucleic acid.

We thank the Rockefeller Foundation and the Northern Council of the British Empire Council Campaign for financial support. One of us (P. E.) also thanks the Department of Scientific and Industrial Research for a maintenance grant. One of us (J. W.) would like to thank Prof. G. de Hevesy for interesting discussions.

P. Emmerson
G. Scholes
D. H. Thomson
J. F. Ward
J. Weiss

Department of Chemistry,
King's College,
University of Durham,
Newcastle upon Tyne, 1.

[1] Scholes, G., Ward, J. F., and Weiss, J., paper presented at the Joint Meeting of the Faraday Soc. and Assoc. for Radiation Res. at King's College, Univ. of Durham, March 23–25, reported in *Int. J. Radiation Biol.*, 1, 312 (1959). Ward, J. F., Ph.D. thesis, Univ. of Durham (1959).

[2] Doty, P., and Zubay, G., *J. Amer. Chem. Soc.*, 78, 6207 (1956).

[3] Farmer, F. T., Stein, G., and Weiss, J., *J. Chem. Soc.*, 3241 (1949).

[4] MacNutt, W. S., *Biochem. J.*, 50, 384 (1952).

[5] Daniels, M., Scholes, G., and Weiss, J., *Experientia*, 11, 6, 219 (1953).

[6] Kaufmann, B. P., McDonald, M. R., and Bernstein, M. H., *Ann. N.Y. Acad. Sci.*, 59, 553 (1955).

BIOPHYSICS

Electrostatic Measurement of the Geoelectric Effect in Coleoptiles

The so-called geoelectric potential, which develops between the upper and lower side of a plant when it is placed in a horizontal position, has been investigated by many workers[1–5] using different types of fluid electrodes which were applied directly to both sides of the plant. The original explanation of the cause of this potential given by Brauner[6] has lately proved to be unsatisfactory[7] and a new theory was proposed[8]. To test this theory it was necessary to carry out electric measurements on plants during much longer periods of time than has been done earlier. This was possible by using electrodes somewhat similar to those devised by Clark[9]. The results obtained by this method were difficult to reproduce and differed generally from those reported by earlier workers. During extensive measurements on *Avena* coleoptiles, *Pisum*, *Helianthus* and *Zea mays*, it was found that the results are often strongly influenced by the direct-contact electrodes. Therefore, it was thought necessary to measure these potentials without touching the plants at all, and to this end an entirely new measuring technique was developed.

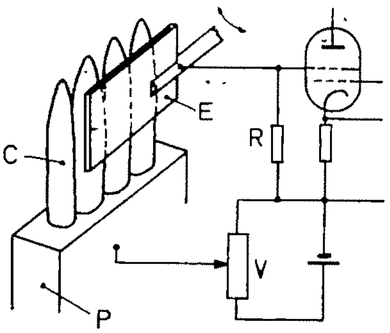


Fig. 1. Measurement of the geoelectric potential by means of the vibrating reed principle. This method permits the potential measurement with the vibrating electrode *E* without touching the coleoptiles *C*

This method makes use of the vibrating reed principle[9]. A thin plane gold electrode, 5 mm. × 10 mm., is placed at a distance of about 1 mm. from three to seven *Avena* or *Zea mays* coleoptiles placed in a row (see Fig. 1). This electrode is carefully insulated and is vibrated at a frequency of about 250 c./s.; it is earthed through a resistance *R* of 10^{10} ohms. If an electric field exists between the coleoptiles and the vibrating electrode, an alternating voltage will be generated across the resistance *R*. This voltage signal is applied to the grid of an electrometer tube connected as a cathode follower, and after further selective frequency amplification displayed on a cathode-ray tube screen. The other plate of the vibrating condenser is formed by the coleoptiles themselves. They are usually cut about 15 mm. from the apex and inserted into a 'Plexiglas' container *P* filled with tap water. With a miniature calomel electrode[10] in contact with this water reservoir, the potential of the coleoptiles can be varied at will by a variable voltage *V* (Fig. 1).

The a.c. signal generated by the vibrating electrode *E*, which is displayed on the cathode-ray tube, is roughly proportional to the magnitude of the electric field between the coleoptiles *C* and the electrode *E*. Therefore, by adjusting the voltage *V* properly, the a.c. signal can be reduced to zero, thus indicating that the field-strength and the potential between the coleoptiles *C* and the electrode *E* is zero.

If, after this adjustment, the apparatus is placed in a horizontal position and a geoelectric potential appears on the surface of the coleoptiles, an a.c. signal is generated again because of the electric field due to this potential. By varying the voltage *V*, this signal can be reduced to zero again, the variation of *V* being roughly equal to the potential developed by the coleoptiles. Measuring this potential with the electrode *E* above and below the plants and applying a correction factor for the geometry of the coleoptiles, the true geoelectric potential can be found.

The results of such measurements, the reproducibility of which is definitely superior to the conven-

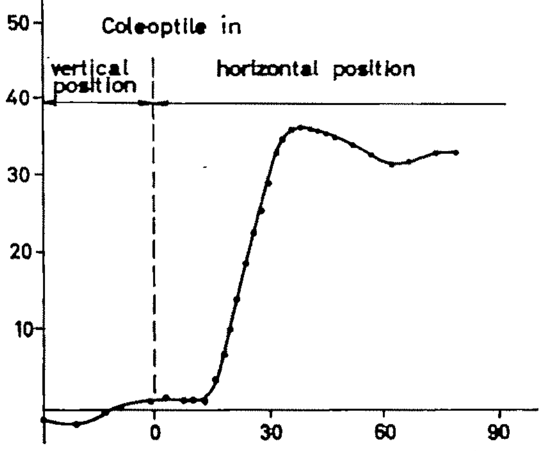


Fig. 2. Geoelectric potential generated across etiolated *Avena* coleoptiles when placed in a horizontal position, as measured by the vibrating reed method

tional method, are shown in Fig. 2. The measurements have been made on etiolated *Avena* and *Zea mays* coleoptiles in the dark. Contrary to previous results, the geoelectric voltage does not appear until 15 min. after tilting the plants into a horizontal position. This has been corroborated with *Avena*, *Pisum* and *Zea mays* by our extensive experiments with the conventional method using electrodes similar to the Clark type[5]. Further, the magnitude of the voltage is greater than that reported by the majority of previous authors. A more detailed description of the method and results with different plant materials will be published elsewhere.

I thank Prof. H. Burström, of the Botanical Laboratory, Lund, for his encouragement and advice.

CARL HELLMUTH HERTZ

Biophysics Group,
Department of Physics,
University of Lund,
Lund, Sweden.

[1] Bose, J. C., "Comparative Electrophysiology", 434 (London, 1907).
[2] Brauner, L., *Jahrb. f. wiss. Botanik*, 66, 381 (1927).
[3] Schrank, A. R., *Plant Physiol.*, 20, 133 (1945); "Bioelectric Field and Growth", 75, edit. by Lund, E. I. (1947).
[4] Amlong, H. U., *Planta*, 21, 211 (1933).
[5] Clark, W. G., *Plant Physiol.*, 12, 409 (1937).
[6] Brauner, L., *Rev. Fac. Sci. Univ. Istanbul*, 10, 1 (1945).
[7] Brauner, L., *Planta*, 53, 449 (1959).
[8] Hertz, C. H., and Grahm, L., *Naturwiss.*, 45, 624 (1958).
[9] Palensky, H., Swank, R. K., and Grenchik, R., *Rev. Sci. Instr.*, 18, 298 (1947).
[10] Hertz, C. H., and Siesjö, B., *Acta physiol. Scand.*, 47, 115 (1959).

●

BIOCHEMISTRY

Screw Sense of the α-Helix in Poly-β-benzyl-L-aspartate

Blout and Karlson[1] have reported that the constant b_0 in Moffitt's equation for the dispersion of optical rotation[2] has values up to + 630° for solutions of poly-β-benzyl-L-aspartate in chloroform; the usual value for solutions containing α-helices of polypeptides is about − 600°, and corresponds to right-handed helices[3]. We have studied the dispersion of a number of copolymers of β-benzyl-L-aspartate with other amino-acids, and believe that the results demonstrate that the positive b_0 found for poly-β-benzyl-L-aspartate is due to a left-handed helix and not to an optical anomaly.

If we plot b_0 against composition for a series of random copolymers of β-benzyl-L-aspartate and γ-benzyl-L-glutamate, we find that although the values of b_0 for the two simple polymers are almost equal (though of opposite sign) the curve is very far from symmetrical. Eight mole per cent of L-glutamate is sufficient to reduce b_0 to zero[4], and more than 85 per cent of the total change in b_0 is produced by the addition of 15 mole per cent of L-glutamate; the effect of L-alanine residues is similar. These results are best explained by the hypothesis that the two simple polymers form α-helices of opposite screw senses, and that the preference of the L-aspartate residues for a left-hand helix is much less marked than that of the L-glutamate residues for a right-hand helix, so that comparatively few of the latter can dictate the sense. To explain these results on the basis of an optical anomaly we would have to postulate that this anomaly depends on long unbroken sequences of L-aspartate residues. However, other experiments show that the sequences of L-aspartate residues may be interrupted by either D-glutamate or D-aspartate residues with very little effect on b_0.

These conclusions are confirmed by measurements on a number of other copolymers, both random and block, and by building molecular models. A full account of this work will be published elsewhere.

E. M. BRADBURY
A. R. DOWNIE
A. ELLIOTT
W. E. HANBY

Courtaulds, Ltd., Research Laboratory,
Maidenhead, Berks. March 4.

[1] Blout, E. R., and Karlson, R. H., *J. Amer. Chem. Soc.*, 80, 1259 (1958); corrected value of b_0 given in same ref., p. 6701.
[2] Moffitt, W., *J. Chem. Phys.*, 25, 467 (1956); *Proc. U.S. Nat. Acad. Sci.*, 42, 736 (1956).
[3] For example, Moffitt, W., and Yang, J. T., *Proc. U.S. Nat. Acad. Sci.*, 42, 596 (1956).
[4] Bamford, C. H., Ballard, D. G. H., and Elliott, A., Symp. on Macromolecules, Wiesbaden (1959); *Makromol. Chem.*, 35 (2), 222 (1960).

Isolation and Probable Functions of Betaine Esters in Brain Metabolism

IN previous work, Hosein[1] reported that γ-butyrobetaine was found in extracts made from brain tissue of rats in convulsions which had been induced by intraperitoneal injections of cerebral convulsants. We have now found that fractionation of the gold precipitate formed from eluates of the chromatograms made from these extracts by the procedure of Linneweh[2] enables the identification of two other betaines. The melting points of the gold derivatives of the betaines obtained in this investigation are shown in Table 1 and compared with those obtained by Linneweh for synthetic betaines.

Table 1. MELTING POINTS OF GOLD DERIVATIVES OF VARIOUS BETAINES

Substance	Melting point (with decomposition) in deg. C Linneweh	 Betaine isolated
γ-Butyrobetaine	180–184	177–181
Crotonbetaine	212–214	209–211
Carnitine	150–153	149–153

From these results we conclude that the brain extracts from animals treated with cerebral convulsants contained free γ-butyrobetaine, crotonbetaine and carnitine.

Other work by Hosein[3] has shown that in normal brain extracts these betaines in the free form could not be detected. It was shown that the 'free' or immediately extractable acetylcholine from aqueous brain extracts (supernatant *A*) contained acetylcholine and propionylcholine, while the 'bound' fraction, released after chloroform treatment (supernatant *B*), contained, in addition to these choline esters, a mixture of the coenzyme A ester derivatives of the betaines mentioned above. These betaine esters were contained in a band of the chromatogram developed in the butanol/water system with an R_F between 0·45 and 0·56. The chromatogram pattern obtained from the 'bound' acetylcholine fraction in brain was similar to that obtained by Bannister *et al.*[4], who used ox spleen. We have synthesized enzymatically γ-butyrobetaine–coenzyme *A*, and this substance has an R_F of 0·55 in the butanol/water system. This thiol ester was found to possess acetylcholine-like properties similar to those obtained with eluates of the 0·45–0·56 band obtained from brain extracts. In both cases their physiological effects are abolished by atropine. Accordingly, it appeared from these results that both the 'free' and 'bound' extractable acetylcholine from brain is not solely due to acetylcholine alone. The presence of the betaine-coenzyme *A* esters exclusively in the 'bound' acetylcholine fraction may accordingly be of significance in brain metabolism.

Other experiments by our group[3,6] and by others[7,8] have shown that ester derivatives of these betaines have acetylcholine-like properties, whereas the free (unesterified) betaines are inactive. Previously, Hosein and McLennan[5] described some pharmacological properties of the methyl ester of γ-butyrobetaine. In that paper γ-butyrobetaine was described as having these acetylcholine-like properties, but actually the methyl ester was used; this material was erroneously supplied to us as γ-butyrobetaine and accordingly it was used as such. We[1] have found that the methyl, ethyl and choline esters of γ-butyrobetaine are extremely powerful convulsants. Accordingly, it seemed possible that, *in vivo*, betaine esters could also be concerned with convulsive activity in brain, while the presence of the free betaines mentioned above could have been due to ester hydrolysis either *in vivo* or during the extraction process.

We have repeated our previous experiments, in which cerebral and spinal convulsants were injected intraperitoneally into rats, to determine whether betaine esters could be detected in the supernatant *A* fraction of the brain suspensions of these treated animals. The convulsants used were dieldrin, ammonium chloride, metrazol, picrotoxin, camphor and strychnine. In comparison experiments, cerebral convulsions were produced by electroshock. As before, all animals were killed during the convulsions and untreated animals served as controls. Examination of the chromatogram shown in Fig. 1 shows that, in addition to acetylcholine and propionylcholine normally present in supernatant *A*, when brain extracts made from animals treated with electro-shock or when cerebral convulsants were used, there was a band at R_F 0·45–0·56, which contained the betaine coenzyme *A* esters. This was not observed when strychnine was used. In normal animals this band was only found in supernatant *B*, that is, the tissue residue which had been treated with chloroform[3]. The presence of the betaine esters in the supernatant *A* fraction suggests that they were released from their normal cellular attachments by some action of the convulsive agents, and since they have been found to be indistinguishable from acetylcholine on assay preparations, they may be concerned with the initiation of the convulsions.

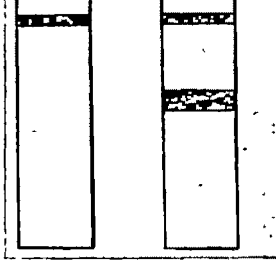


Fig. 1

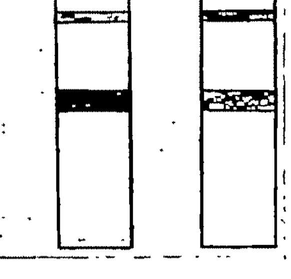


Fig. 2

Fig. 1. Release of betaine esters (R_F 0 45–0 56) in brain tissue during convulsions

Fig. 2. Distribution of betaine esters in the cerebellum and the cerebral cortex of normal rats

There are many indications that there may be several substances in brain other than acetylcholine which could have transmitter properties. The low choline acetylase activity and concentration of acetylcholine in the cerebellum are indicative of this[9,10]. Results of paper chromatographic analysis of chloroform-treated extracts, supernatant *B*, of the cerebellum and of the cerebral cortex of normal rats (see Fig. 2), have shown that the cerebellum contains a higher concentration of these betaine coenzyme *A* esters than does the cerebral cortex. This suggests that these betaine coenzyme *A* derivatives may function as transmitter substances in the cerebellum and perhaps also in other regions of the brain. An evaluation of the physiological properties of the coenzyme *A* ester derivatives of γ-butyrobetaine, crotonbetaine and carnitine is now in progress.

This work was supported by a grant from the United States Public Health Service, Project *B*–1756, to which we express our appreciation.

E. A. HOSEIN
PETER PROULX

Department of Biochemistry,
McGill University,
Montreal.

[1] Hosein, E. A., *Canad. J. Biochem. and Physiol.* (in the press).
[2] Linneweh, W., *Z. physiol. Chem.*, 181, 42 (1929).
[3] Hosein, E. A., "Protides of the Biological Fluids", edit. by Peeters, H., 7, 275 (Elsevier, Amsterdam, 1959).
[4] Bannister, J., Whittaker, V. P., and Wijesundera, S., *J. Physiol.*, 121, 55 (1953).
[5] Hosein, E. A., and McLennan, H., *Nature*, 183, 328 (1959).
[6] Hosein, E. A., Ottolenghi, E., and Dorfman, S., Second Int. Symp. Myasthenia Gravis, edit. by Viets, E. (Charles C. Thomas, Springfield, 1960).
[7] Burgen, A. S. V., and Hobbiger, F., *Brit. J. Pharmacol.*, 4, 229 (1949).
[8] Strack, E., and Foesterling, K., *Z. physiol. Chem.*, 295, 377 (1953).
[9] Hebb, C. O., *Physiol. Rev.*, 37, 196 (1957).
[10] Crossland, J., and Merrick, A. J., *J. Physiol.*, 125, 56 (1954).

Effect of Potassium Cyanide Poisoning on the γ-Aminobutyric Acid-Level in the Brain

SEVERAL substances, which affect brain metabolism, act upon the γ-aminobutyric acid-level in that organ[1]. Insulin-induced hypoglycæmia brings about a drop in the γ-aminobutyric acid-level, probably as a result of decreased glutamic acid concentration. The administration of some substances, known to inhibit glutamic acid decarboxylase, leads also to a drop in the level of γ-aminobutyric acid in the brain. Thus, semicarbazide, an inhibitor combining with the aldehyde group of pyridoxalphosphate, reduces the γ-aminobutyric acid-level in the brain by approximately 30 per cent[2]; in a similar way, 2-methyl-4-amino-5-oxymethylpyrimidine brings about a drop[3]. After the ethanol ingestion, however, the level of γ-aminobutyric acid content in the brain was found to be increased[4].

Potassium cyanide is a substance which inhibits the activity of glutamic acid decarboxylase, as has been shown by *in vitro* experiments by Wingo and Awapara[5]. This inspired me to follow the effect of cyanide poisoning on γ-aminobutyric acid in the brain.

Experiments were carried out on albino rats of Wistar *B* strain weighing 200–300 gm. Cyanide was administered intraperitoneally in the doses of 40 and

10 mgm./kgm. in 0·5 ml. After the stage of convulsions (1–4 min. following administration of potassium cyanide), the animals were decapitated. After weighing, the brain was homogenized in a homogenizer according to Potter and Elvehjem in 1 per cent picric acid solution. The homogenate was centrifuged, and the picric acid removed on a 'Zerolith *FF*' column. The brain extract thus treated was placed on chromatography paper Whatman 1 and submitted to electrophoretic partition in pyridin–acetate buffer at 26 V./cm. Electrophoretic partition and quantitative determinations of γ-aminobutyric acid and glutamic acid were made according to Wingo and Awapara[5], with the only difference that 0·5 per cent ninhydrin solution was prepared in aqueous acetone (90 ml. acetone + 10 ml. water), saturated with sodium carbonate. Optical density was measured on Zeiss spectrophotometer at 570 mμ.

Table 1

	No. of determ-mations	γ-Amino-butyric acid (μgm./gm. of wet weight)	*P*	Per cent
Control animals	25	303 (417–236)		100
Animals poisoned with potassium cyanide—40 mgm./kgm.	25	244 (330–186)	<0·01	80·5
Animals poisoned with potassium cyanide—10 mgm./kgm.	13	252 (341–180)	<0·01	83·0

As shown in Table 1, potassium cyanide poisoning causes a decrease of γ-aminobutyric acid by 19·5 or 17 per cent respectively.

When calculated for the dry weight of the brain of the control animals and of those poisoned with potassium cyanide, the concentrations in per cent were the same as given in Table 1.

After the administration of potassium cyanide the blood-level of γ-aminobutyric acid did not rise.

Table 2

	No. of determ-mations	Glutamic acid (μgm./gm. of wet weight)	*P*	Per cent
Control animals	14	1,855 (1,750–2,250)		100
Animals poisoned with 40 mgm. potassium cyanide/kgm.	14	2,130 (1,840–2,560)	<0·02	115
Animals poisoned with 10 mgm. potassium cyanide/kgm.	13	2,040 (1,720–2,620)	<0·05	110·5

Table 2 illustrates the changes of glutamic acid concentration in the brain following poisoning with potassium cyanide.

The decrease of concentration of γ-aminobutyric acid is probably due to inhibition of glutamic acid decarboxylase. This presumption is confirmed by the inhibition of glutamic acid decarboxylase *in vitro*, partly by a rise in glutamic acid concentration. In 1 gm. of wet tissue, there is a rise of 1·5–2·0 μ*M* in glutamic acid concentration. There is a drop of 0·5–0·6 μ*M* of γ-aminobutyric acid concentration, meanwhile.

The activity of the mechanisms of γ-aminobutyric acid degradation *in vitro* (transamination and oxidation) is relatively low. On the other hand, the rate at which changes in γ-aminobutyric acid-levels occur, following poisoning with potassium cyanide, indicates that this compound is intensely metabolized in the brain tissue *in vitro*.

T. Turský

Department of Biochemistry,
Komensky's University,
Bratislava.

---

[1] Gravioto, R. O., Massieu, G., and Izquierdo, J., *Proc. Soc. Exp. Biol. Med.*, 78, 856 (1951).
[2] Willam, K. F., and Bain, J. A., *J. Pharmacol.*, 119, 255 (1957).
[3] Rindi, G., and Ferrari, G., *Nature*, 183, 608 (1959).
[4] Häkkinen, H. M., and Kulonen, E., *Nature*, 184, 726 (1959).
[5] Wingo, W. J., and Awapara, J., *J. Biol. Chem.*, 187, 267 (1950).
[6] Turský, T., and Bielik, E., *Bratisl. Lekár. Listy*, 36, 404 (1956).

A New Method for the Differential Precipitation of Nucleic Acids from Aqueous Solutions

Many metallic ions are capable of reacting with sodium nucleates in aqueous solutions[1,2]. In these investigations, no attempt seems to have been made to differentiate between the reactivity of the two types of nucleic acid.

It has been found that the addition of an aqueous solution of indium chloride ($InCl_3$) to acetate-buffered solutions of highly polymerized nucleic acids in the presence of sodium chloride results in the formation of a precipitate containing indium and nucleic acid. This reaction, which does not seem to have been previously described, is a function of *p*H and ionic strength. By varying the ionic strength, it was possible to precipitate selectively either deoxyribonucleic acid or ribonucleic acid from aqueous solutions.

The quantitative precipitation of the two acids was carried out in a final volume of 5·0 ml. containing the following:

Deoxyribonucleic acid, prepared according to Kay *et al.* (ref. 3), 0·4 per cent in 0·14 *M* sodium chloride	0·5 ml.
Ribonucleic acid, prepared according to Crestfield *et al.* (ref. 4), 1·0 per cent in 0·14 *M* sodium chloride	0·5 ml.
Acetate buffer, 0·4 *M*, *p*H 5·0	0·5 ml.
Distilled water	3·0 ml.
Indium chloride, purchased from the Indium Corporation of America, Utica, N.Y., 0·05 *M* aqueous (freshly prepared)	0·5 ml.

After thorough mixing of these components, the solution is allowed to stand for 30 min. at room temperature and then centrifuged at 1,400*g* (International Laboratory Centrifuge) for 10 min. The supernatant solution contains only negligible quantities of material absorbing ultra-violet light at 260–280 mμ.

The optimal *p*H for the quantitative precipitation of the nucleic acids in the presence of 0·005 *M* indium chloride was established on the basis of experimental data shown in Fig. 1. In these experiments carried out separately with either deoxyribonucleic acid, ribonucleic acid or protein, the *p*H of the acetate buffer was varied over the range 2·9–5·8. The extent of precipitation of either nucleic acid, and for comparison bovine serum albumin (purchased from the Nutritional Biochemicals Corp., Cleveland, Ohio), was measured by determining the optical density of the supernatant solution at 260 mμ (nucleic acids) or 280 mμ (protein). Results for deoxyribonucleic acid and albumin were reproducible from one preparation to another. Ribonucleic acid was dialysed against 0·14 *M* sodium chloride at 4° C. for 48 hr. and if used immediately gave closely reproducible results. It should be emphasized that more than 95 per cent of

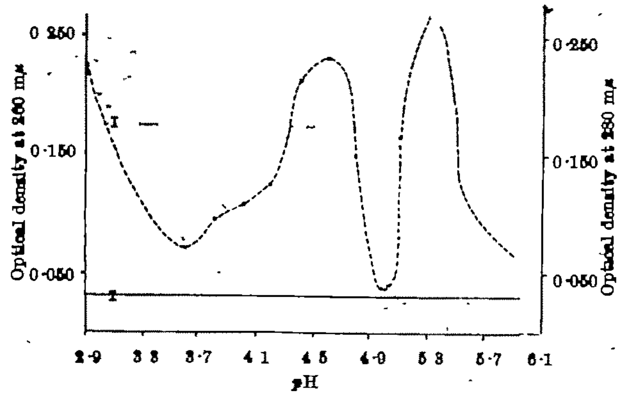


Fig. 1. Amounts of deoxyribonucleic and ribonucleic acids and bovine albumin remaining unprecipitated by indium at various pH levels and expressed as optical densities of the supernatant solutions as described in the text. Ribonucleic acid was dialysed against 0·14 *M* sodium chloride and used immediately after dialysis. ——, Deoxyribonucleic acid; – – – –, ribonucleic acid; . . . . , albumin

the ribonucleic acid in solution has been precipitated even at pH 5·3.

It was found that, by increasing the sodium chloride concentration to 4 *M* (other conditions remaining as described above), deoxyribonucleic acid remained in solution whereas ribonucleic acid under the same conditions was precipitated. Thus, after precipitation of ribonucleic acid at a final concentration of sodium chloride of 4 *M*, deoxyribonucleic acid remains in solution and, in turn, can be isolated by dialysis against buffered 0·14 *M* sodium chloride followed by addition of indium chloride to the dialysed solution. The two nucleic acids can be separated from a mixture quantitatively by this procedure.

This investigation, which was supported in part by a grant from the U.S. Atomic Energy Committee, will be reported elsewhere in detail, together with data on the isolation of pure nucleic acids from tissues.

WILLIAM G. ALDRIDGE*

Division of Experimental Radiology and
Department of Anatomy,
University of Rochester School of Medicine
and Dentistry,
Rochester, New York.

* Post-sophomore Research Fellow of the National Institutes of Health.

[1] Stern, K. G., and Steinberg, M. A., *Biochim. Biophys. Acta*, 11, 553 (1953).

[2] Trim, A. R., *Biochem. J.*, 73, 298 (1959).

[3] Kay, E. R. M., Simmons, N. S., and Dounce, A. L., *J. Amer. Chem. Soc.*, 74, 1724 (1952).

[4] Crestfield, A. M., Smith, K. C., and Allen, F. W., *J. Biol. Chem.*, 216, 185 (1955).

5-Hydroxytryptamine in Cerebrospinal Fluid

ALTHOUGH the 5-hydroxytryptamine content of human cerebrospinal fluid has been reported by Sachs[1] to increase after various head injuries or cerebral tumours, there appears to be no other reference in the literature to conditions resulting in an alteration in the content. While studying tuberculous meningitis in children, the opportunity arose for the cerebrospinal fluid to be tested for various amines including 5-hydroxytryptamine.

The cerebrospinal fluid was withdrawn from the patients using conventional methods, taking special care not to contaminate the samples with blood. The fluid was then tested either directly or after acetone extraction on the rat fundus preparation according to the method of Vane[2]. In 20 cases of tuberculous meningitis, the range of 5-hydroxytryptamine values was 0·2–3·0 μgm./ml., whereas in control children it was 0·03–0·1 μgm./ml. The more severe cases always showed high 5-hydroxytryptamine activity. Further, the clinical course of the disease closely followed the 5-hydroxytryptamine content of the cerebrospinal fluid. The significance of these findings is not yet clear.

A. AKCASU
M. AKCASU
S. B. TUMAY

Department of Pharmacology and
the Pediatric Clinic,
University of Istanbul.

[1] Sachs, *J. Neurosurg.*, 14, 22 (1957).

[2] Vane, *Brit. J. Pharmacol.*, 12, 344 (1957).

Viscosity of Concentrated Urea–Lithium Bromide Solutions

IN the course of studies involving the physicochemical characterization of a proteolytic enzyme from a strain of *B. subtilis* (*NOVO* enzyme), viscosity measurements of the protein in concentrated urea and lithium bromide solutions were undertaken. For these studies, a 1 per cent solution of the protein was employed, and outflow times were measured at 20·0° in a modified Ostwald viscometer.

The results obtained in simple aqueous solution, 8 *M* urea and 7 *M* lithium bromide, are presented in Table 1. The significance of these results, in so far as characterization of the specific protein is concerned, will be discussed elsewhere (Geschwind and Ottesen, to be published). Of interest here are the outflow times found for the solvent, which is both 8 *M* with respect to urea and 7 *M* with respect to lithium bromide. Even in the absence of protein the outflow time for this solution is very great, as is shown in Table 1; the actual increment in outflow time above that found for water is approximately nine times greater than the sum of the individual increments for 8 *M* urea and 7 *M* lithium bromide. The outflow time is strikingly dependent upon the concentration of the two solutes, for as shown in the last line of Table 1, dilution of the solution by a factor of less than 8 per cent diminishes the outflow time by more than one-third. At the higher concentrations of urea and lithium bromide, the addition of protein to 1 per cent further increases the outflow time by approximately 150 sec.

Table 1

Solvent	Protein present	Outflow time (sec.)
Water	–	67·4
	+	69·0
8 *M* urea	–	99·2
	+	102·5
7 *M* lithium bromide	–	111·0
	+	122·5
8 *M* urea + 7 *M* lithium bromide	–	726
	+	874
7·4 *M* urea + 6·5 *M* lithium bromide	–	469

These results indicate that when both urea and lithium bromide are present in high concentrations in a solution marked interactions occur, and further, that the contribution of the protein in increasing the outflow time may be envisaged as arising from its effect on the solvent, rather than from an effect of the solvent on the protein. One type of interaction that might be involved is the formation of complexes of the general formula $LiBr.nCO(NH_2)_2$ (ref. 1). Another type of interaction is suggested by the claim that in strong urea solutions chain-like molecules form and collect together to give fibrils[2]. Such chains would arise from linear hydrogen-bonding, and the fibrils from lateral dipole–dipole interactions. On the basis of further experimental results, it was concluded that such fibrils are readily destroyed by the addition of dilute acetic acid to the strong urea solutions[2]. When the concentrated urea–lithium bromide solution employed here, however, was diluted with 1 *M* acetic acid rather than with water, to give a solution which is 7·4 *M* in urea and 6·5 *M* in lithium bromide (see last line of Table 1), no reduction in outflow time beyond that recorded for the solution diluted with water was observed.

If long fibrils do indeed form in 8 *M* urea solutions, their stability may be decidedly enhanced in the presence of concentrated lithium bromide by a mechanism (depression of the thermodynamic activity of water) similar to that proposed[3] for the stabilization by lithium bromide of hydrogen-bonding in proteins. If such a mechanism were operative, then the marked reduction in outflow time effected by dilution, as reported above, must arise from an inability of the long chains to form as readily in 7·4 *M* urea as in 8 *M* urea, rather than from the small difference in the activity of water in the two solutions.

This work was carried out at the Carlsberg Laboratory during the tenure of a National Science Foundation Senior Post-doctoral Fellowship.

IRVING I. GESCHWIND*

Chemical Department,
Carlsberg Laboratory,
Copenhagen.

---

* Permanent address: Hormone Research Laboratory, University of California, Berkeley 4, California.

[1] McGavock, W. G., Bryant, J. M., and Wendlandt, W. W., *Science*, 123, 897 (1956).

[2] Clark, R. E. D., *Nature*, 151, 642 (1943).

[3] Harrington, W. F., and Schellman, J. A., *C.R. Lab. Carlsberg*, Sér. chim., 30, 167 (1957).

An Inverse Relation between the Liver Glycogen and the Blood Glucose in the Rat adapted to a Fat Diet

THE discovery by Claude Bernard[1] of the role of the liver glycogen in maintaining the blood sugar is well known. The liver was observed by Soskin *et al.*[2] to remove glucose from the blood when there was hyperglycaemia and to add it to the blood during hypoglycaemia. Later, the rate of uptake or output of glucose was shown to be directly proportional to the degree of the hyper- or hypo-glycaemia[3]. Recently an enzymic mass-action mechanism dependent on the effective intracellular concentration of hepatic glucose-6-phosphate has been put forward[4] to explain this regulation (the liver cells being freely permeable to glucose). However, while this mechanism may operate in animals adapted to the metabolism of glucose as the primary fuel, experiments in this laboratory have shown that in the rat adapted to a fat diet, the relationship between the liver glycogen and the blood glucose as outlined above is no longer evident.

Table 1. QUANTITY OF LIVER GLYCOGEN AND LEVEL OF BLOOD GLUCOSE IN RATS STARVED FOR 24 HR. THEN FED ON VARIOUS AMOUNTS OF BUTTER-FAT FOR FIVE DAYS

	Butter-fat fed (gm./day)				Normal fed controls
	2	4	5	6	
Liver glycogen (mgm./100 gm. of initial body-weight)	2·9 ± 0·9 (8)	25·1 ± 7·2 (8)	49·0 ± 6·8 (7)	63·7 ± 10·5 (10)	190·5 ± 11·6 (11)
Blood glucose (mgm./100 ml.)	64·4 ± 6·6 (8)	58·6 ± 4·8 (8)	55·1 ± 6·4 (6)	38·6 ± 4·0 (10)	79·4 ± 1·8 (14)

Values are the mean results ± the *S.E.* The number of animals is shown in parentheses.

Female albino rats (200 gm.), fasted for 24 hr. to reduce the liver glycogen to negligible amounts, were fed with 2, 4, 5 or 6 gm. of butter-fat per day. After five days on this diet, blood was taken from the tail for estimation of glucose[5], the animals were killed, and their liver glycogen content determined. The experimental procedures are described in greater detail in a previous publication[6]. The results (Table 1) show that the liver glycogen content rose proportionately to the quantity of fat fed per day ($P <$ 0·001), confirming previous results[6]. On the other hand, as the daily intake of fat was increased so the blood glucose-level fell ($P =$ 0·001–0·01), establishing an inverse relationship between the liver glycogen content and the blood glucose concentration ($P =$ 0·001–0·01).

When the female rat, weighing 200 gm., is consuming 6 gm. of fat per day, the calorie requirement is satisfied and ketogenesis becomes reduced or absent[6]. The tissues must have become adapted to utilize an all-fat substrate, together with a small amount of endogenous protein. In view of the accumulation of liver glycogen, it is possible that one mechanism of adaptation is a conversion of fatty acids to carbohydrate precursors which are stored in the liver as glycogen and later released as glucose into the blood for transport to the tissues. However, since Soskin and Levine[7] have demonstrated that glucose uptake by the tissues varies directly with the blood sugar concentration, the foregoing explanation receives little support from the present observation of a marked hypoglycaemia, indicating that glucose utilization in the fat-adapted rat is much reduced. Increased insulin secretion would enhance glucose utilization in hypoglycaemia, but it is generally held to be low under conditions of carbohydrate deprivation[4]. Therefore, there is apparently no large-scale conversion of fatty acids to glucose involving transport of the glucose by the blood. The accumulation of liver glycogen can be accounted for satisfactorily by gluconeogenesis from endogenous protein and by the glycerol moiety of the fat molecule.

A more likely explanation of the mechanism of adaptation is that carbohydrate formed from non-carbohydrate sources is spared as catabolism of fat as a fuel is increased, permitting the liver glycogen content to rise. The mechanism for maintaining a normal blood glucose-level may become less active due to relative disuse of glucose by the tissues, thus allowing hypoglycaemia to develop. The condition may be compared to that prevailing in the normal ruminant, in which a low blood sugar-level may be attributed to relative disuse of glucose as a fuel because of its replacement, or partial replacement, by the volatile fatty acids produced in ruminant digestion. Apparently, even in the non-ruminant animal, provided there is a suitable period of adaptation, brain tissue is able to survive in the presence of a very low blood sugar-level (several results as low as 25 mgm. per 100 ml. have been observed in these experiments).

It is clear that hypoglycæmia does not always stimulate glycogenolysis. If the maintenance of the blood sugar in the normal animal depends on an enzymic mass-action mechanism, then under conditions of fat adaptation where an inverse relation between liver glycogen and blood sugar concentration prevails, there must be a metabolic block in the conversion of glycogen to glucose in the liver. The possible nature of the block may be a reduction in activity of glucose-6-phosphatase, since hypoglycæmia in the presence of reserves of liver glycogen is characteristic of glycogen storage (von Gierke's) disease, in which there is a deficiency of glucose-6-phosphatase[8].

P. A. MAYES

Division of Biochemistry,
Department of Physiology,
Royal Veterinary College,
London, N.W.1.

May 23.

---

[1] Bernard, C., *C.R. Acad. Sci., Paris*, 31, 571 (1850).

[2] Soskin, S., Essex, H. E., Herrick, J. F., and Mann, F. C., *Amer. J. Physiol.*, 124, 558 (1938).

[3] Hlad, C. J., Elrick, H., and Witten, T. A., *J. Clin. Invest.*, 35, 1139 (1956).

[4] Cahill, G. F., Ashmore, J., Renold, A. E., and Hastings, A. B., *Amer. J. Med.*, 26, 264 (1959).

[5] Somogyi, M., *J. Biol. Chem.*, 160, 61 (1945).

[6] Mayes, P. A., *Biochem. J.*, 71, 459 (1959).

[7] Soskin, S., and Levine, R., "Carbohydrate Metabolism", 187 (University of Chicago Press, 1946).

[8] Cori, G. T., and Cori, C. F., *J. Biol. Chem.*, 199, 661 (1952).

Pterin Synthesis in the Amphibian Neural Crest Cell

A LARGE amount of fluorescent substances of pterin type has been known to exist in the coloured skin of amphibians and they were shown to accumulate in chromatophores such as melanophores and xanthophores (allophores), as in the bull-frog[1]. During the development, pterins appear simultaneously with the pigmentation in chromatophores[2]. Moreover, certain substances of pterin type have been reported to accelerate the *in vitro* formation of Dopa-melanin[3,4]. These facts suggest an intimate relation between the pterins and pigment formation in chromatophores. To analyse such a relation, it is desirable to know where pterins are synthesized in the course of embryonic development. The present experiment was carried out to ascertain the capacity of pterin synthesis in the pro-pigment cells of urodelan embryos. Pterins were extracted with 70 per cent ethanol and chromatographed on paper using the following solvents: *n*-propanol/1 per cent ammonia (2 : 1), *n*-butanol/acetic acid/water (4 : 1 : 1) and 5 per cent acetic acid.

Pterin Fractions in the Middle Neurula and Larva. As a preliminary experiment, qualitative determinations were made of pterins in the neurula, where pigment-cells had not yet differentiated, and in the larva, having well-developed melanophores and xanthophores in the trunk area. 30 intact middle neurulæ of *Hynobius nigrescens* (a salamander, Usui and Hamasaki's table, stage 17[5]), 50 intact middle neurulæ of *Triturus pyrrhogaster* (a newt, Okada and Ichikawa's table, stage 18[6]), trunk skins of 15 *Hynobius* larvæ at fore-limb-bud stage (stage 41–43), and 15 intact *Triturus* larvæ at fore-limb-bud stage (stage 37–38) were tested. Pterins were not found in the intact embryos at the middle neurula stage of either species, so naturally they were absent from the neural crest cells and the presumptive epidermis at that stage. At the fore-limb-bud stage, 2-amino-4-hydroxy-6-(1′,2′-dihydroxypropyl)-pteridine (biopterin[7]), 2-amino-4-hydroxypteridine, rhacophoro-jaune[8] (the same or similar with the 'sepia-pterine'[9] in *Drosophila*), *iso*xanthopterin, and 2-amino-4-hydroxypteridine-6-carboxylic acid occurred in both species. Of these five substances, rhacophoro-jaune and 2-amino-4-hydroxypteridine-6-carboxylic acid were found in abundance in both animals. In *Hynobius*, biopterin and *iso*xanthopterin were abundant, while there was only a small quantity of 2-amino-4-hydroxypteridine. In *Triturus*, on the contrary, biopterin, and especially *iso*xanthopterin, were much less, but 2-amino-4-hydroxypteridine was very abundant.

Pterin Synthesis in the Neural Crest Explant Enclosed in the Presumptive Epidermis. A small fragment of the trunk neural crest of the middle neurula was enclosed in the presumptive epidermis of the same embryo to ensure the sufficient differentiation of pigment cells. The epidermal explant without the neural crest served as a control. As a culture medium, Holtfreter's saline solution was used in order to avoid the additional complicating influences on pigmentation and pterin synthesis expected to occur in the explant. Each explant was cultured up to the stage where melanophores and xanthophores developed in the trunk region of the intact larvæ of the same breed (*Hynobius*, stage 41–43, 8 days at about 22°; *Triturus*, stage 37–38, 14 days at about 16°). 18–30 explants were used in each experiment. Whereas the explant with a neural crest had well-developed melanophores and xanthophores as in the intact embryos, the control epidermal explant was completely lacking in chromatophores. The fluorescent substances of pterin type were present in the former, and absent in the latter. Rhacophoro-jaune and 2-amino-4-hydroxypteridine-6-carboxylic acid were plentiful in both *Hynobius* and *Triturus* explants. Biopterin and *iso*xanthopterin were in much greater amount in *Hynobius*, and 2-amino-4-hydroxypteridine was abundant in *Triturus*. These quantitative relations of pterins in each explant were quite comparable with those found in intact larvæ of the respective species.

Hanging-drop Culture of Trunk Neural Crest. The pigmentation of chromatophores has been shown to be influenced by the surrounding epidermis in the field of experimental embryology. The synthesis of pterins in an explant, then, might be realized by the co-operation of epidermis, not by the pro-pigment cell itself. The fact that the epidermis had an indispensable role in the pterin formation was demonstrated in the following experiment. A small fragment of trunk neural crest of *Hynobius* middle neurula (stage 17) was cultured in Holtfreter's solution for 8–11 days at about 25° (stage 41–43 in controls). The melanophores and xanthophores in the explant showed little retardation as to the stage of pigmentation, but many of these pigmented poorly compared with those of the intact embryo. All kinds of fluorescent substances found in the intact larva at that stage were detected in these explants, although no quantitative results were obtained.

These results indicated clearly that the fluorescent substances of pterin type found in the intact larvæ of *Hynobius* and *Triturus* were synthesized in the pro-pigment cells in the process of their differentiation. This may strongly suggest that the simultaneous appearance of the pigmentation and pterins during the chromatophore differentiation is an expression of the inseparable relation of the two. However, this does not necessarily mean that all pterins found in intact larvæ are formed in the pro-pigment cells during pigmentation. In fact, a very small but perceptible amount of fluorescent substances of pterin type is found usually in larval and adult tissues other than skin. Whether these small quantities of pterins are derived from pigment cells, or synthesized *in situ*, or even supplied by way of nutrition, remains to be settled.

We wish to thank Prof. Adrien Albert of the Australian National University for his assistance in the preparation of this manuscript.

TADAO HAMA
MASATAKA OBIKA

Biological Laboratory,
Keio University,
Yokohama-Hiyoshi,
Japan.

[1] Hama, T., and Obika, M., *Anat. Rec.*, 134, 25 (1959).
[2] Hama, T., and Goto, T., *C.R. Soc. Biol.*, 149, 859 (1955).
[3] Polonovski, M., Gonnard, P., and Baril, A., *Enzymol.*, 14, 311 (1951).
[4] Akino, M., and Isaka, S., *J. Coll. Art. and Sci., Chiba Univ.*, 2, 225 (1955).
[5] Usui, M., and Hamasaki, M., *Zool. Mag.*, 51, 195 (1939).
[6] Okada, Yô K., and Ichikawa, M., *Jap. J. Exp. Morph.*, 3, 1 (1947).
[7] Patterson, E. L., Broquist, H. P., Albrecht, A. M., von Saltza, M. H., and Stokstad, E. L. R., *J. Amer. Chem. Soc.*, 77, 3167 (1955).
[8] Ziegler-Günder, I., and Hadorn, E., *Z. Vererb.-Lehre*, 89, 235 (1958).

PHYSIOLOGY

Effect of Cortisone on Degenerating Nerve Fibres in Birds

THE observation that the usual appearance of the Marchi stage of Wallerian nerve fibre degeneration in experimental material is strikingly altered by cortisone acetate (Pfizer, Ltd.) led us to try to discover whether cortisone would also alter in any way the effects of tri*ortho*cresyl phosphate poisoning, which are usually most apparent in the myelin sheaths of nerve fibres. Our results so far seem encouraging. A single application of tri*ortho*cresyl phosphate painted on the combs of hens (the dose being 0·1 c.c. per kgm. body-weight) invariably causes general symptoms of intoxication and paralysis in the legs after 8–25 days[1]. The administration of 25 mgm. of cortisone by mouth three days before the application of tri*ortho*cresyl phosphate and further doses of 25 mgm. every third day thereafter in all cases prevented the onset of paralysis and reduced the other general symptoms. Even if the administration of cortisone was delayed until the hens were severely stricken by the poison, its beneficial effects were still apparent, for the general condition of the birds rapidly improved, they began to feed avidly, and the paralysis was reduced to a mild state of postural imbalance. Similar results were obtained if the dose of tri*ortho*cresyl phosphate was increased to 0·15 c.c./kgm.

In view of the outbreak of tri*ortho*cresyl phosphate poisoning in Morocco last year involving 10,000 people, these preliminary results may be of assistance in efforts to treat the crippled victims.

P. GLEES

University Laboratory of Physiology,
Oxford.

[1] Glees, P., and White, W. G., *J. Physiol.*, 152 (1960).

Potentiation of Contractility in the Heart Muscle of the Rat and Some Other Mammals

THE steady-state amplitude of rhythmical myocardial contractions reached after the period of 'staircase' varies regularly with the frequency, following a typical curve in most animal species: it decreases at first, at very low frequencies, passes through a minimum (least favourable frequency), then at higher rates it increases up to a maximum (optimal frequency), to decrease again, at still higher rates, up to the limit of frequency which the preparation can follow[1]. The shape of the curve is, however, much modified in the rat in comparison with that of other species, the initial decrease of contractility being very marked, while the following increase to the optimum is, on the contrary, only small or absent[2]. In contrast to the classical staircase phenomenon, an inverted staircase (decrease of contraction) has been observed in the auricular or ventricular strips of the rat after a period of rest, or after the transition from a lower to a higher rate of stimulation[3].

These variations of contractility as a function of frequency may be interpreted as resulting from the interaction of two factors or effects, varying in opposite senses with the interval between the succeeding contractions[1]. One, namely, augmentation of amplitude on lengthening and diminution on shortening of preceding interval, has been called 'restitution'; the other, an augmenting effect on the shortening of the previous interval, has been termed 'potentiation' (Fig. 1). The 'potentiation' effect occurs only at short (least favourable) intervals, is cumulative and forms, in our interpretation, the common basis of the positive staircase, of the post-stimulation and post-extrasystolic potentiation, as well as of the steady-state amplitude variations. The terms 'restitution' and 'potentiation' are meant to be provisional, without any prejudice concerning the true nature of each of these effects, which may be dissociated and followed separately in their variation as a function of frequency[4] (Fig. 1).

The restitution effect may be measured by the change of amplitude in a number of single premature and delayed beats, intercalated in regular steady-state contractions. The 'potentiation' effect is indicated by the augmentation of the contraction next to the premature one (conditioning contraction), provided it follows at the basal interval. This point is very important, since in the case of an extra beat followed by a longer (compensatory) interval as well as in that of an intrapolated beat followed by a shorter interval, the change of contractility of the next contraction is due to both effects. The immediate return to the previous (basal) interval maintains, however, the 'restitution' effect constant, so that only a pure 'potentiation' effect appears. (For details of technique see our previous paper[4].)

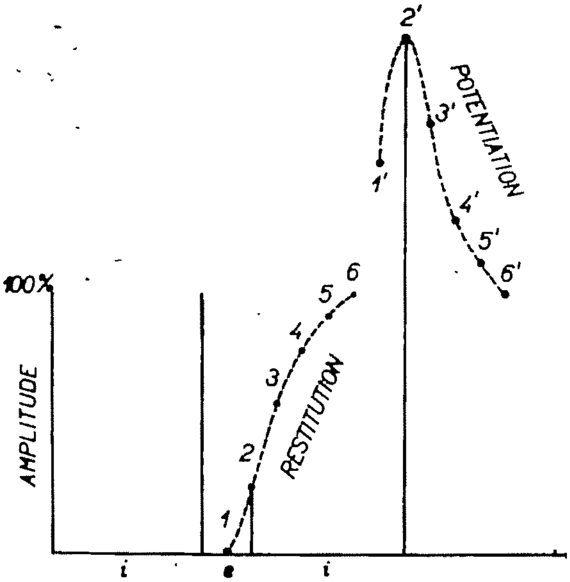


Fig. 1. Separate evolution of the 'restitution' and 'potentiation' effects. 100 per cent represents basal amplitude reached after a period of regular stimulation; i, interval between successive regular stimuli; e, interval of a premature beat conditioning potentiation of the next contraction. Amplitudes of premature beats following different pre-extrasystolic intervals 1–6 form a curve indicating the degree of restitution of contractility. Amplitudes of the respective post-extrasystolic beats 1′–6′ form a typical curve of 'potentiation'. Left auricle of the dog, 30° C.; basal rate, 60 beats/min.

Comparison of results of experiments on 78 isolated left auricles of the dog (15), cat (3), rabbit (16), guinea pig (20) and rat (24) shows that: (1) the restitution effect has a markedly steeper course in the rat than in the other mammals examined; (2) the potentiation effect in the rat myocardium is very small and occurs only when the premature beat is elicited at a very short interval (Fig. 2).

Also reactions of rat myocardium to some drugs (for example, strophantin) differ from those of other species[5]. Experiments on this matter are in progress in our laboratory and will be reported later.

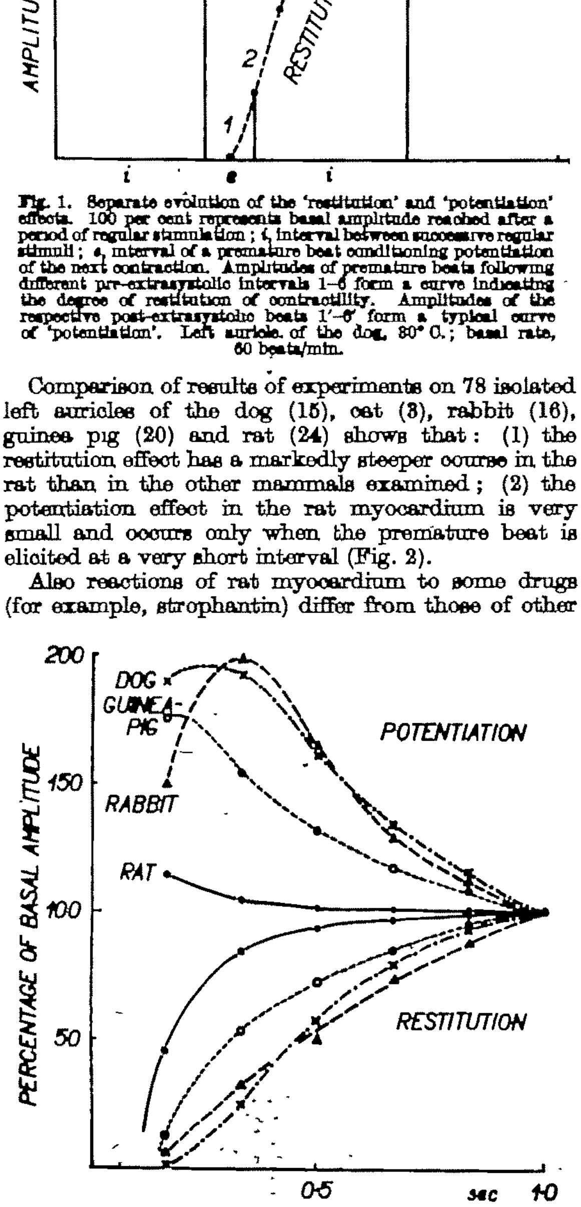


Fig. 2. Variations of the 'restitution' and post-extrasystolic potentiation effects as a function of the conditioning interval on the rat auricle compared with those of some other mammalian species. Values for the cat auricle, being very close to those of the guinea pig, have not been included. Individual experiments. Temperature, 30° C.; basal rate, 60 beats/min.

The differences described in the behaviour of amplitude in relation to the interval between contractions show clearly that rat heart muscle cannot be considered as representative of mammalian myocardium, and no direct conclusions from experiments with it can be drawn for the physiology of contractility of the heart muscle of other mammals and especially man. The distinction and dissociation of two effects underlying the relationship of the rhythm to the contractile force may prove useful in the analysis of these complex but remarkably regular phenomena.

V. KRUTA
P. BRAVENÝ

Department of Physiology,
Faculty of Medicine,
University of Brno,
Czechoslovakia.

Jan. 22.

[1] Kruta, V., *Arch. Int. Physiol.*, 45, 332 (1937).
[2] Kruta, V., and Stejskalová, J., *Arch. Int. Physiol. Biochem.*, 68, 152 (1960).
[3] Whalen, W. J., *Science*, 127, 468 (1958). Spann, R. L., *Nature*, 184, 66 (1959).
[4] Bravený, P., and Kruta, V., *Arch. Int. Physiol. Biochem.*, 66, 633 (1958).
[5] Benforado, J. M., *J. Pharm. and Exp. Therap.*, 122, 86 (1958).

Potassium Tolerance Tests in South Indian People

POTASSIUM tolerance in man was studied by Zwemer and Truskowski[1] in relation to adrenal gland activity. After an oral intake of 20 mgm. of potassium chloride/kgm. body-weight, no rise of the plasma potassium-level is observed in normal Europeans, while a rise of 30 per cent or more is established in cases of cortical insufficiency. Accordingly, Henrotte (unpublished work) found a mean rise of 6 per cent in 12 healthy Belgian students. However, in Dakar, Leschi[2] obtained, in the same experimental conditions, an average of 4·1 ± 4·8 and 13 ± 8·1 per cent, respectively, for the maximal rise in potassium of 6 Europeans and 32 Negroes of male sex. Consequently, I suggest the occurrence of a lower cortical metabolism in Negroes and its relation with the pigmentation.

Similar experiments have been undertaken in Madras with 26 Indians and 9 White Europeans or Americans, all male. The potassium tolerance tests were conducted according to Leschi's method[2], before breakfast and early in the morning, the room temperature being 29–32° C. (with 60–80 per cent humidity) throughout all the experiments. After the intake of potassium chloride, blood samples were taken every 20 min. for 1 hr. The potassium was determined in the plasma by flame spectophotometry. The maximal rise observed during the test and expressed in percentage of the fasting-level was as an average equal to 12·4 ± 7·5 per cent for White people and to 14 3 ± 7·3 for Indians. The differences between Indians, Africans and White people of Madras are not significant. In the case of the last-named, the maximum rise in potassium bears a direct relationship to the length of stay in Madras (Fig. 1), the relation being significant at the level of 5 per cent.

Our results indicate the occurrence of a climatic factor in the variation of tolerance of potassium in man, that is, of human cortex activity, rather than a racial factor. Our findings are confirmed by a fall of 27·3 per cent in 17-ketosteroid excretion observed

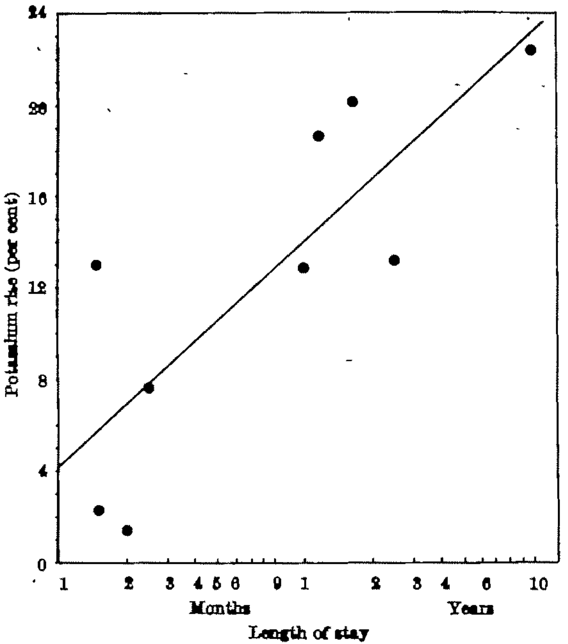


Fig. 1. Ordinate, maximal potassium rise observed during the test in White people and expressed in percentage of the fasting potassium-level; abscissa, length of stay in Madras expressed in months on a logarithmic scale

By Robinson *et al.*[3] during the hot season in Australian White people. On the contrary, urinary 17-ketosteroids determinations carried out in India[4] and in Africa[5] with both indigenous and Europeans show much larger values in Europeans than in the two melanodermic races. The discrepancy between these latter results and ours could be explained by the fact that urinary 17-ketosteroids represent the amount of cortical hormone excreted rather than the real activity of the gland. Relation between excretion of steroids and their amount in the blood could vary in the same conditions and should be further investigated.

We acknowledge with thanks the technical facilities provided for our work by Profs. K. P. Anandan and N. Verghese.

J. G. Henrotte
G. Krishnamurthi
G. Ranganathan

Departments of Physiology and Biochemistry,
Madras Medical College, Madras,
and
Laboratoire de Pathologie et Thérapeutique générales,
University of Liège.

[1] Zwemer, R. L., and Truszkowski, R., *Proc. Soc. Exp. Biochem. and Med.*, 35, 424 (1936).

[2] Leschi, J., "Races melanodermes et leucodermes", Thèse sciences (1951) (Masson, Paris, 1952).

[3] Robinson, K. W., Howard, B., and MacFarlane, W. V., *Med. J. Australia*, 2, 756 (1955).

[4] Friedmann, H. C., *Lancet*, ii, 262 (1954).

[5] Barnicot, N. A., and Wolffson, D., *Lancet*, i, 893 (1952).

Effect of the Cations of the Lyotropic Series on the Tension of Vascular Muscle

It has been found that, in experimental corticosteroid-induced hypertension, the content of potassium in the vascular wall increases according to the hypertension[1]. On the other hand, experiments *in vitro* with carotis strips showed that an increase of the potassium concentration of the bath solution causes a rise in tension which runs different from that of smooth muscle in the colon. The difference is due to the fact that potassium penetrates into the vascular muscle but not into the smooth muscle of the colon. In the vascular muscle the tension rises parallel to the intracellular potassium and remains constant as long as the latter is not diminished[2]. The relation between $[K]_i$ and the resting potential as well as between the resting potential and the change of length in muscle (contraction) are rather well known and will be discussed in another communication. There arises the problem of the effect of the intracellular potassium. The influence of other monovalent cations of the lyotropic series (caesium, rubidium, sodium) on the tension of vascular muscle has been investigated, too, under the same conditions as the potassium effect. The results are illustrated in Figs. 1–3. They show: (1) The threshold concentration which induces a rise in tension of the vascular muscle increases with the diameter of the ion (caesium, 5 m*M*; rubidium, 10 m*M*; potassium, 30 m*M*). To obtain an increase of the tension by means of sodium chloride, the sodium concentration of the Tyrode solution has to be augmented by 140 m*M*. At this concentration, the increase in tension can be effected merely by the high osmotic pressure, as it is in the case of sucrose, for example. (2) At equal concentrations of alkalichlorides, the increase in tension is smaller with increasing diameter of the ions (Fig. 3). (3) At higher caesium concentration, the increase of tension is not continuous.

If the same concentration either of potassium or of caesium is used, the amount of caesium which penetrates into the vessel wall is only 42·5 per cent of the amount of the penetrating potassium. The fact that for caesium the threshold concentration which causes

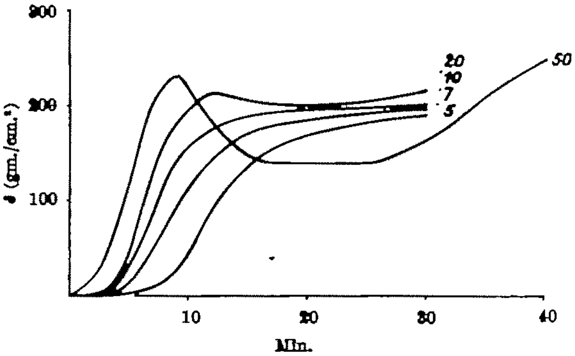


Fig. 1. Rise of tension with different concentrations of caesium chloride. Figures on the right indicate m*M* caesium. Initial tension, 310–335 gm./cm.^{2}

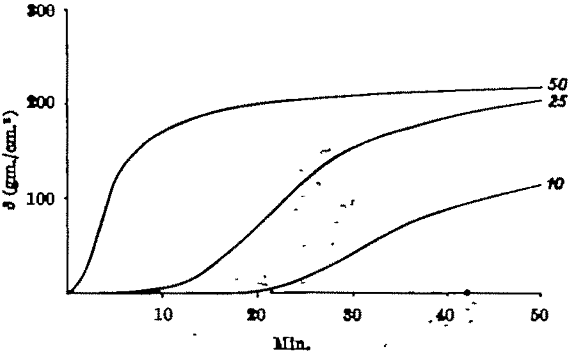


Fig. 2. The same as Fig. 1 with rubidium chloride

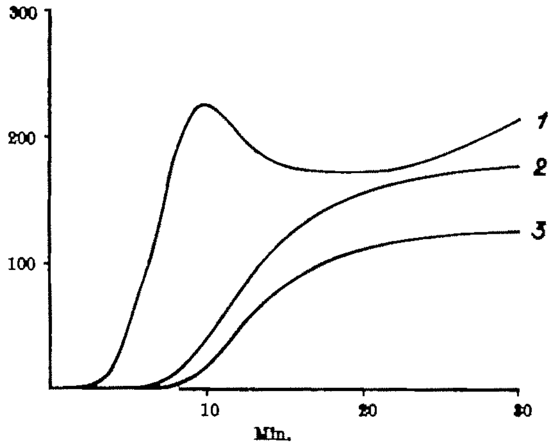


Fig. 3. Rise of tension with caesium chloride 30 mM (1), rubidium chloride 30 mM (2), potassium chloride 30 mM (3). Initial tension 325 gm./cm.²

an increase of tension is of 5 mM only might be considered as especially interesting. Since the permeability constant for caesium is smaller than for potassium and since the muscle fibre releases no potassium during the increase of the tension, contrary to what usually happens in contractures, we assume that the increase in tension is effected by the caesium which penetrates into the muscle fibre. The rise in tension after the extracellular potassium has been increased as well as the recovering after it has been decreased take place in a medium free both of oxygen and of glucose. These results led us to the working hypothesis that the increase of tension is caused by the discharge of a protein anion by means of a lyotropic cation. As it is known, the smaller the diameter of the monovalent cation, the closer is its approach to the protein and the stronger its attraction. To evidence the same change of state of the protein, more potassium is used than caesium (see threshold value). The tension is maintained by the new state of the protein, that is, without use of energy.

L. LASZT

Department of Physiology,
University of Fribourg.

---

[1] Laszt, L., *Nature*, 185, 695 (1960).

[2] Laszt, L., *Nature*, 185, 696 (1960).

Visco-elastic Behaviour of Blood Vessels of the Muscular Type

It was shown in the previous communication that the 'threshold-concentration' of ions of the lyotropic group which produce a rise in tension of the muscles in a vessel increases with increasing diameter of the lyotropic ion. Because this process also works in the absence of oxygen, we might assume that a discharge of protein ions takes place which causes a change of state. We presume that this change of state also produces a change in the visco-elastic behaviour.

The visco-elastic behaviour of ring-shaped or rectangular pieces of a cow carotis has been established with an oscillographic method using periodical stretches (frequency 1–1·8 cycles/sec.). The stress-strain relation (Young's modulus), as well as the phase shift between these, could be measured with a method described in an earlier publication[1] and now considerably improved. During the measurements, the samples of vessels were immersed in Tyrode's solution at body temperature. The questions treated were the following: (1) the influence of potassium (60–70 mM); (2) the influence of suprarenin; (3) the influence of electrical excitation on Young's modulus and on the viscosity constant η or its product $\omega\eta$ with the angular frequency, which can be computed from the phase shift between stress and strain and Young's modulus. The heat dissipated in the sample can then be found from $\omega\eta$.

(The heat generated by friction can be found as follows: the resistance to stretch for a piece of arterial wall of length l and cross-section q will be $R = \eta q/l$, where η is the viscosity constant. For a periodic stretch we might put $l = l_0 + \Delta l.\sin(\omega t)$. To overcome the friction, we need the force $F = R\, dl/dt$. The work done during a period is found by integration:

$$\int R.\frac{dl}{dt}.dl = \pi.R.\omega(\Delta l)^2$$

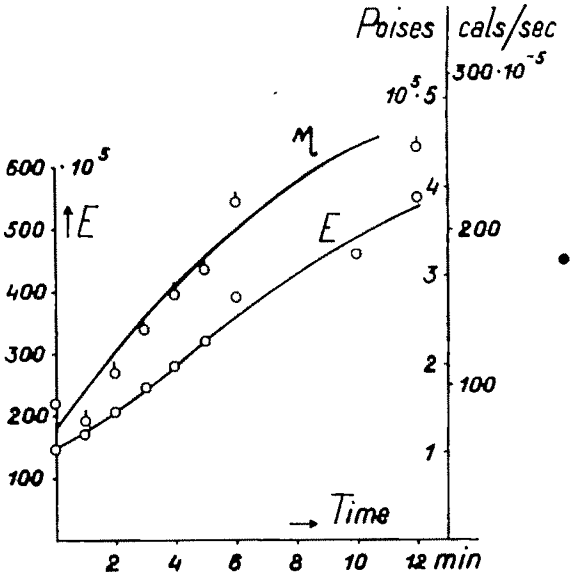


Fig. 1. Carotis (cow), stretch perpendicular to axis of vessel. Effect of potassium (70 mM) on the dynamic modulus of elasticity E and the viscosity constant η. Abscissa, time (min.); ordinates, left side Young's modulus E in dynes/cm.²; right side left scale, viscosity constant in poises; right side right scale, heat dissipated in a cube of 1 c.c. with an amplitude of stretch of 0 05 cm. due to internal friction. Angular frequency, ω = 13 9

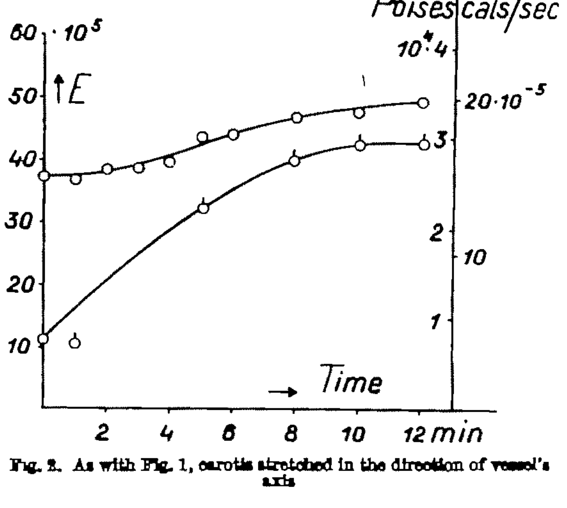


Fig. 2. As with Fig. 1, carotis stretched in the direction of vessel's axis

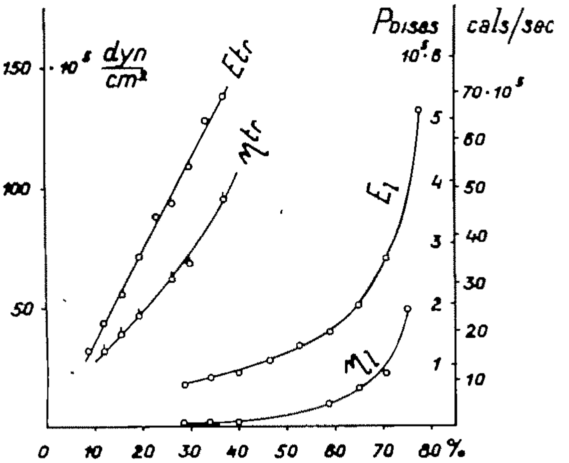


Fig. 3. Dynamic modulus of elasticity E_{tr} and viscosity η_{tr} in transversal, E_l and η_l in longitudinal direction as functions of relative stretch (cow carotis). External scale to the right gives the heat dissipated in a cube of 1 c.c. with an amplitude of stretch of 0·05 cm. due to internal friction. Angular frequency, $\omega = 6·5$

For the power we obtain $P = (\omega\eta).\omega(\Delta l)^2 q/(2l)$. The product $\omega\eta$ is the quantity obtained by the experiment. It is of the same dimension as Young's modulus. In order to get a more concrete picture, we have calculated the heat generated in a cube of material of 1 c.c., where the amplitude Δl of stretch is taken to be 0·05 cm. For this specific assumption we obtain $H_{sp.} = (\omega^2\eta).0·298 \times 10^{-10}$ cal./sec.)

Potassium always brought about a considerable increase of tension and of Young's modulus perpendicular to the axis of the vessel, which reached their maximal value within a range of time of 12 min. after the administration of potassium. In some cases, according to [K] Young's modulus rose to about four times its original value and remained constant after this time. The internal energy dissipation increased in the same time.

If we carried out the same experiment with rectangular samples, one cut perpendicularly to, and the other in the direction of, the vessel's axis, we obtained an increase of Young's modulus from 15×10^6 to 55×10^6 dynes/cm.² in the first case (Fig. 1). η and the dissipated energy enhanced about at the same rate. Because only few muscle fibres run in the direction of the axis, we obtained in this direction an increase of Young's modulus only from $3·8 \times 10^6$ to $5·0 \times 10^6$ using the same initial stretch of 26 per cent (Fig. 2). The relative increase of the dissipated energy remained about the same as in the first case. In carrying out comparative measurements as mentioned here, care has to be taken that the experiments are performed with the same initial relative stretch, because the visco-elastic behaviour of vessels depends on it to a large extent. This we have illustrated with a set of experiments the results of which are given in Fig. 3.

When the immersion of 60–70 mM K was replaced by normal Tyrode's solution, the tension as well as Young's modulus dropped to the original value. Experiments with suprarenin and electrical excitation showed considerable increase in tension, but only a slight increase in Young's modulus. Skeletal muscle of frog (sartorius and musc. rect. abd.) showed no change in the visco-elastic behaviour either with potassium or with electrical excitation.

The importance of these results regarding the development of arterial tension in normal and in hypertensive individuals will be discussed in a further publication.

V. Hardung
L. Laszt

Department of Physiology,
University of Fribourg.

---

[1] Bettiсher, A., Hardung, V., and Maillard, J., *Kolloid Z.*, 148, 66 (1956).

Osmotic Regulation in the Larvæ of some Euryhaline Diptera

The relationship between blood concentration and the external medium is known in only one salt-water dipteran, the larva of *Aedes detritus*[1,2]. During a recent study of a small salt-marsh, on the Northumberland coast, several euryhaline Diptera were investigated with regard to survival and blood regulation in sea-water media. Some of the results are briefly reported here.

Groups of 10 larvæ of *Ephydra riparia* were kept in shallow dishes containing media ranging in concentration from tap-water to sea-water evaporated to half its original volume. Larvæ were not fed during the course of experiments at room temperature (18–22° C.).

In tap water, and concentrations less than normal sea-water all of the larvæ survived; several pupated, and adults emerged successfully during the course of the experiments. In concentrations greater than normal sea-water some of the larvæ lost water, became shrunken in appearance, and eventually died. The majority survived for at least two weeks in sea-water equivalent to 8·0 per cent sodium chloride.

Blood samples from individual larvæ were taken after 7 days for micro-chloride and freezing-point depression measurements. Both are powerfully regulated (Fig. 1B) to a greater extent than in *Aedes detritus* in concentrated sea-water media[1]. As in

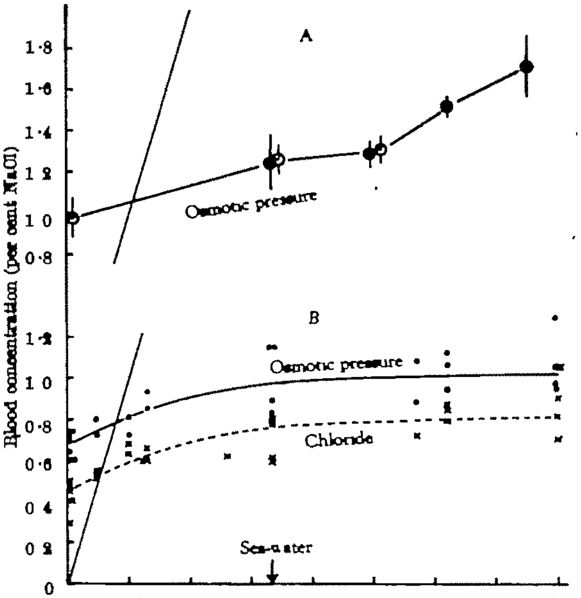


Fig. 1. Relation between osmotic pressure of the medium and of the blood in: *A*, *Cricotopus vitripennis*, typical form ● and var. *halophilus* ○, points mean of six larvæ, vertical lines extent of standard deviation; *B*, *Ephydra riparia*

Table 1. OSMOTIC PRESSURES OF BODY FLUIDS IN DIFFERENT CONCENTRATIONS OF SEA WATER

Ephydra riparia			*Coelopa frigida*		
Osmotic pressure (sodium chloride, per cent)			Osmotic pressure (sodium chloride, per cent)		
Blood	Rectal fluid	Sea-water medium	Blood	Rectal fluid	Sea-water medium
0·80	0·91	0·46	1·02	0·27	0·0
0·72	1·01	0·46			
			0·75	2·00	1·70
			1·00	2·17	1·70
0·81	1·47	1·00			
			1·00	2·87	3·37
			1·02	3·44	3·37
1·15	4·83	3·37	1·01	3·20	3·37
			1·16	6·45	3·55
0·95	>10·0	8·02	1·10	3·73	3·55
1·05	>10·0	8·02	1·28	1·96	3·55
			—	3·12	3·55
			1·07	7·05	7·20
			1·07	7·40	7·20
			1·30	7·84	8·20

A. detritus the slight but gradual increase in blood osmotic pressure is due to an increase in blood chloride concentration, which is relatively high and accounts for approximately 75 per cent of the total blood concentration.

Similar observations were made on larvæ of two varieties of *Cricotopus vitripennis* (Fig. 1A). The estuarine form var. *halophilus*, obtained from the salt-marsh, completed its life-cycle in concentrations less than 5·0 per cent sodium chloride. In higher concentrations of sea water nearly all the larvæ became shrunken in appearance and died within 4 days. Larvæ of the typical form were obtained from coastal rock-pools at high water mark. These larvæ survived direct transference from tap-water into sea-water equivalent to 7·5 per cent sodium chloride, in which the life-cycle was completed, and they showed no signs of loss of water in this concentration of sea-water. These observations suggest that the two forms of *C. vitripennis* may be physiologically distinct, although each form is well adapted to survive the range of salinity normally encountered in its habitat.

The degree of osmotic independence shown by larvæ of *A. detritus*, *E. riparia* and *C. vitripennis* can probably be achieved only by a considerable degree of impermeability to water and salts, and it is significant that they do not possess functional anal papillæ, which are characteristic of aquatic dipterous larvæ. Intake of salt-water through the gut is, however, likely to occur, and the larvæ must then elaborate a fluid in the rectum at least as concentrated as the external medium. Preliminary measurements of the freezing-point depression of rectal fluid obtained from larvæ of *E. riparia* show that this species can elaborate fluid considerably more concentrated than the medium (Table 1). Similar measurements were also made on larvæ of *Coelopa frigida* (Table 1), which live in wrack beds stranded at high tide-level. As in *A. detritus*[2], the ability of *C. frigida* to elaborate a fluid hyper-osmotic to the medium is not so well developed as in larvæ of *E. riparia*.

This work was supported by a maintenance grant from the Department of Scientific and Industrial Research.

D. W. SUTCLIFFE*

Department of Zoology,
King's College, Newcastle upon Tyne.

* Department of Scientific and Industrial Research Fellow.

---

[1] Beadle, L. C., *J. Exp. Biol.*, 16, 346 (1939).

[2] Ramsay, J. A., *J. Exp. Biol.*, 27, 145 (1950).

HÆMATOLOGY

Immuno-electrophoretic Demonstration of Precipitating Components in Sera from Pregnant Women

Smithies[1] and also Thornes[2] recently described the occurrence of certain serum proteins in sera from pregnant or recently pregnant women. According to Smithies[1], an α_2-globulin is present in sera from about 10 per cent of women in late pregnancy or shortly after delivery, and is demonstrable by means of starch-gel electrophoresis. Thornes[2], by means of gel-diffusion experiments, demonstrated serologically specific components in pregnancy sera by absorbing the immune serum prepared in rabbits with normal human serum. In each of 29 sera collected from patients during the last three months of pregnancy, he found this serologically distinct component. Immunization of rabbits with placental extracts made possible the demonstration of one to four different antigens serologically different from the serum proteins of normal sera, two of which were also found in sera from patients with abnormal tissue metabolism.

In order to study the possible occurrence of 'pregnancy-specific components', an antihuman immune serum, prepared in rabbits by immunizing with serum from patently normal blood donors, was absorbed with serum from one such blood donor by means of the intra-basin-gel absorption[3,4], and used to develop the immunoelectrophoretic pattern of sera from 7 women taken immediately after normal delivery. In five of these sera a precipitate in the fast α_1-globulin region was demonstrable (precipitate *A*). In two of these five sera also another precipitate (precipitate *B*) appeared in the slow α_2-β_1-globulin region.

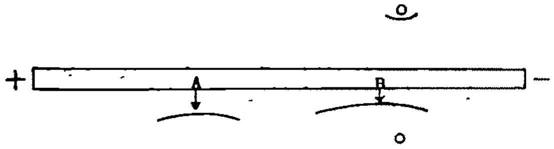


Fig. 1. Diagrammatic representation of presumed *C*-reactive protein precipitate (upper basin) and the 'pregnancy precipitates *A* and *B*' (lower basin) in immunoelectrophoresis

It was also found that some normal sera prevented the appearance of precipitates *A* and *B* or one of these components when used to absorb the immune serum in the intra-basin-gel absorption technique. This property of normal sera appears to be constant in the same individual for at least one year.

Sera from 20 normal subjects (males and females) and sera from 3 of 4 patients with diseases involving 'tissue destruction' did not give any precipitates against absorbed immune serum. The serum of one of these 4 patients did, however, give precipitate *A*. This serum also formed a precipitate against a commercially available *C*-reactive protein immune serum (Schieffelin, New York) in immunoelectrophoresis. This presumed *C*-reactive protein precipitate differed from the precipitates *A* and *B* in that it occupied different electrophoretic and diffusion positions, and its shape was different. The two pregnancy sera possessing both precipitates *A* and *B* did not show precipitate formation against *C*-reactive protein immune serum.

In conclusion, it can be stated that certain anti-human immune sera absorbed with selected normal sera give two electrophoretically different precipitates with some sera from recently pregnant women. Other 'pregnancy sera' when examined by the present technique[4] lack either both or one of these precipitates.

Precipitate formation between selected 'pregnancy sera' and absorbed immune serum will also distinguish between four types of normal sera, by their capacity of completely inhibiting the formation of visible precipitate, by inhibiting only one of these precipitates but not the other and finally by not inhibiting the formation of any of these 'pregnancy precipitates', when used as absorbing reactants of the immune serum.

We gratefully acknowledge the liberal supply of sera from the Department of Women's Diseases, Sabbatsberg Hospital, Stockholm.

JAN HIRSCHFELD

Department of Bacteriology,
Karolinska Institutet,
Stockholm, 60.
State Institute for Blood Group Serology,
Stockholm, 60.
State Bacteriological Laboratory,
Stockholm.

ULF SÖDERBERG

Nobel Institute for Neurophysiology,
Karolinska Institutet,
Stockholm, 60.

[1] Smithies, O., "Adv. Protein Chem.", 14, 65 (1959).
[2] Thornes, D. R., thesis, University of Dublin (1958).
[3] Hirschfeld, J., *Acta Path. et Microbiol. Scand.* (in the press).
[4] Hirschfeld, J., *Nature* (in the press).

Sickling Phenomenon in Deer

GULLIVER[1] described peculiarly shaped red cells in deer blood and Undritz[2] was able to produce these cells *in vitro* by passing oxygen through the blood. The cells looked remarkably like human sickle-cells. Gulliver examined three tropical deer: *Cervus mexicanus*, *Cervus reevesii* and *Cervus porcinus*. He also mentions a Persian deer, but its scientific name is not given. O'Rouke[3] investigated 178 deer in the United States and found 'sickle-cells' in 14. Undritz obtained positive results with the blood of *Cervus elaphus*, *Dama dama*, *Sambar* (*Rusa*), *Pseudaxis sika*, *Pseudaxis hortulorum*, *Axis axis*. The present investigation has been carried out with blood from *Elaphurus davidianus* (Père David deer). No sickle-cells could be produced with the blood of *Rangifer tarandus* (reindeer), *Alces alces* (elk), and *Cervus canadiensis* (Wapiti deer).

In man, sickle-cells are produced when erythrocytes containing the abnormal hæmoglobin *S* are deoxygenated. This hæmoglobin is relatively insoluble in the reduced state and on deoxygenation it forms intracellular tactoids which stretch the cell envelope and give the cell its bizarre sickle shape. It might seem that in the deer the effect is just the opposite, particularly because the sickling produced by treatment with oxygen can be reversed by addition of the reducing agents $NaHSO_3$ and $Na_2S_2O_4$. However, we can now report that sickling of deer cells occurs equally well when the blood is saturated with nitrogen or carbon monoxide but not with carbon dioxide. The effect of oxygen, nitrogen and carbon monoxide is due to a replacement of the carbon dioxide which causes as it were a 'respiratory alkalosis'. The reducing agents are acid, and hence they reverse the alkaline *p*H and the sickling.

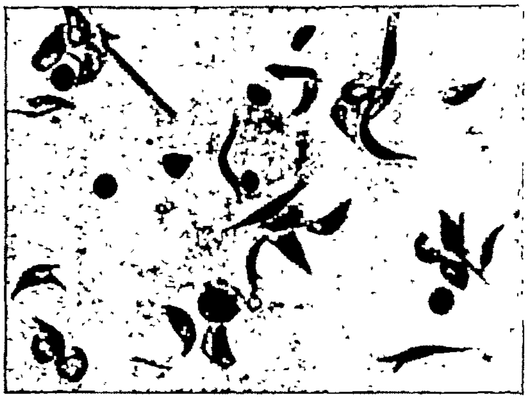


Fig. 1. Red cells of *Elaphurus davidianus* (Père David Deer) at *p*H 7·8. (× 750). Heparinized blood was mixed with an equal volume of 0·1 *N* Sørensen phosphate buffer *p*H 7·8 and the mixture was saturated with carbon monoxide

When deer cells are suspended in 0·1 *N* KH_2PO_4, no sickling can be produced by gassing with oxygen, and when they are suspended in 0·1 *N* Na_2HPO_4 they sickle without any further treatment. There is a relatively sharp transition from the normal to the sickle-shape between *p*H 7·0 and *p*H 7·5; some sickle-cells can already be noted at *p*H 7·2 and nearly all cells are sickled at *p*H 7·4.

When the solubilities of oxygen, of reduced and of carbon monoxide hæmoglobin are compared, they

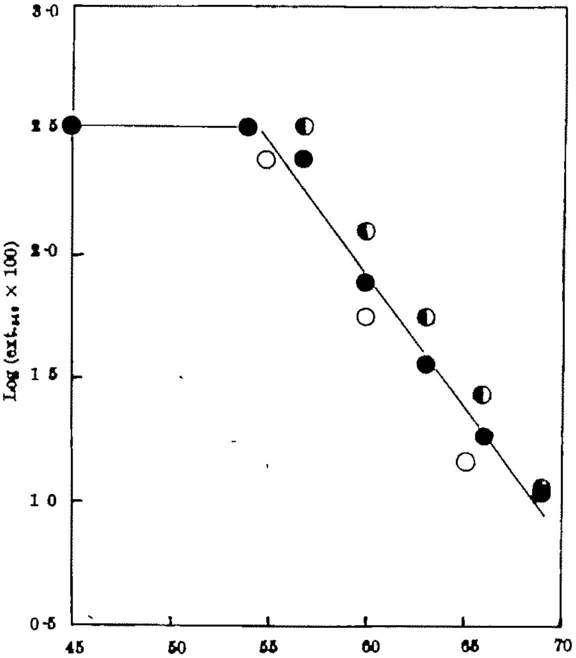


Fig. 2. Solubility in ammonium sulphate solutions of oxyhæmoglobin (○), reduced hæmoglobin (●) and carboxyhæmoglobin (◐) of *Elaphurus davidianus* (Père David Deer). To 9·5 ml. $(NH_4)_2SO_4$ solution of increasing saturation were added 0·5 ml. 0·5 per cent deer hæmoglobin. Reduced hæmoglobin was produced by addition of 30 mgm. $Na_2S_2O_4$. After mixing, the 10 ml. samples were kept in a stoppered vessel for several hours at 23·5° C. and then filtered. The hæmoglobin filtrate was converted into cyanmethæmoglobin and measured colorimetrically. It will be seen that there is no significant difference in solubility of the three hæmoglobins

are seen to differ little, and indeed Fig. 2 shows that the values for reduced deer hæmoglobin lie between those for oxygen and carbon monoxide hæmoglobin.

There is no significant difference in the solubility at increasing concentrations of phosphate buffers of pH 7 and pH 8. It was noticeable in these tests as well as in those described in Fig. 2 that precipitated oxyhæmoglobin which was left on the filter paper after filtration was rapidly transformed into methæmoglobin, whereas this was not so in the case of the human hæmoglobin controls. Deer hæmoglobin is oxidized by $K_3Fe(CN)_6$ about twice as fast as human hæmoglobin.

We wish to thank Dr. E. Lang, director of the Basle Zoo, for kindly supplying the deer blood.

E. UNDRITZ
Pharmacological Laboratory,
Sandoz, Basle.

K. BETKE
University Children's Hospital,
Freiburg-i.-Br.

H. LEHMANN
St. Bartholomew's Hospital,
London.

---

[1] Gulliver, G., *Phil. Mag.*, 17, 325, 327, 330 (1840).

[2] Undritz, E., *Arch. Vererbungsf.*, 21, 288 (1946); *Verhandl. Schweiz. Naturf. Ges.*, 127, 102 (1947); *Revue d'Hématologie*, 5, 644 (1950); *Sang*, 25, 296 (1954).

[3] O'Rouke, B. C., *Proc. Soc. Exp. Biol. Med.*, 34, 788 (1936).

Platelet-Count Differences in Blood of the Rabbit Right and Left Heart Ventricles

THIS work was undertaken in an attempt to determine whether a difference could be demonstrated in the platelet counts of the blood of the rabbit right and left heart ventricles. That such a difference might occur suggested itself from the recent work of Sharnoff and Kim[1,2], which studies revealed that megakaryocytes are present normally in the lung blood vessels of all mammals, where they appear to break up in the pulmonary capillary anastomoses into platelets. Therefore, it was postulated that if the lung vessels were a possible site of platelet formation, the blood of the left heart ventricle could contain a higher number of platelets than that of the right ventricle. The difference in number of platelets, it was believed, would depend only on the number of megakaryocytes present and breaking up at any one time in the lung vessels.

Twenty young female Belgian hares weighing 2–4 lb. were killed by rapid air embolism and within 1 min. the chest cavity was opened and the heart exposed. Blood samples were obtained by needle aspiration from both ventricles while the heart was still in ventricular flutter. The blood was preserved with 'Versene' (disodium salt of ethylenedinitrotetra-acetic acid, Eastman-Kodak). Indirect platelet counts were performed in duplicate by Fonio's method and averaged. Erythrocytes were determined by the counting chamber method. The animals were raised and maintained under outdoor conditions and temperatures except for short periods when unheated housing was provided. The work was begun in August 1958 and completed in February 1959. On this basis the animals could be divided into two equal groups of 10 each. The first group of 10 was studied during warm and mild autumn weather. The second group was studied during the winter months. For convenience the groups are designated accordingly as summer and winter animals.

A striking difference in platelet counts of the blood of the right and left ventricles was noted with two exceptions in the winter animals. No essential difference was found in the platelet counts of the blood of both ventricles of the summer animals and in the two exceptions of the winter animals. The winter animals, including the two exceptions, revealed the platelet counts of the right ventricle averaging 245,000 per cm.³, while the left ventricle blood revealed platelet counts averaging 408,000 per cm.³. Average platelet counts of the right and left ventricle bloods of the summer animals were respectively 256,000 and 254,000 per cm.³ (Fig. 1). Erythrocyte counts of the 20 animals averaged 5·4 million per cm.³.

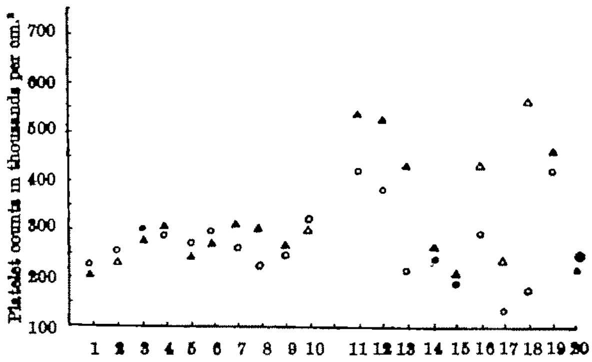


Fig. 1. △, Left ventricle; ○, right ventricle. 1–10, Summer animals; 11–20, winter animals

These studies indicate that from the lung vascular system there is added to the blood of the winter animals a significant number of platelets. This would tend to substantiate the earlier suggestion of Sharnoff and Kim[1] that the lung vessels may be a significant site of platelet formation. The significant increase of platelets in the winter animals in this study also complements the observation by Sharnoff and Kim[2] in an earlier study where significantly high numbers of platelets were observed in the peripheral blood of winter control animals compared to summer control animals.

It is suggested that the source of the increased platelets are the pulmonary megakaryocytes usually present in the lung vessels. It is also suggested that the stress of winter cold may stimulate an increase in number of pulmonary megakaryocytes which on the further stress of killing the animals break up rapidly into platelets. It may also be postulated that where no significant increase in platelets occurs the lung vessels may have a low number of megakaryocytes.

This work also corroborates earlier findings that the lungs may be a source of platelets. Howell and Donahue[3] in dog lung perfusion studies, and later Bierman[4] in human studies, recorded such evidence. In this report, however, a more rational explanation of this phenomenon is presented. This is further supported by the histological observations of Sharnoff[5] revealing that the pulmonary megakaryocytes are moulded and broken asunder in the pulmonary capillaries and their anastomoses and thus emerge as casts of the capillaries and at times, therefore, appear in the peripheral blood as long platelets.

J. GEORGE SHARNOFF
VITO SCARDINO

Department of Pathology,
Mount Vernon Hospital,
Mount Vernon, New York.

---

[1] Sharnoff, J. G., and Kim, H. S., *Amer. Med. Assoc. Arch. Path.*, 66, 176 (1958).

[2] Sharnoff, J. G., and Kim, H. S., *Amer. Med. Assoc. Arch. Path.*, 66, 340 (1958).

[3] Howell, W. H., and Donahue, D. D., *J. Exp. Med.*, 65, 177 (1937).

[4] Bierman, H. R., *Amer. J. Surg.*, 89, 130 (1955).

[5] Sharnoff, J. G., *Nature*, 184, 75 (1959).

PATHOLOGY

Absence of Local Cytotoxic Change in Man from Griseofulvin

WITH the importance of griseofulvin in the treatment of superficial fungous infections, it is imperative to know more about the toxic reactions especially if treatment is prolonged. Since the significant studies of Paget and Walpole[1] on the interference with mitosis under massive parenteral administration of griseofulvin in rats, there has been continued interest in investigations of this phase of reaction in man. Our purpose was to develop a technique for studying possible local cytotoxic reactions in man from locally deposited griseofulvin.

Supersaturated solutions of microcrystalline griseofulvin were prepared in saline, sterilized by autoclaving, and after vigorous agitation, 0·1–0·2 ml. was injected into 14 patients into areas of normal skin of the back and arm and into the scalp in the occiput area. In many instances the injection site was tatooed with indian ink to localize the crystal mass. Controls had been done previously with indian ink particles. In addition, in 6 patients, griseofulvin was injected into three basal cell tumours, one squamous malignancy, one melanoma and one malignant lymphoma. In four additional subjects, a lotion containing 1 per cent griseofulvin was rubbed daily for three weeks into basal cell carcinoma, squamous cell carcinoma, and into the so-called precancerous senile keratosis. To detect any anti-inflammatory activity of griseofulvin, saline suspensions of griseofulvin were injected repeatedly into spots of psoriasis, and neurodermatitis.

No local anti-inflammatory property could be detected. In normal skin, the biopsies were taken at intervals ranging from 1 hr. to three months after local injection and were studied in frozen section and in prepared sections with routine hæmatoxylin–eosin, toluidine blue *p*H 6, periodic acid–Schiff, Feulgen stains. The frozen sections were examined under the polarizing microscope to detect the depots in the dermis of the insoluble crystals. After a period of several days, crystals could not be detected under the polarizing microscope. In three instances, a bioassay of the skin extract was performed to detect antifungal activity of the tissue. In all these experiments, there were no spectrofluorometric determinations for griseofulvin in extracts of the injected skin. A total of 30 injections of griseofulvin was given.

In brief, there was only occasionally a mild foreign-body reaction of non-specific type about the depot of crystals. This subsided rapidly, usually within three or four days, and then no demonstrable inflammatory activity could be detected except occasional perivascular lymphocytic infiltrate. In one patient, after three weeks there were still a few histiocytes and foreign-body giant cells. There was no change in mitosis in any portion of the epidermis surrounding this, or in any portion of the adjacent hair follicle. In only one experiment, vacuolization of the cells in the adjacent portion of the hair follicle was found. In one instance, three months after injection, no change was found. In all the human tumour experiments there was no effect in either retardation or acceleration of the tumour growth, nor any demonstrable local effect on the individual tumour cell. In clinical observation[2] of a year's experience with oral griseofulvin in fungous therapy programme on more than 400 patients, there has been no evidence of any effect upon associated skin tumours, including basal cell, squamous cell and melanomas. In two patients with melanomas, griseofulvin was given in dosages of 2–4 gm. There is no information available on the effect on any associated internal visceral tumours other than the melanomas.

To amplify this study in the Department, the effect of griseofulvin in animal tumour experiments was initiated.

Griseofulvin crystals were furnished by Dr. G. Kenneth Hawkins, Clinical Research Division, Schering Corporation, Bloomfield, New Jersey.

LEON GOLDMAN
AMANDA BEYER
JAN SCHWARZ

Department of Dermatology,
College of Medicine,
University of Cincinnati,
Cincinnati, Ohio.

---

[1] Paget, G. E., and Walpole, A. L., *Nature*, 182, 1320 (1958).

[2] Goldman, Leon, Preston, Robt. H., Beyer, Amanda, and Loutzenhiser, James, *J. Amer. Med. Assoc.*, 532 (Feb. 6, 1960).

Tumour-promoting Effect of Excessively Large Doses of Oral Griseofulvin on Tumours Induced in Mice by Methylcholanthrene

LARGE intravenous doses of griseofulvin in rats have been found to arrest mitosis in metaphase in certain organs, for example, bone marrow, seminal epithelium and intestinal epithelium. We postulated that since griseofulvin taken orally is soon found in the keratin layer of the skin, there might be an antimitotic effect with a delay in the production, and a reduction in the number, of tumours that would be produced by applications of methylcholanthrene to the epidermis of mice. A pilot experiment was performed which gave quite unexpected results.

White Swiss male mice of 24–28 gm. per mouse were divided into five groups. One drop of 0·5 per cent 3-methylcholanthrene in acetone was applied twice weekly for 4 weeks to the lower back of the mice of groups 1, 2 and 3.

Group 1 consisted of 20 mice receiving standard mouse food and having applications of methylcholanthrene. None of the 20 mice had any tumours formed as late as 12 weeks after the start of methylcholanthrene applications.

Group 2 consisted of 10 mice receiving a 1 per cent griseofulvin mouse food mixture for 6 weeks prior to, during and after the applications of methylcholanthrene. This group showed 5 of the 10 mice to have papillomas formed at the end of the first month of applications of methylcholanthrene. By the end of the second month of the experiment, 6 of

10 mice had tumours formed, and in several cases multiple tumours were seen. A few of these tumour growths were biopsied at the ninth week of the experiment and showed extraordinary hyperkeratosis and much mitotic activity. One was judged to be premalignant.

Group 3 consisted of 10 mice receiving 0·5 per cent griseofulvin mouse food mixture for 6 weeks prior to, during and after the applications of methylcholanthrene. At the end of a month, one of 10 mice showed a neoplasm which was biopsied at the ninth week and proved to be a well-differentiated epidermoid carcinoma. At the end of two months, 2 of 10 mice had tumour growths.

Group 4 consisted of 10 mice receiving a 1 per cent griseofulvin food mixture as long as group 2, and group 5 consisted of 10 mice receiving a 0·5 per cent griseofulvin food mixture as long as group 3. No methylcholanthrene was applied to these groups. No tumour growths have appeared in groups 4 and 5, which have received griseofulvin for 18 weeks.

We are repeating this experiment in larger groups of animals at the present time, and at the sixth week of the new experiment find that we are obtaining similar results. An addition to the experiment showed no tumours to have formed in mice receiving either a 0·01 per cent or a 0·1 per cent griseofulvin food mixture and having methylcholanthrene applications twice weekly for 6 weeks.

It is emphasized that the dosage used in the 1 per cent experiments was approximately 100 times that used in man.

This experiment was sponsored through the United States National Institutes of Health, Division of Research Grant *CY*-5071 (*A*). Griseofulvin powder was obtained from Dr. Clarence Denton, Division of Clinical Investigation, McNeil Laboratories, Inc., and Dr. G. Kenneth Hawkins, Clinical Research Division, Schering Corporation.

Louis L. Barich
Takashi Nakai
Jan Schwarz
Donna Jean Barich

Department of Dermatology,
College of Medicine,
University of Cincinnati,
Cincinnati, Ohio. Feb. 14.

ANATOMY

Presence of a Pituitary Portal System in Elasmobranchs

Since the discovery in the 1930's of the pituitary portal system in man, a similar system has been described in a large number of vertebrates, from amphibians to mammals[1]. Green did not notice a portal system in fishes, but suggests that the large sinusoids lying between the neurohypophysis and pars intermedia might serve a similar function, namely, a neurovascular contact involved in the control of the adenohypophysis.

The present investigations of the pituitary vascular system of some elasmobranchs (*Scyllium canicula*, *Squalus acanthias*, *Raja batis* and *Raja radiata*) have shown the presence of a definite portal system in these species. It consists of a primary plexus on the ventral surface of the hypothalamus, portal vessels running along a kind of infundibular stem to the neuro-intermediate lobe, the sinusoids of which thus make up the secondary plexus. From the primary plexus, more or less extensive portal vessels may also open into the sinusoids of the anterior lobe, thus resembling conditions in the tetrapods.

In *Scyllium canicula*, the median hypothalamic floor between the inferior lobes is modified to a kind of median eminence. This is covered with the capillaries of the primary plexus, and the anterior lobe of the adenohypophysis attaches to its median surface. This part of the hypothalamus is very similar to the median eminence of higher vertebrates, partly because of its vascularization and contact with the adenohypophysis, but also in other details. The fibre layer under the ependyma thus contains the tractus preoptico-hypophyseus, and outside this is a zone with only scattered nerve fibres. The capillaries of the primary plexus are buried in furrows on the surface of this outer zone. The furrows are most distinct laterally; along the median part, which is in contact with the anterior lobe, the capillaries are of a simpler type.

From the primary plexus, portal vessels run backwards along the thin ventricular floor behind the inferior lobes, and enter the neuro-intermediate lobe (Fig. 1). Most of the blood enters the large sinuses between the thin 'neural lobe' and the cell cords of the pars intermedia. From these sinuses smaller vessels branch through the remainder of the neuro-intermediate lobe. A few portal vessels run from the anterior part of the primary plexus to the sinusoids of the anterior lobe.

Besides the portal system, which is median, there is also a lateral venous supply to the neuro-intermediate lobe: on either side a large vein, collecting blood from the diencephalon and anterior mesencephalon, enters the lobe[2]. Part of these veins can be seen in Fig. 1.

The arterial supply is small; there are no distinct arteries to the adenohypophysis, although small

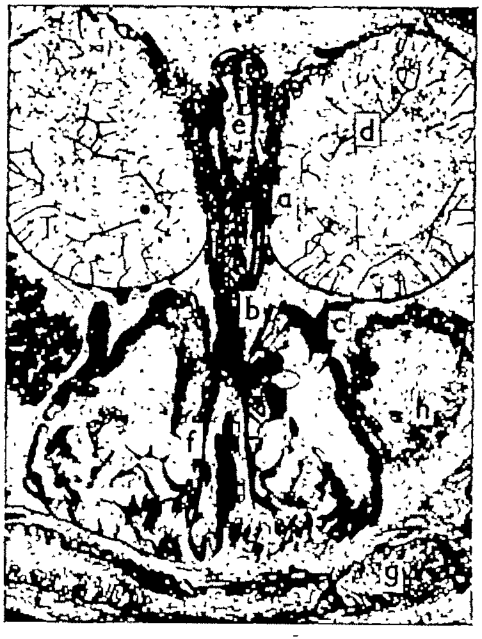


Fig. 1. *Scyllium canicula*, horizontal section through pituitary. Indian ink injection, 'Celloidin', 100*µ*. *a*, Primary plexus; *b*, portal vessels; *c*, lateral afferent vein; *d*, inferior lobe; *e*, anterior lobe; *f*, neuro-intermediate lobe; *g*, ventral lobe; *h*, saccus vasculosus

vessels reach its margins. Thus, small arteries run along the inferior lobes, close to either side of the anterior lobe, supplying mainly the primary plexus, with no observable direct branches to the anterior lobe. There are also arteries to the posterior part of the infundibulum; they probably give a small arterial contribution to the neuro-intermediate lobe and saccus vasculosus.

The gland is drained by a short venous trunk at the posterior ventral aspect of the neuro-intermediate lobe. It enters the large transversal sinus interorbitalis.

In *Squalus acanthias* the primary plexus is less distinct and most of the portal vessels enter the anterior lobe; only a small number run caudally to the neuro-intermediate lobe. Lateral afferent veins and a ventral drainage are also present in this species.

In *Raja batis* and *R. radiata* the ventricular floor behind the inferior lobes is very much expanded laterally and is covered by a dense system of parallel, longitudinal portal vessels. They enter the neuro-intermediate lobe in a manner similar to that of *Scyllium canicula*. Lateral afferent veins appear to be absent in *Raja*, but there is a large ventral vein draining the gland, running along the interhypophysial peduncle. Both *Raja* and *Squalus* have distinct arteries to the neuro-intermediate lobe.

In view of the constant occurrence of the pituitary portal system in the tetrapods, it is interesting to find a similar system also among the elasmobranchs. A noticeable difference is that in *Scyllium* and *Raja* most of the portal vessels enter the neuro-intermediate lobe, with only minor connexions with the anterior lobe. In higher vertebrates the portal vessels invariably run to the pars distalis, and appear to be the only or main vascular supply to this part of the pituitary.

The presence of a pituitary portal system and a distinct median eminence in elasmobranchs makes it necessary to modify earlier opinions on the phylogenetical derivation of the tetrapod neurohypophysis[3]. The differentiation of the neurohypophysis into a median eminence and a neural lobe may thus have taken place at an earlier stage in vertebrate evolution than previously assumed.

PATRICK MEURLING

Zoological Institute,
Lund, Sweden.

[1] Green, J. D., *Amer. J. Anat.*, 88, No. 2 (1951).

[2] Rex, H., *Morph. Jahrb.*, 17, 436 (1891).

[3] Wingstrand, K. G., Symp. Comp. Endocrinol., edit. by Gorbman, A. (1959).

Sensory Innervation of the Anal Canal

Duthie and Gairns in a short communication[1] directed attention to the rich sensory innervation of the mucosa of the human anal canal.

This is a preliminary report of a further investigation of the sensory innervation of the anal mucosa and of the adjacent external (voluntary) anal sphincter.

Autopsy and operative specimens of whole human anal canals, excised with the last centimetre or so of the rectum and the attached circumanal skin, were fixed in 10 per cent formal saline. Fresh specimens of cat and rat anal canals were similarly fixed. Longitudinal serial $7\frac{1}{2}$-μ sections through the canals were either stained with Ehrlich's hæmatoxylin and eosin, or impregnated with silver according to Bodian's silver protargol method, using silver proteinate obtained from Roque's Laboratory, Paris[2]. Other blocks of material were impregnated according to the Bielschowsky method for pieces with pyridine treatment[3], and then serially sectioned at $7\frac{1}{2}$μ. Frozen 20-μ sections of the fixed rat material were impregnated by the Bielschowsky–Gros silver diamine ion technique[4].

In the human material the distribution of the encapsulated, or organized, sensory nerve endings conforms to Weddell's generalization[5] that such endings are only found in non-hairy skin.

Three kinds of encapsulated ending were found, lying either immediately beneath the stratified epithelium of the canal or deep in the connective tissue of the lamina propria.

The largest endings are approximately 900μ in size and possess an elongated lamellated capsule similar to that of Pacinian corpuscles. The nerve terminals, however, are not of the simple kind found in Pacinian corpuscles but are branched and coiled (Fig. 1). This large variety of ending is only infre-

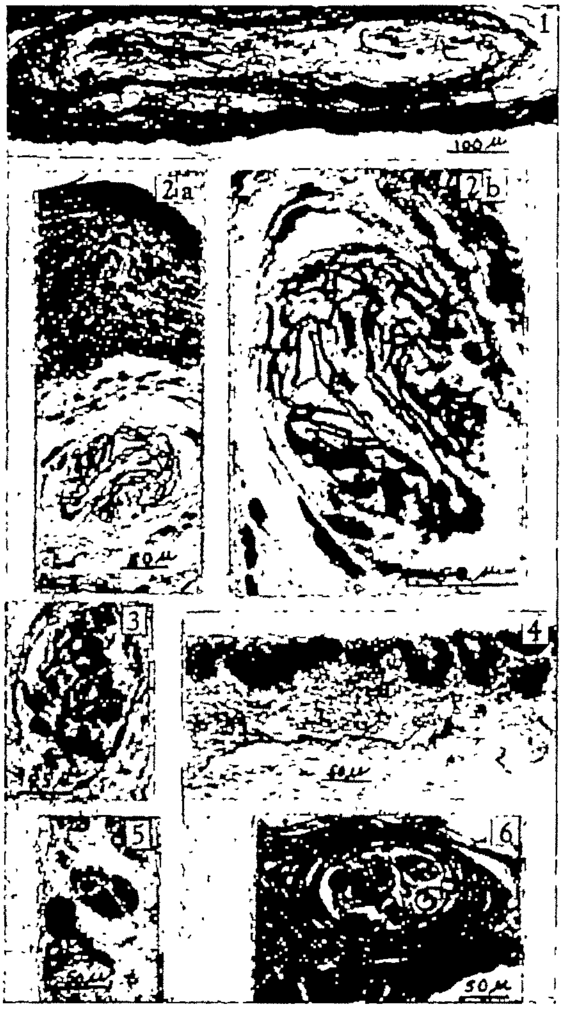


Fig. 1. Large encapsulated nerve ending. Fig. 2a. Low power showing medium-sized, organized ending lying under anal epithelium. Fig. 2b. High power of same ending showing the reticulum of sensory nerve endings. Fig. 3. Small organized ending. Fig. 4. Plexus of free nerve fibres at junction of rectal type epithelium and stratified squamous epithelium of anal canal. Fig. 5. T.S. muscle spindle from cat external sphincter. Fig. 6. T.S. muscle spindle from human external anal sphincter

quently found, usually lying close to the smooth muscle of the internal sphincter.

The most prevalent ending is globular or oval in shape, some 200μ in diameter. The nerve terminals form a branched tangled reticulum surrounded by a fairly simple capsule of connective tissue fibres and cells (Figs. 2a and b).

Fig. 3 shows the smallest kind of end-bulb, 100μ in diameter. Their nerve terminals are branched but relatively uncomplicated in their ramifications.

These encapsulated endings are most numerous in the mucosa of the upper part of the canal—six or more endings may often be observed in one section—and gradually become sparser in distribution as the anal orifice is approached.

Unencapsulated naked nerve terminals form a particularly rich subepithelial and intraepithelial plexus. In the circumanal skin typical peritricheal endings and free nerve endings were observed, but no organized endings.

No encapsulated endings were found in the rat anal mucosa, only a plexus of free nerve terminals, which was particularly obvious in the first segment of the canal (Fig. 4).

Proprioceptive endings of the muscle-spindle kind were observed in both human and cat external sphincters (Figs. 5 and 6). The correlated physiological observations in the cat have been reported elsewhere[6].

The human spindles are histologically more complicated than those found in the cat. Their connective tissue capsule is thicker and usually there are more intrafusal fibres present. Often the intrafusal fibres are arranged in two separate groups, each surrounded by its own connective tissue sheath, and both groups bound together in a common capsule. In serially sectioned cat sphincters not more than six spindles have been counted. They appear to be equally sparse in human sphincters.

It is concluded that the rich sensory innervation of the anal mucosa and the proprioceptive endings in the external sphincter provide a morphological basis for the extreme sensitivity of the anal region and must be taken into consideration in explaining the physiology of defaecation.

May I thank Prof. E. W. Walls for his directing my attention to this problem and his guidance throughout the work.

R. P. GOULD

Department of Anatomy,
Middlesex Hospital Medical School,
London, W.1.

---

[1] Duthie, H. L., and Gairns, F. W., *J. Physiol.*, 148, 1, P (1958).

[2] Polley, E. H., *Anat. Rec.*, 125, 509 (1956).

[3] "The Microtomist's Vade Mecum", 528 (1950)

[4] Garven, H. S. D., and Gairns, F. W., *Quart. J. Exp. Physiol.*, 37, 131 (1952).

[5] Weddell, G., Palmer, E., and Pallie, W., *Biol. Rev.*, 30, 159 (1955).

[6] Chennells, M., Floyd, W. F., and Gould, R. P., *J. Physiol.* (in the press).

BIOLOGY

Laminated Structure of Bones from Some Marine Mammals

IN recent years much attention has been paid to methods of age determination for marine mammals, and several reliable techniques are now available. Ovarian corpora albicantia counts[1,2], baleen plate ridges[3], internal growth layers in the dentine and cementum of teeth[4], and laminations in the ear plug of baleen whales[5] are in use. Certain of these techniques have been applied with success to some terrestrial mammals, notably the method based on tooth structure[6,7]. In other species, marine and terrestrial, these methods cannot be used.

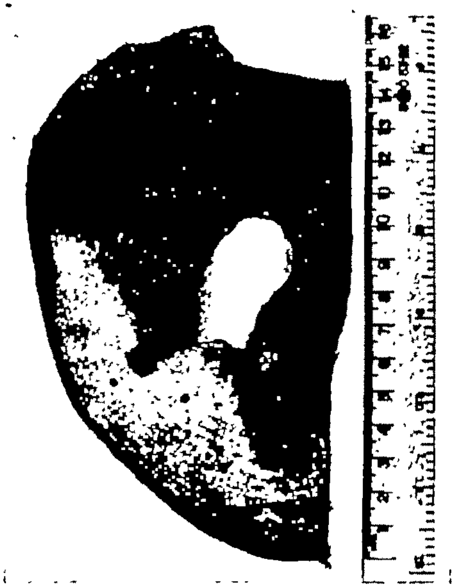


Fig. 1. Photograph of polished section of left ramus of lower jaw of an adult male sperm whale

In 1953 I described and figured the layered appearance of the dense bone of the tympanic bulla of some elephant seals, *Mirounga leonina* L.[8], but was then unaware of a paper by Chapskiy[9] in which he describes and figures such layers in the mandibles of *Phoca groenlandica* and *Odobenus rosmarus*. He showed that the number of layers is correlated in a general way with estimates of age based on other characters, and suggested that the layers are annual formations. The greatest number present in his relatively small sample of harp seals was 25. He mentions that this layered structure is found in other bones and gives reasons for preferring the mandible for routine use. It is usually the most convenient bone to collect.

I recently had occasion to examine the lower jaw of a large male sperm whale, *Physeter catodon*, caught in the Antarctic. The ventro-lateral part of the mandible is composed of compact bone, some 3–4 cm. thick in places, in contrast to the remaining spongy bone. In section it shows a number of distinct layers (Fig. 1).

These layers may be of fairly general occurrence and the purpose of this communication is to direct attention to them as a possible method of age determination. Chapskiy's important paper[9] would appear not to be generally known to biologists interested in these problems. Dr. D. E. Sergeant of the Arctic Unit, Montreal, has confirmed the layering of harp seal mandibles and found clear layers in *Phoca vitulina*, *Phocaena* and *Delphinus*. These layers will probably be useful for ageing the small delphinids, with minute teeth that may cease to grow at an early age. It may also be a possible method of ageing those baleen whales (for example, *Balaenoptera acutorostrata*) in which the ear plug has proved unsatisfactory. Game biologists may find it applicable to some terrestrial mammals in which the cementum increments are too small to use for age determination.

I am indebted to Dr. Sergeant for confirming the presence of layers in the mandibles of seal and Delphinid species. Chr. Salvesen and Co. kindly provided the sperm whale jaw and Mr. A. Madgwick took the photograph.

R. M. LAWS

National Institute of Oceanography,
Wormley, Godalming,
Surrey.

[1] Mackintosh, N. A., and Wheeler, J. F. G., "Discovery Rep.", 1, 257 (1929).
[2] Laws, R. M., *Norsk Hvalfangsttid.*, 48 Årg. (5), 225 (1958).
[3] Ruud, J. T., *Hvalrådets Skr.*, No. 29, 1 (1945).
[4] Laws, R. M., Sci. Rep. Falkland Is. Dep. Surv., No. 2, 1 (1953).
[5] Purves, P. E., "Discovery Rep.", 27, 293 (1955).
[6] Christian, J. T., *Amer. Midl. Nat.*, 55 (1), 66 (1956).
[7] Sergeant, D. E., and Pimlott, D. H., *J. Wildlife Mgt.*, 23 (3), 315 (1959).
[8] Laws, R. M., Sci. Rep. Falkland Is. Dep. Surv., No. 8, 1 (1953).
[9] Chapskiy, K. K., *Izv. Estestv.-Nauchn. in-ta im. P.F. Lesgafta*, 25, 47 (1952).

Dichorial One-Egg Twins in the Mouse

In a survey of the embryological evidence of one-egg twinning in man, Corner[1] has classified one-egg twins according to their time of separation, as follows:

(1) Separation of early blastomeres inside the zona pellucida. Each then develops its own blastocyst, the two becoming completely separate on dissolution of the zona, and implanting separately in the same way as two-egg twins.

(2) Duplication of the inner cell mass in a single blastocyst. The two embryos implant together; but their amnia and placentae are separate.

(3) A single inner cell mass differentiates two primitive streaks. The embryos will have a common amnion. Imperfect duplication of the primitive streaks will give all stages from Siamese twins to two-headed monsters.

The evidence for type 1 consists of two extreme sets of data. On one hand, it has been found in the rat[2] and rabbit[3] that after killing one blastomere at the two-cell stage, the other one is capable of developing into a normal embryo. The potentiality of a single blastomere to develop into an embryo does not, however, prove that *two* blastomeres confined within the same zona could both develop into embryos. One might expect considerable mechanical difficulties in the production of two blastocysts in the confined space. No one appears to have seen, among the thousands of mammalian ova examined (I have inspected hundreds of mouse eggs myself), any instance of two complete ova developing within one zona pellucida.

At the other extreme are the numerous examples of dichorial one-egg twins, which independent workers[4,5] have estimated to represent one-third of all one-egg twins.

The evidence for type 2 is more conclusive. At one end of the scale, isolated instances of blastocysts with two inner-cell masses have been recorded in sheep[6] and pig[7]. At the intermediate level Corner[1] gives examples of early human monochorial twin embryos with separate amnia, placentae and yolk sacs (though sometimes one yolk sac is shared). At the other end of the scale, the majority of full-term one-egg twins are monochorial with separate amnia.

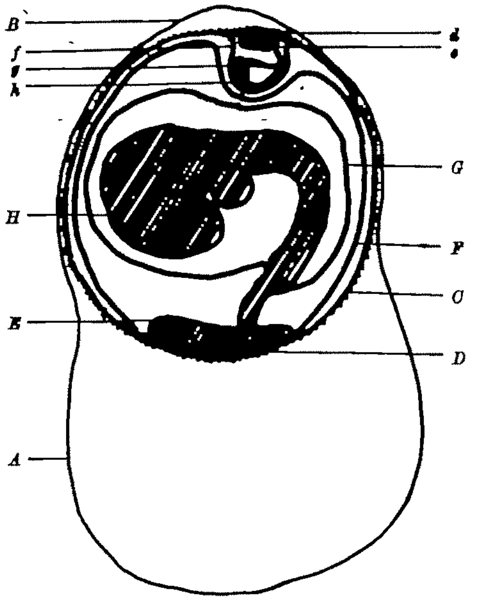


Fig. 1. Diagrammatic representation of monozygotic twin embryos in the mouse at 9½ days gestation. The uterus is not represented. *A*, Decidua basalis; *B*, decidua capsularis; *C*, trophoblast. For the other symbols, capitals stand for structures of the larger (normal) embryo and small letters for structures of the smaller (retarded) embryo. *Dd*, Ectoplacental cone; *Ee*, chorion; *Ff*, yolk sac; *Gg*, amnion; *Hh*, foetus

Type 3, illustrated by numerous human examples of twins with a common amnion, can be readily induced in Amphibia and fish. It is also the normal reproductive method in armadilloes[8], where four or eight embryos, according to the species, develop from a single egg.

I have obtained evidence of type 2 in mice, in circumstances which explain why it has not been recorded more frequently, and throws new light on the distinction between monochorial and dichorial twins. While dissecting early mouse embryos I have twice found in females, 9½ days from insemination, among numerous normal embryos, one implantation with two separate embryos within a single trophoblast (Fig. 1). The embryos were at opposite ends of the vesicle. Judging by the sheep and pig blastocysts, this is the usual arrangement. The one at the mesometrial end, attached to the decidua basalis, was much the larger of the two. In the mouse, placentation is restricted to the mesometrial line. Only the larger twin, therefore, has any future. The placenta is beginning to develop at 9½ days. The distal embryo has probably already ceased to grow and will soon be stretched out of existence by the expansion of the distended trophoblast. This makes it unlikely that one-egg twins in mice could be recognized later than 9½ days, but one would expect to have found them at earlier stages with less discrepancy in size. That I have not yet done so may be merely a matter of chance. It is just conceivable that the smaller embryo at 9½ days is secondary, developing after the larger, from trophoblast. This would account both for its small size and its absence from earlier stages.

In man, where placentation is unrestricted, both embryos such as those found in the mouse would be free to develop their own placenta and would have equal chances of survival.

Other forms of 'twinning' in the mouse are undoubtedly two-egg. It is common for two advanced (12½ days) embryos to share a common implantation site, with separate though contiguous placentæ. In litters segregating for albino these twins will often be found to differ in eye colour. I have also found two trophoblasts, one above the other at the same site. In this case they were both greatly dwarfed, presumably because each had inhibited the other.

It will be noticed from Fig. 1 that the one-egg mouse twins with a single trophoblast are dichorial, whereas most one-egg human twins are monochorial. This is because the two animals have very different types of chorion. That of the mouse is formed of extra-embryonic mesoderm, in contact with a restricted area of trophoblast, the ectoplacental cone, from which the placenta later develops. By contrast, the human chorion envelops the embryo and yolk sac. According to Corner (personal communication) it is formed from trophoblast, though it is vascularized by mesenchyme from the allantois.

The significance of dichorial one-egg twinning will obviously depend on the origin of the chorion, and since mouse chorion and human chorion do not appear to be homologous, the significance of such twins will be different in the two species. In the mouse, as in the cases described in this communication, they will signify duplicate inner cell masses from a single blastocyst (type 2). In man they will signify duplicate trophoblasts (two blastocysts from a single egg: type 1). There remains the problem of how two viable blastocysts could develop inside the same zona pellucida.

It is a pleasure to acknowledge the generous advice of Dr. George Corner of the Rockefeller Institute, New York, and of Mr. S. Bender of Chester.

A. J. BATEMAN

Cytogenetics Laboratory,
Christie Hospital and
Holt Radium Institute,
Manchester.

[1] Corner, G. W., *Amer. J. Obstet. Gynec.*, 70, 933 (1955).

[2] Nicholas, J. S., and Hall, B. V., *J. Exp. Zool.*, 90, 441 (1942).

[3] Seidel, F., *Naturwiss.*, 39, 355 (1952).

[4] Essen-Möller, E., *Hereditas*, 27, 1 (1941).

[5] Vermelin, H., and Ribon, M., "Encyclopédie Medico-Chirurgicale", second ed., Paris, Section 5030, 1 (1949).

[6] Assheton, R., *J. Anat. Physiol.*, 32, 362 (1898).

[7] Streeter, G. L., *Amer. J. Anat.*, 34, 183 (1924).

[8] Newman, H. H., and Patterson, J. T., *J. Morphol.*, 21, 359 (1910)

Wound Healing in the New-Born Opossum (*Didelphis virginianam*)

WHILE engaged in experiments on the development of feathers in chick embryos, Saunders and Weiss[1] noted that skin wounds failed to heal when the embryos were less than 3 days old. On further investigation Weiss and Matoltsy[2,3] found, for unknown reasons, that this inability to initiate wound healing persisted until the chick embryos were at least 10 days old.

Because of the absence of an accessible experimental subject, it had not been feasible to investigate wound healing in very immature mammalian embryos. However, I have found that the new-born opossum (*Didelphis virginianam*), because of its 12-day gestation period, is an exceptionally suitable subject for elucidation of this problem in mammals. At birth the opossum is physiologically and anatomically an embryo, corresponding in development to the following embryos: 10-day chick, 12-day rat and mouse, 13-day rabbit, 28-day guinea pig and 8-week human.

Two types of skin wounds were made in opossums 1–40 days old. The first series consisted of a non-sterile incision 2–4 mm. in length and extending into the muscle. The second series were burns of the same size made by application to the skin of needles heated at 200° to 210° F. The incised wounds became grossly infected; the burns did not.

There was a 90 per cent mortality within 2 or 3 days of injury in animals less than 6 days of age with wounds induced by incision. This mortality decreased with advancing age so that the mortality was less than 2 per cent in animals of 10 days of age and older. In contrast, the mortality following a burn was less than 10 per cent in animals less than 6 days of age, and had decreased to zero in animals at least 10 days of age.

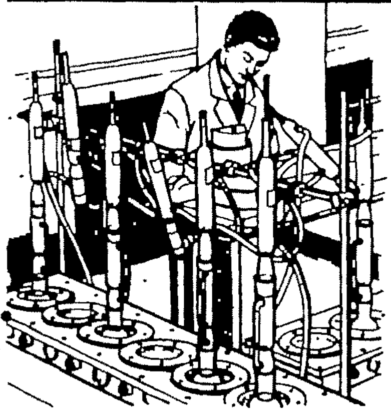
In all animals less than 6 days of age there was an almost complete lack of inflammatory reaction at the site of injury. The slight increase in cells was due to a few mitoses in local mesenchymal cells. This lack of reaction was unimportant when the wound was essentially sterile, and when there was little tissue necrosis, as occurred following the burn. In these circumstances the local mesenchymal cells were able to remove the debris and form a suitable base for spread of the epidermis over the ulcer. In contrast, when the wound became infected, as occurred after the non-sterile incisions, or if the burn was unusually deep, causing marked tissue necrosis, the injury became the site of a massive gangrenous infection resulting in death of the fœtus.

However, in all animals beginning 6 days of age the local injury elicited an intense mononuclear inflammatory response. The inflammatory cells successfully combated the local infection and within 48 hr. removed all necrotic tissue, leaving a clean base across which the epidermis bridged the defect.

The difference in reaction prior to, and subsequent to, 6 days of age was explicable by examination of the blood and hæmatopoietic tissues. Before 6 days of age there was not sufficient development of the hæmatopoietic tissues to produce significant numbers of white blood cells for the circulating blood. As a result the local mesenchyme was the only source of inflammatory cells to clear necrotic tissue and control infection. Thereafter, with progressive development of the hæmatopoietic tissues a large number of white blood cells entered the circulating blood and were able to supplement the mesenchymal cells at the site of injury as a source of inflammatory cells. The inflammatory reaction was almost as effective between 6 and 10 days of age, when the only apparent source of lymphocytes was the thymus, as after 10 days of age when lymphocytes were derived from the spleen and nodes as well as from the thymus.

These results suggest that in the opossum of less than 6 days of age wound healing ensues even in the absence of an intense inflammatory reaction provided the injured area is small and the lesion remains sterile. When the area is infected or when there is extensive local injury in animals less than 6 days of age, wound healing does not occur because the local mesenchymal cells alone are unable to control injection and clear debris. Only after 6 days of age have the hæmatopoietic tissues of the opossum developed sufficiently to provide an adequate number of circulat-

EXTRACTION AND DISTILLATION UNITS

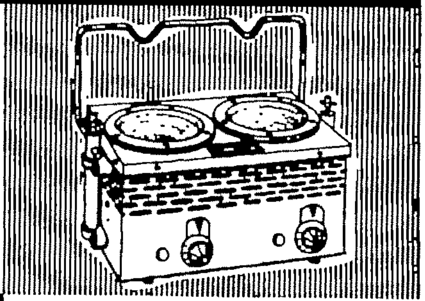


Perfect heat transfer
Accurate temperature control
Maximum safety
Minimum attention required

Extraction Units are available with three or six recesses, accepting flasks up to 1000 ml., and a controller and indicator lamp for each recess.
Non-standard units can be supplied to meet any requirement.

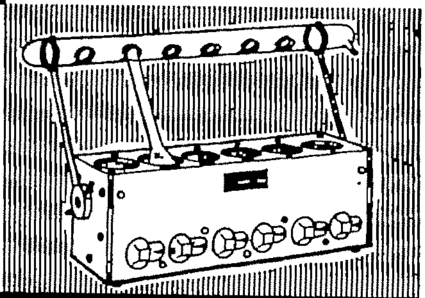
SERIES:— ME. MM. MQ.

Macro-Kjeldahl Units are supplied for six tests accepting flasks up to 800 ml., with a controller and indicator lamps fitted to each recess.
Units with two recesses are also available. All units are equipped with adjustable flask rests and are suitable for rack mounting.



Micro-Kjeldahl Digestion Units constructed of acid-resisting material are the most compact apparatus available. Fume tubes are fully adjustable for height and angle.

Available from all Laboratory Supply Houses.
Please request literature.

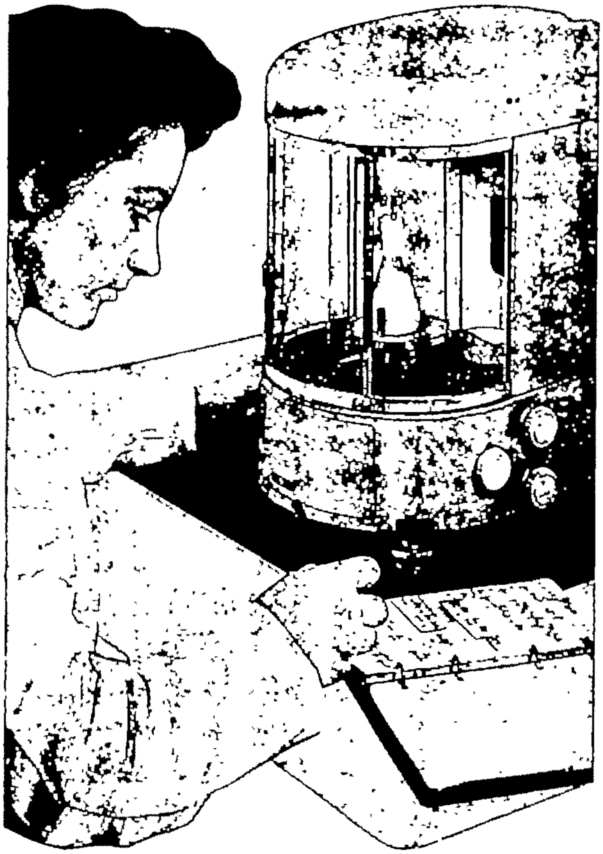


Electrothermal R

ELECTROTHERMAL ENGINEERING LTD

270 Neville Road London E7 Telephone GRAngewood 9011

As good as it looks



The NEW Sauter

Monopan

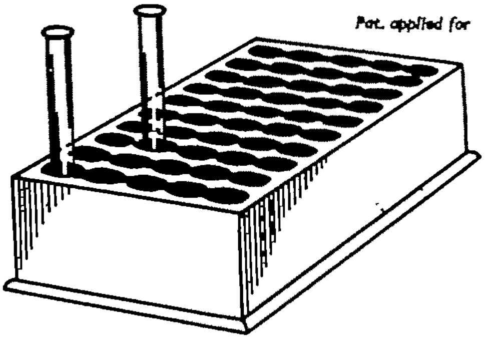
Rapid single-pan analytical balance

The 'Monopan' is an ENTIRELY NEW instrument whose fine craftsmanship and brilliant design make it the acme of constant-load substitution balances. Controls are where you want them—low down at the sides, for comfort and convenience. The magnified projection scale, recessed to prevent reflection, is in the same field of vision as the specimen. The air damping allows very rapid reading of the screen.

All the weights—enclosed in a protective compartment underneath the pan—are manipulated mechanically. There is a taring device for containers up to 30 g. The large cylindrical weighing chamber and the special suspension of the pan, obviating swing, all help to make this new balance a joy to use. Its capacity is 200 g and it can be read easily to 1/20 mg—0·00005 g. We shall be glad to send you full details.

SHANDON

SHANDON SCIENTIFIC COMPANY LTD.
6 Cromwell Place, London, S.W.7. Tel: KNI 1131



"E.R.L."

RUBBER HOLDERS

for

TEST TUBES, AMPOULES, BOTTLES, ETC.

Ref. No.	Number of Cavities	Diameter of Each Cavity
TTS1	100	$\frac{1}{2}$ in.
TTS6	56	$\frac{5}{8}$ in.
TTS2	50	$\frac{3}{4}$ in.
TTS3	45	$\frac{7}{8}$ in.
TTS4	18	1 in.
TTS5	15	$1\frac{3}{16}$ in.
HH1	11	Assorted

Made either in soft red organic rubber or harder type black synthetic rubber.

PRICE £1 or $2.80 each.

ESCO (RUBBER) LTD.
34/36 Somerford Grove, London, N.16

GLASS

All Glass Requirements for Scientific Instrument Manufacturers and Research Workers

- SHEET & PLATE-GLASS—cut and ground to exact dimensions.
- LENSES, PRISMS & FLATS—to any standard of accuracy.
- MIRRORS—back silvered and front surface aluminised, etc.
- BLOOMING of optical components.

C. J. WHILEMS, LTD.
ILFORD OPTICAL WORKS
FOREST ROAD, BARKINGSIDE, ESSEX

Telephone : HAInault 5454-5

ing leucocytes to serve as a source of inflammatory cells. It thus seems probable that the leucocytes of the circulating blood and not the local mesenchymal cells are the major source of the inflammatory cells needed for wound healing in the embryo-like new-born opossum.

I thank the Texas Game and Fish Commission for obtaining the animals and Braniff Air Lines for flying the animals from Waco, Texas, to Denver, Colorado.

Supported by a grant from the U.S. Public Health Service.

Matthew Block

Department of Medicine,
University of Colorado Medical School,
Denver, Colorado.

---

[1] Saunders, jun., J. W., and Weiss, P., *Anat. Rec.*, 108, 93 (1950).

[2] Weiss, P., and Matoltsy, A. G., *Nature*, 180, 854 (1957).

[3] Weiss, P., and Matoltsy, A. G., *Developmental Biol.*, 1, 302 (1959).

Development of the Gonads in Parasitic and Non-Parasitic Lampreys

In relation to the origin of the non-parasitic brook lampreys the view now generally accepted is that these forms have arisen from closely related parasitic species by virtue of a precocious development of the gonads[1-3]. As a result, sexual maturity is attained so soon after metamorphosis that the migratory, parasitic phase has been eliminated from the life-cycle. The recent discovery of neotenous female ammocoetes of the Italian brook lamprey, *L. zanandreai* Vladykov[4], tends to support the view that brook lampreys show an inherent tendency towards paedomorphosis.

Through the co-operation of Dr. V. C. Applegate, of the U.S. Department of the Interior, Fish and Wildlife Service, it has been possible to examine the condition of the gonads in ammocoetes of the parasitic sea lamprey of the Great Lakes Basin, *P. marinus*, and to compare the pattern of gonad development in this species with that of the brook lamprey, *L. planeri*.

Length-frequency curves for 847 ammocoetes of *P. marinus* collected in the Ocqueoc River, Michigan, in September 1957, suggest the presence of six age classes with frequency maxima at about 25, 55, 80, 105, 124 and 140 mm. Metamorphosing specimens were found in the size-range 123–170 mm. with a frequency peak at about 145 mm. Since the 25-mm. group represents the young of the year, it is thought that the duration of the larval period is similar to that of the brook lamprey[5], that is, about five years.

To compare the size of the gonad in the two species transverse sections were cut through the mesonephric region and either photographed or traced with the camera lucida. The area of the gonad was then measured planimetrically and expressed as

$$\frac{\sqrt{\text{gonad area in mm.}^2}}{\text{total length mm.}} \times 100$$

For the first year of larval life (up to about 30 mm.), the gonad of *L. planeri* is in the proliferative phase during which the small number of germ cells present at hatching undergo successive divisions to produce follicles of undifferentiated gonia. By the early spring of the second year (35–40 mm.) some gonads already contain oocytes in the earlier stages of cytoplasmic growth. In the definitive ovary, growth is now rapid, and the gonad soon consists almost entirely of auxocytes. However, in a small proportion of ammocoetes, the gonad remains small with follicles of gonia only, while others contain, in addition to such follicles, a smaller number of oocytes. Future testes are recognizable at this stage only by their small size, relatively fewer auxocytes, and the presence of undifferentiated gonial follicles. By the summer or autumn of the second year, at lengths of about 50–60 mm., differentiation of the gonads is almost completed but the testes show little further growth between this period and metamorphosis.

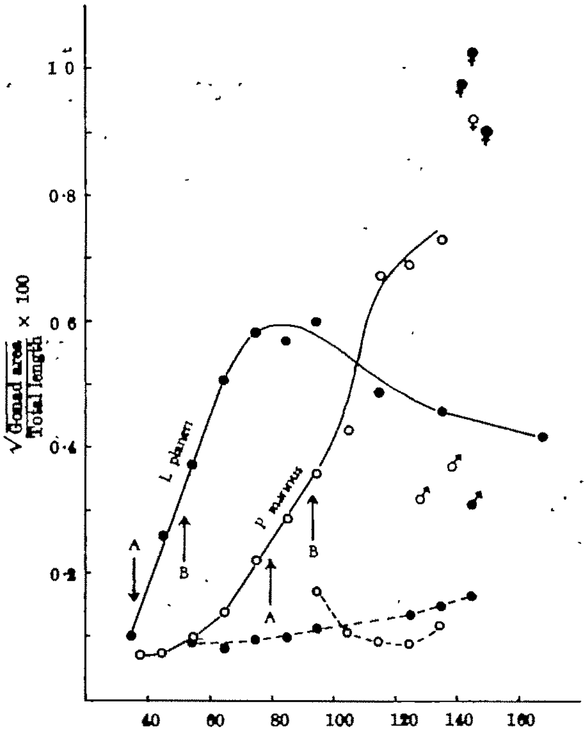


Fig. 1. Relative growth of gonads in ammocoetes of *P. marinus* and *L. planeri*. Continuous lines, ovaries and indeterminate gonads; broken lines, testes; ♀, metamorphosing females; ♂, metamorphosing males of *P. marinus*. The arrows at *A* and *B* indicate respectively the appearance of auxocytes and the onset of sex differentiation

The rapid initial growth of the oocytes is reflected in the increase in size of the gonad between 35 and 75 mm. total length (Fig. 1), beyond which the relative size of the ovary actually diminishes. There is, however, a final phase of growth, not represented in the graph, between metamorphosis and full sexual maturity, during which the diameter of the oocyte is increased from about 0·12 mm. in the largest ammocoetes to 1·0 mm. at the time of spawning.

Initially the gonads of *marinus* ammocoetes are smaller than those of *planeri* and grow more slowly up to a length of about 100 mm. Thus, in a 100-mm. sea lamprey ammocoete the gonad is no larger than that of a brook lamprey at 55 mm. and, up to lengths of 70–80 mm., it still consists of undifferentiated germ cell follicles. This extension of the period of proliferation must, of course, be associated with the vastly greater number of oocytes (or spermatocytes) produced by the sea lamprey. Oocytes in the first growth-phase occurred in the majority of animals at 80–90 mm.; but it was not possible in all cases to distinguish the definitive ovary and testis at lengths below 90–100 mm. Growth of the ovary appears to be most marked between 105 and 115 mm., and in animals above this length the gonad is relatively larger than in the corresponding brook lamprey ammocoetes. This increased size is due to the larger number of oocytes; a single transverse section often containing as many as 200 oocytes compared with an average of about 30 in the brook lamprey, while the oocytes themselves are smaller than those of *planeri* (mean diameter in the largest ammocoetes 0·3–0·4 mm. compared with 0·12 mm.). Judging from the size of the gonad in metamorphosing animals, a marked acceleration of growth must occur in both ovary and testis at this time.

Although the duration of the larval period and the linear growth-rate appear to be similar in the two species there are thus very marked differences in gonad development, both sex differentiation and oocyte growth occurring at a much earlier stage in *planeri* ammocoetes. In considering the relevance of these findings to the question of speciation in lampreys it must, however, be recognized that, except for its earlier differentiation in the brook lamprey, there are no obvious indications that the testes of these animals are in a more advanced state of development and it may perhaps be significant that all the cases of neoteny reported by Zanandrea[4] occurred in female ammocoetes.

M. W. HARDISTY

College of Technology,
Bristol.

[1] Zanandrea, G., *Nature*, 184, 380 (1959).

[2] Leach, J. W., *J. Morph.*, 89, 217 (1951).

[3] Young, J. Z., "The Life of Vertebrates" (Oxford, 1950).

[4] Zanandrea, G., 179, 925 (1957).

[5] Hardisty, M. W., *Nature*, 167, 38 (1951).

An Acid-tolerant and Non-sporulating Yeast from Passion Fruit Juice

DURING the course of studies in the preservation of passion fruit juice (*Passiflora edulis*, Sims.)[1,2], a survey of literature revealed little published information on the nature of spoilage organisms present in the juice.

Passion fruit juice normally has 14·4–21·9 °Brix, 2·4–4·8 per cent acidity (as anhydrous citric acid), 2·60–3·22 *p*H, 3·6–8·3 per cent reducing sugars and 7·4–13·3 per cent total sugars (as invert)[3]. The juice, though acidic, is fairly rich in sugars and is easily fermentable[1]. A fermenting sample of the juice, when examined microscopically, revealed the presence of yeast cells only. No bacteria were noted.

The spoilage organisms were isolated by plating them out on potato–dextrose–agar[4] and transferring the well-defined colonies to slants of the same medium. Taxonomic studies[4,5] revealed the presence of two strains of yeast, one of which was identified as *Candida krusei*[6]. The summary of morphological and physiological studies on the other organism (*Passiflora* strain) is given below.

Cells small, oval (1·8–4·5) × (1·8–8·8) μ; no formation of pseudomycelium; a sediment after a week and a ring after a month in liquid media; no sporulation on carrot, Gorodkowa agar, potato malt-extract agar, etc.

Only glucose is fermented and assimilated. The following compounds are not assimilated by this *Passiflora* strain: galactose, sucrose, maltose, lactose, L-sorbose, cellobiose, trehalose, melibiose, raffinose, melezitose, D-xylose, L-arabinose, D-arabinose, D-ribose, rhamnose, erythritol, adonitol, dulcitol, mannitol, sorbitol and methyl glycoside, salicin, lactic acid, succinic acid and citric acid. Ethanol may be weakly assimilated. Nitrate is not used, and arbutin is not split.

The *Passiflora* strain resembles *Torulopsis glabrata* (Anderson) Lodder and de Vries, but differs from this species in that the latter ferments trehalose.

Comparing the strain to sporogenous species, it bears resemblance, in fermenting dextrose only, to: *Sacch. bisporus* (Naganishi) Lodder and van Rij, *Sacch. mellis* (Fabian and Quinet) Lodder and van Rij, *Pichia pastori* (Guilliermond) Phaff and *Sacch. delphensis* van der Walt and Tscheuschner[7].

The cells of *Sacch. mellis* and *Sacch. bisporus* are somewhat bigger than those of the *Passiflora* strain, though the difference with *Sacch. bisporus* is not great. However, *Sacch. bisporus*, *Sacch. mellis* and also *Pichia pastori* can assimilate mannitol and sorbitol, which compounds are not used by the *Passiflora* strain.

On the other hand, the assimilation tests of the *Passiflora* strain and *Sacch. delphensis* show much correspondence, differing only by a weak assimilation of succinic acid found in the latter. For growth, both strains need the addition of vitamins to the medium. They grow at 37° C. Also in the morphological properties, there is similarity, apart from the formation of kidney-shaped spores after isogamous conjugation in *Sacch. delphensis*. This species has been isolated from the sugary efflorescence on dried figs (Kregar-van Rij, N. J. W., private communication).

Based on the above observations, we are inclined to consider the *Passiflora* strain provisionally as a non-sporulating strain of *Sacch. delphensis*.

We are indebted to Mrs. N. J. W. Kregar-van Rij, Centraalbureau voor Schimmelcultures, Yeast Division, Julianalaan 67A, Delft, Holland, for help rendered in the identification of the yeast, to Dr. Girdhari Lal, assistant director, and Dr. V. Subrahmanyan, director of this Institute, for their keen interest in this investigation, and to Shree S. A. Jaleel, for assistance in the work.

B. A. S. RAO
J. S. PRUTHI

Central Food Technological Research
Institute,
Mysore, 2.

[1] Pruthi, J. S., Ph.D. thesis (1955), Pb. Univ., Solan, India; *Food Science*, 8, 396 (1959).

[2] Pruthi, J. S., *et al.*, *J. Sci. Indust. Res.*, 17, C (8), 129 (1958).

[3] Pruthi, J. S., and Lal, G., *J. Sci. Food Agric.*, 10, (8), 188 (1959).

[4] Lodder, J., and Kregar-van Rij, N. J. W., "The Yeasts—a Taxonomic Study" (Interscience Pub., New York, 1952).

[5] Wickerham, L. J., "The Taxonomy of Yeasts", Tech. Bull. No. 1029, United States Department of Agriculture, Washington, D.C. (1951).

[6] Pruthi, J. S., *et al.*, *Curr. Sci.* (in the press).

[7] Walt, J. P. v. d., and Tscheuschner, J. T., "Antonie van Leeuwenhoek", 22, 162 (1956).

Ensete berryi: Revised Name for *Musa enseteformis* Berry

WORKING on some petrified plants from the Deccan Intertrappean Series of India, I have found certain well-preserved specimens of fossil bananas to be described in detail elsewhere. Looking into the geological history of the genus *Musa*, I find that *Musa enseteformis* Berry[1] is the only definite palæobotanical record of the old genus *Musa* L. This species was based on some carbonized seeds recovered from the coal beds of Cerros de Guadalupe and Montserrate in the eastern border of the Sabana of Bogota, Colombia. The exact horizon from which these seeds were obtained was not known; but Berry considered them to be of Oligocene age.

Recently, Cheesman[2] has split the old genus *Musa* into *Ensete* Horan. and *Musa* L. As evident from their structure and as suggested by the specific name *ensetaformis*, the seeds described by Berry[1] are clearly referable to the newly revived genus *Ensete*. In the light of these facts, the name of *Musa ensetaformis* should be revised. Usually in such cases the generic name is changed and the specific name is combined with it. But to avoid the repetition of the generic name in the specific epithet, I propose a new combination *Ensete berryi*, with the specific name in honour of the original author.

My sincere thanks are due to Dr. R. N. Lakhandal for going through this communication critically.

R. K. Jain

Birbal Sahni Institute of
Palæobotany,
Lucknow, India.
Feb. 5.

---

[1] Berry, R. W., *Amer. J. Sci.*, 10, 530 (1925).

[2] Cheesman, E. E., *Kew Bull.*, No. 2, 97, 106 (1948).

Unproductivity in the Colchicine-Induced Tetraploids of *Annona squamosa* L.

Only two out of a large number of colchicine-treated *Annona squamosa* plants reported earlier[1] proved pure tetraploid on chromosome examination. The one suspected to be tetraploid on morphological grounds and reported in that paper to have borne fruits earlier than the control was found to be diploid. The two pure tetraploids have been under observation since 1951 but until now neither of them has borne any fruit although they come to blossom every year. The flowers on both these plants wither away on the day following their opening.

Selfing did not help in the fruit formation nor pollination by the pollen from the diploid parent. Application of hormone on the flower stalk did not also prevent the shedding of flowers. The addition of nitrogen, phosphorus and potassium in various combinations, and the root exposure did not improve the situation.

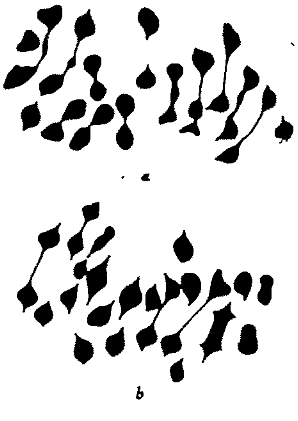


Fig. 1. (*a*) and (*b*), Side view of metaphase I showing 1III, 10II and 5I and 1III, 7II and 11I respectively. × 1,200

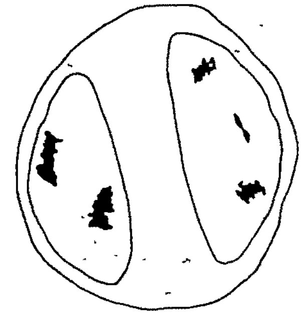


Fig. 2. Side view of anaphase II. Note the lagging chromosome in the right-hand cell. ×600

In order to understand the causes of unproductivity meiotic studies were made from pollen mother-cells in aceto-carmine. Early stages of prophase could not be studied as the chromosomes took feeble stain. None of the diakinetic nuclei studied showed any quadrivalents. Trivalents, bivalents and univalents were only found, the maximum number of trivalents and univalents observed in any pollen mother-cell being 3 and 7 respectively. The side view of metaphase I was studied from 30 pollen mother-cells. Various associations of trivalents, bivalents and univalents were seen, the number of trivalents ranging mostly from one to two and that of univalents from three to as many as eleven. Figs. 1*a* and *b* show one trivalent and five and eleven univalents respectively. The presence of trivalents and a large number of univalents led to a more unequal segregation of the chromosomes at anaphase I than what would have been expected if the quadrivalents were present in place of trivalents and univalents. Lagging chromosomes were also seen in anaphase I as well as in anaphase II (Fig. 2).

These meiotic irregularities resulted in the formation of sporads containing from 1–5 cells (Fig. 3). Some of the sporads formed a linear tetrad instead of the usual isobilateral type. A count of the unstainable pollen grains showed that these were present to the extent of about 80 per cent. Megasporogenesis has not been studied, but it may be presumed that this

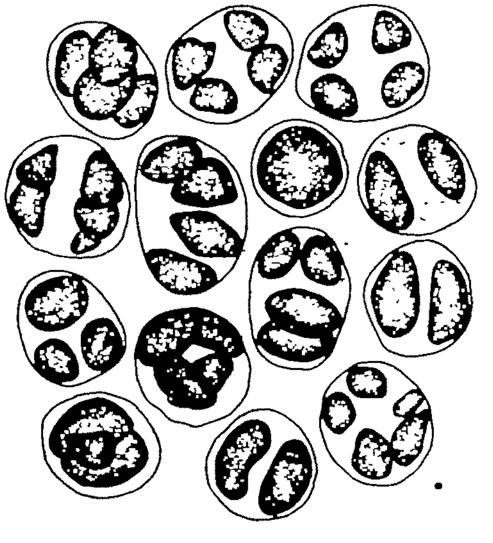


Fig. 3. One- to five-cell sporads in the *c*-tetraploid *Annona squamosa* L. × 275

kind of irregularity in meiosis may lead to a high percentage of aborted megaspores. Chances are therefore very remote for a normally developed megaspore to be fertilized by a balanced male gamete. Thus the failure of fruit formation may be primarily due to irregular meiosis which results in the abortion of as much as 80 per cent pollen grains and possibly the same percentage of megaspores.

The artificial induction of polyploidy always brings about sterility in the induced plants but the report of complete sterility in the colchicine-induced tetraploids is rare. The complete unproductivity of the c-tetraploid *A. squamosa* is quite contrary to the expectation as the experiments on induced polyploids in the past have shown that cross-pollinated diploid plants with a low number of small sized chromosomes (to which class *A. squamosa* belongs) respond favourably to the action of chromosome doubling[2].

I gratefully acknowledge the financial assistance received from the Food and Agriculture Council of Pakistan in carrying out this piece of research work. My thanks are also due to Dr. Majeed Ahmad, University of Dacca, for giving me facilities to work in the laboratory and the botanic garden where the two tetraploid plants are growing.

AHMAD SHAMSUL ISLAM

Department of Botany,
University of Sind,
Hyderabad (West Pakistan).

---

[1] Islam, A. S., *Curr. Sci.*, 22, 118 (1953).

[2] Elliott, F. C., "Plant Breeding and Cytogenetics", 158 (McGraw-Hill Book Co., New York, 1958).

Intracellular Configuration and Dedifferentiation in *Splachnum ampullaceum* (L.) Hedw.

IN studies on protonematal regeneration from gametophore leaves of *Splachnum ampullaceum* (L.) Hedw., it was found that isolation and not wounding is the most important factor in the realization of regenerative potentialities[1]. The removal of correlative inhibition by means of isolation initiates cellular dedifferentiation, followed generally by cellular redifferentiation. The present work was undertaken in order to investigate certain aspects of cellular dedifferentiation.

The plant material was grown under sterile conditions on Beijerinck's inorganic medium solidified with 1 per cent agar and was kept under continuous white light provided by fluorescent lamps. Cells of detached half-leaves were compared with those of half-leaves attached to a stem segment. Protonematal regeneration occurs readily from cells of the former while it does not occur from those of the latter[1].

Table 1 shows a comparison of nuclear size and chloroplast size and number between cells of attached and detached half-leaves. Measurements were made at selected time-intervals following the surgical treatment. Cells in the immediate neighbourhood of the wound surface are not included. These results show that nuclear size increases considerably in cells of the detached half-leaves during the first 24 hr. after isolation while remaining approximately constant in cells of the attached half-leaves. Similarly, chloroplast size decreases slightly and chloroplast number increases greatly in cells of detached half-leaves while remaining approximately unchanged in attached half-leaves. Since attached and detached half-leaves have about the same wound surface present, the recorded changes in the nuclei and chloroplasts are due not to wounding but to leaf isolation. Isolation, therefore, results apparently in greatly increased synthetic activity of the cells. Preliminary comparisons between cells of older detached half-leaves and those of younger ones indicate that these changes occur at considerably slower rates in the cells of the older leaf.

Table 1. NUCLEAR SIZE, CHLOROPLAST SIZE AND NUMBER IN CELLS OF ATTACHED AND DETACHED HALF-LEAVES

Hr. after treatment	Diameter of nucleus (mm. × 10^{-3})		Diameter of chloroplast (mm. × 10^{-3})		No. of chloroplasts	
	Attached	Detached	Attached	Detached	Attached	Detached
0	6·29	6·14	6·03	6·20	73	65
10	6·14	6·52	6·08	6·05	69	66
24	6·68	7·50	6·13	5·49	75	99
48	6·29	—	6·06	—	75	—
72	6·74	—	6·11	—	79	—

Fundamental changes in the relative position of the various cellular components in cells of detached half-leaves precluded observations on nuclear size and chloroplast size and number beyond 24 hr. after isolation. In a mature leaf cell the cytoplasm is limited to a thin layer along the cell wall surrounding a large vacuole. Under the present light conditions the chloroplasts are in peristrophe. The nucleus is in a peripheral position. While this pattern is maintained in cells of the attached half-leaf, there is a pronounced change in cells of the detached leaf. Within a few hours after isolation intravacuolar strand formation is observed, a primary cytoplasmic strand being formed first connecting the cytoplasm around the nucleus with the cytoplasm at the side opposite the nucleus across the vacuole (Fig. 1). Primary cytoplasmic strand formation is followed by the formation of other strands reaching a maximum

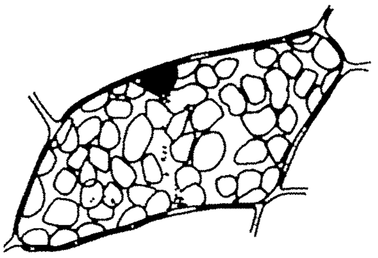


Fig. 1. Surface view of leaf cell 6 hr. after leaf isolation

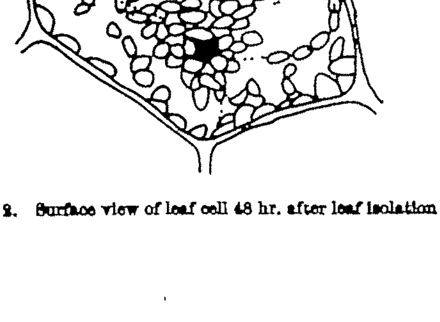


Fig. 2. Surface view of leaf cell 48 hr. after leaf isolation

between 24 and 48 hr. after isolation of the leaf. Intravacuolar strand formation is followed by the movement of the nucleus and the chloroplasts from a peripheral to a more central position in the cell. Hence the cytoplasmic strands facilitate a clustering of cytoplasm and chloroplasts around the nucleus, resulting in a typical systrophe or cluster formation (Fig. 2). Ultimately one cytoplasmic strand becomes the most prominent one, and cell wall formation is initiated along this strand. This strand represents, therefore, the phragmosome[1]. The remaining strands disappear gradually.

Strand formation leading to systrophe is, therefore, an important event in cellular dedifferentiation and results here simply from isolation. These results are in agreement with Heitz's[3] important observations on regeneration and his suggestion that wounding cannot be the important factor in the initiation of events leading to cellular regeneration. Sinnott and Bloch[2] have described cell division in vacuolate plant cells in normal plant development. Their illustrations show strand formation resulting in a more central position of the nucleus and cytoplasmic cluster formation around the nucleus. Thus in normal plant development enlarging yet still actively dividing cells undergo dedifferentiation accompanied by cytoplasmic cluster formation before each division. Hence changes in intracellular configuration which occur during dedifferentiation and which in the present instance are the result of isolation appear also to be a characteristic of normal plant development.

This work was supported by a grant from the National Research Council of Canada.

KRAFT E. VON MALTZAHN
MARY M. MACNUTT

Botanical Laboratories,
Dalhousie University,
Halifax, N.S.

---

[1] MacQuarrie, L. G., and Maltzahn, K. E. von, *Canad. J. Bot.*, 37, 121 (1959).

[2] Sinnott, E. W., and Bloch, R., *Amer. J. Bot.*, 28, 225 (1941).

[3] Heitz, E., *Z. Zellforsch.*, 2, 69 (1925).

ENTOMOLOGY

Prevention and Artificial Induction of the Imaginal Diapause in *Coccinella* *7-punctata* L.

By field observations, dissections and analyses of field samples it was discovered that the female diapause in *Coccinella 7-punctata* L. (Col.: Coccinellidae) is connected with a gonotrophic dissociation, which is not the case in male individuals. After the induction of diapause the adults of both sexes accumulate reserves (fats and glycogen); afterwards they stop feeding and migrate towards the winter quarters. During this prehibernation accumulative feeding-period, the females remain sexually immature. On the other hand, for males the maturation of gonads is not such a strain on energy reserves; both diapausing and active males rapidly reach maturity and only stop tissue activity in testicular follicles immediately before hibernation. At this period they have already accumulated sperm reserves in the seminal vesicles and encysted sperms in the testicular follicles. Already before hibernation they fertilize a part of the females, hibernating afterwards with sperm reserves in the spermatheca. In the spring the males renew their sexual activity long before the females. They fertilize females in the hibernating quarters. The ovaria mature later—only after feeding on the essential aphid food. During hibernation the fat reserves in both sexes are reduced to a half; the glycogen in males to one-fifth, in females to one-third.

A mixed population, consisting of monovoltine insects with the obligate diapause and of polyvoltine insects with the facultative diapause, obviously lives in Central Europe.

In order to reveal the mode of action of factors inducing the diapause we tried to prevent this phenomenon experimentally and, on the other hand, to induce it artificially.

By breeding the Coccinellidae under optimal conditions of a continual excess of food (aphid *Pergandeida medicaginis* Koch), long photoperiod (16–18 hr.) and a higher slightly alternating temperature (mean 25° C.; 22–28° C.) we succeeded in gradually preventing the diapause[1]. It is obvious that a gradual selective elimination of the monovoltine insects resulted. It is then possible to breed the ladybirds continuously. When any departure from the optimal culture conditions has arisen (especially from excess of food in cages with many individuals) a certain amount of diapausing ladybirds also developed in the next generations. This situation is very similar to that in *Leptinotarsa 10-lineata* Say. The possibility of interpreting this feature in the same way in both these insects arises from the results by De Wilde and Stegwee[2]: they found a marked decrease of the number of diapausing females in the cultures of single pairs of *L. 10-lineata*.

Experiments with polyvoltine Coccinellidae from artificial cultures showed that there is a correlation between the photoperiod and temperature in the induction of imaginal diapause, the photoperiod being the more significant factor[3]. The long photoperiod (16 or 19 hr.) appears to prevent the diapause even at a relatively low temperature (18° C.). The short photoperiod (8 or 12 hr.) induces the diapause. In a short photoperiod the induction of diapause is stimulated in addition by a low temperature; but inhibited by a high one.

The character of the artificially induced diapause was studied by comparative dissection and analysis. Dissection did not reveal any differences in the fat body and ovaria. Analysis showed that females with artificially induced diapause had the same glycogen reserve, and that the fat reserve was only one-fifth lower than in the naturally diapausing females. On the other hand, in experimental active females the fats were less than a half and glycogen just half the amount in the experimental diapausing females. On the basis of these results, the artificially induced diapause can be considered equivalent to the natural diapause.

I. HODEK

Entomological Institute,
Czechoslovak Academy of Sciences,
Prague.

J. ČERKASOV

Biological Faculty,
Charles University,
Prague.

---

[1] Hodek, I., and Čerkasov, J., *Ent. Exp. and App.* (in the press).

[2] De Wilde, J., and Stegwee, D., *Arch. néerl. zool.*, 13, 277 (1958).

[3] Hodek, I., and Čerkasov, J., *Ent. Exp. and App.* (in the press).

Immunity of Aphids to Insect Parasites

A STUDY has been made of the susceptibility to, or immunity from, parasitism which certain aphis exhibit towards the insect *Monoctonus paludum* Marshall (Hymenoptera, Braconidae). Starý[1], in a recent revision of the European species of *Monoctonus*, identifies *M. paludum* with *M. crepidis* Haliday, which has been recorded from various aphid hosts on plants related to lettuce. The present account is concerned only with the association between the parasite and aphids which occur on lettuce, and it has been found that although the parasite will readily oviposit into the five species of lettuce aphids which have been studied, successful development of the parasite can only occur in one of these species.

During oviposition the female parasite lays a single egg, with precision, into the fused thoracic ganglia of each aphid, and it has been shown[2] that the parasite will readily attack the following species of aphids occurring on lettuce: *Nasonovia ribis-nigri* (Mosley), *Macrosiphum euphorbiae* (Thos.), *Myzus persicae* (Sulz.), *Aulacorthum solani* (Kalt.), *Aulacorthum circumflexum* (Buckton).

However, of these five species of aphids only *N. ribis-nigri* supports successful development of the parasite's eggs and, in order to determine the reasons for failure of parasite development in the other species, sections and dissections of these aphids have been carried out at various time-intervals after attack.

A full report of this work will be given in a subsequent paper. The interesting facts which emerge at the present time are that segmentation of the parasite egg begins normally in all the aphids studied but that, in the species *Macrosiphum euphorbiae*, *Myzus persicae* and *Aulacorthum solani*, degenerative changes then occur which result in the shrinkage of the parasite tissues and their subsequent disappearance at a later stage.

In the species *Aulacorthum circumflexum*, however, a different form of immunity reaction occurs. This reaction is contrary to the contention of Flanders[3], who stated that cellular or phagocytic immunity does not occur in aphids because the number of blood cells is relatively few, for, in this species of aphid, the development of the parasite is arrested by the secretion, around it, of a capsule formed by certain of the host's blood cells. This capsule differs from the relatively thick capsules described by Salt[4-6] in a variety of different insect species as a result of artificial injection of eggs and larvæ of the parasite *Nemeritis* (Hym. Ichneumonidae) but resembles more the thin, brown capsules described by Schneider[7] in the syrphid *Epistrophe balteata* as a defence against the ichneumon *Diplazon*. The appearance of the capsule in *A. circumflexum* during its process of formation is shown in Fig. 1.

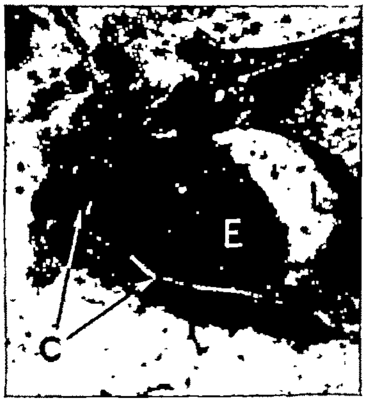


Fig. 1. Section through part of the thoracic nerve ganglia of *Aulacorthum circumflexum*, 24 hr. after attack by *Monoctonus paludum*. The capsule (*C*) is beginning to form around the parasite embryo (*E*), which lies in a space in the nervous tissue of the host

D. C. GRIFFITHS

Department of Zoology,
University of Durham,
King's College,
Newcastle upon Tyne.

---

[1] Starý, P., *Acta Soc. Ent. Cecho.*, 56 (3), 237 (1959).

[2] Griffiths, D. C., *Bull. Ent. Res.* (in the press).

[3] Flanders, S. E., *J. Econ. Ent.*, 27 (4), 861 (1934).

[4] Salt, G., *Proc. Roy. Soc.*, B, 144, 380 (1955).

[5] Salt, G., *Proc. Roy. Soc.*, B, 146, 93 (1956).

[6] Salt, G., *Proc. Roy. Soc.*, B, 147, 167 (1957).

[7] Schneider, F. von, *Vjschr. naturf. Ges. Zurich*, 95, 22 (1950).

Function of the Corpus Allatum in 'Dauer-pupa' of the Silkworm, *Bombyx mori*

RECENTLY it was reported[1] than when the corpora allata in the Eri silkworm pupæ were transplanted into artificially diapausing pupæ which were obtained by removing their brains at early pupal time, the diapausing pupæ were induced to emerge in 25 days after the implantation. On the contrary, when the corpora allata derived from the fourth, the fifth instar larvæ or moths of the same insect were transplanted into the artificially diapausing pupæ of the Eri silkworm, most operated animals entered the second pupal instar several weeks after transplantation. The same results were obtained in an experiment on the Cecropia silkworm[2]. When the corpora allata from the Cecropia moths were transplanted into the diapausing pupæ of *Hyalophora cecropia*, the operated insects became the second pupæ.

My co-worker and I have shown[3] that in *Bombyx mori* each corpus allatum removed from the fourth, the fifth instar larvæ, pupæ and moths respectively had a function which brought about imaginal development probably through the prothoracic gland in 'Dauer-pupæ'.

It is not known, however, whether the corpus allatum in 'Dauer-pupa' of the silkworm, *Bombyx mori*, has the same function in relation to imaginal differentiation as corpus allatum in normal larva, pupa and moth.

In this communication a function of the corpus allatum in the 'Dauer-pupa' of the silkworm, *Bombyx mori*, is revealed.

So-called 'Dauer-pupæ' of an F_1 hybrid between two varieties, *J*.122 and *C*.115, which had been obtained by extirpating the brain immediately after pupation and did not show any sign of imaginal differentiation for 45 days at 25° C. after pupation, were used as recipients of the corpora allata which were removed from 'Dauer-pupæ' of 45 days old as grafts.

As shown in Table 1, of 20 'Dauer-pupæ' grafted with 3 pairs of corpora allata derived from the 'Dauer-pupæ', 11 recipients became moths 17–24 days after operation, but the other 4 animals survived

Table 1. Effect of Implantation of Corpora Allata* of 'Dauer-pupa' on the Induction of Imaginal Development in 'Dauer-pupa'

No. of 'Dauer-pupa'† used as recipient	No. of individuals died	No. of moths emerged (days from implantation to emergence)	No. of undeveloped individuals‡
20	5	3 (17), 3 (18), 4 (19), 1 (24)	4

* Three pairs of corpora allata were implanted into each recipient pupa.

† So-called 'Dauer-pupae' which were obtained by depriving the pupae of their brains immediately after pupation, and kept at 25° C.

‡ The result obtained in 30 days at 25° C. after implantation of corpora allata.

having sustained the pupal form until 30 days after implantation.

Twenty control animals not implanted did not show any sign of imaginal differentiation under the same condition as the experimental animals for 100 days after pupation.

Accordingly, from this experiment, it is concluded that the corpus allatum in 'Dauer-pupa' has the same function as silkworm larva, pupa and moth.

In spite of the fact that each 'Dauer-pupa' had a pair of native corpora allata, they did not show any sign of imaginal differentiation for a comparatively long time. The reason why this phenomenon occurred is to be clarified.

MASATOSHI KOBAYASHI

Sericultural Experiment Station,
Suginami-ku, Tokyo.

[1] Ichikawa, M., and Nishiitsutsuji-Uwo, *J. Biol. Bull.*, 116, 88 (1959).

[2] Williams, C. M., *Biol. Bull.*, 116, 323 (1959).

[3] Kobayashi, M., and Yamashita, Y., *J. Sericul. Sci. Japan*, 28, 335 (1959).

BACTERIOLOGY

Recovery in the Presence of Chloramphenicol of *Escherichia coli* B(H) Irradiated with Ultra-violet Light

It has been observed in several instances that protein synthesis is involved in the effects produced in micro-organisms by irradiation with ultra-violet light, as has been shown by changes during post-irradiation incubation. Witkin[1] and Doudney and Haas[2] obtained results which suggested the importance of protein synthesis in the induction of mutation by *Salmonella typhimurium* and *Escherichia coli* respectively, Gillies and Alper[3] in the recovery of *Escherichia coli* B and Harold and Ziporin[4] in the synthesis of deoxyribonucleic acid in *Escherichia coli* B. We have found that the synthesis of ribonucleic acid in *Escherichia coli* B(H)—a strain obtained from Prof. Itaru Watanabe, Virus Laboratory, University of Kyoto, which has a specific property in bacteriophage infection[5]—is completely dependent on the protein synthesis which occurs during the first 30 min. of post-irradiation incubation[6]. We have therefore investigated the biological and chemical nature of protein produced in this way, and some of the results are described here.

When cells of *Escherichia coli* B(H) irradiated with ultra-violet light (surviving fraction 0·1 per cent) were incubated in *tris*-glucose medium[7] at 37° C., the number of colony-forming cells increased about tenfold after 1 hr. Chloramphenicol (40 µgm. per ml.), which was added to the culture at the beginning of incubation, suppressed this increase considerably for at least 2 hr. When, however, the drug was added after incubation for 30 min., recovery was not suppressed but rather stimulated as compared to the control culture which contained no chloramphenicol (Fig. 1).

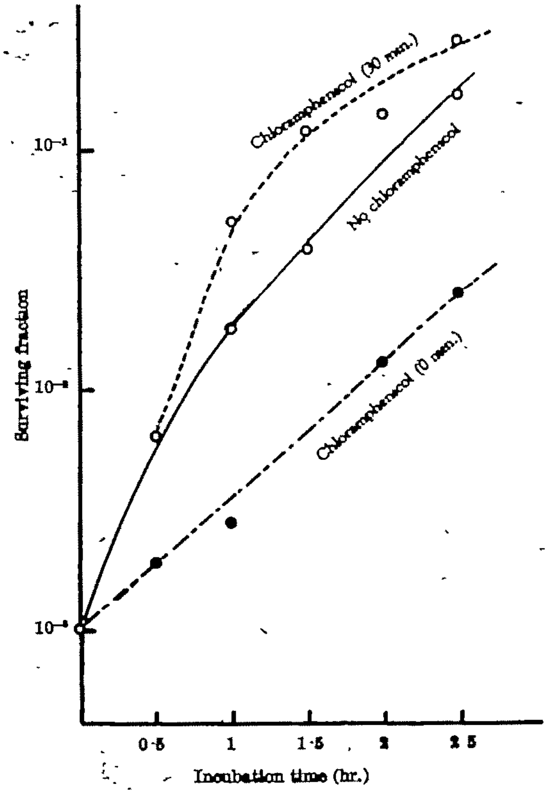


Fig. 1. Effects of chloramphenicol on the recovery of *Escherichia coli* B(H) irradiated with ultra-violet light. The numbers in parentheses show the time of addition of the drug

If protein synthesis during the first 30 min. of incubation is essential for the recovery of the irradiated cells, as suggested by the above experiment, the protein which has already been synthesized as a result of the first irradiation and the following incubation might also be useful during recovery after a second irradiation.

Cells of *Escherichia coli* B(H) in logarithmic growth phase were harvested and irradiated with ultra-violet light; this resulted in a decrease in the number of survivors to 0·2 per cent. These cells were incubated in *tris*-glucose medium for 60 min. at 37° C. in a reciprocal shaker. During incubation the number of survivors increased about tenfold. These cells were subjected to a second irradiation with the same dose as the first one. The decrease in the number of survivors was a little more than in the first irradiation. After this, the cells were incubated in *tris*-glucose medium with and without the addition of chloramphenicol (40 µgm. per ml.). At time intervals colony counts were made by plating on to nutrient agar plates. The results are shown in Fig. 2.

In contrast to the results shown in Fig. 1, when chloramphenicol is added at time zero, it does not suppress recovery but rather stimulates it. The effect is nearly the same as when the drug is added at 30 min. after the first irradiation (Fig. 1). These

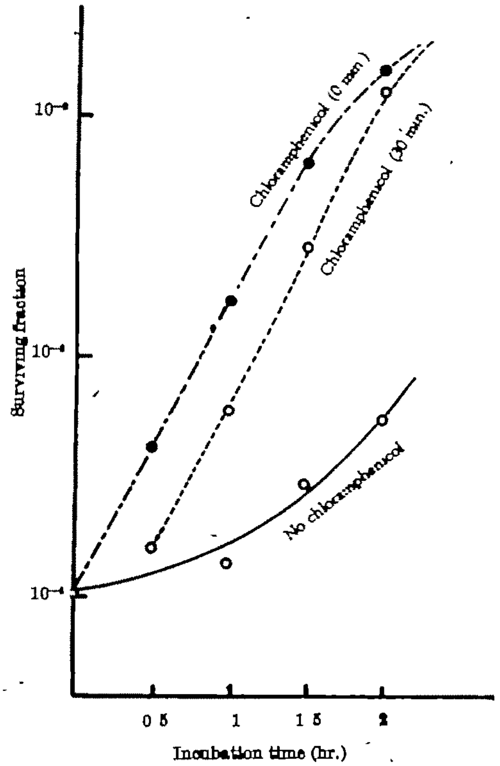


Fig. 2. Effects of chloramphenicol on the recovery of *Escherichia coli* B(H) after second irradiation with ultra-violet light. The numbers in parentheses show the time of addition of the drug

results can be explained if it is supposed that protein synthesis is not necessary for the recovery phenomenon after the second irradiation, because the essential protein has already been synthesized in the cells as a result of the first irradiation and the following incubation. That the observed increase in survival during the post-irradiation incubation is not due to cell division but to 'recovery' is indicated by the fact that it occurs even under severe conditions such as nitrogen or phosphorus starvation, addition of antibiotics, etc. Further, the rate and extent of recovery are usually very high; for example, about one hundredfold recovery is observed during incubation for 2 hr. The one-generation time for non-irradiated *E. coli* B(H) in *tris*-glucose medium is about 60 min.

Further work on the nature of this protein is now in progress in our laboratory.

KENSHI SUZUKI
YUKIKO IWAMA

Biochemistry Laboratory,
Chemistry Division,
National Institute of Radiological Sciences,
250, Kurosuna, Chiba City,
Japan.

[1] Witkin, E., *Cold Spring Harbor Symp., Quant. Biol.*, 21, 123 (1956).
[2] Doudney, C. O., and Haas, F. L., *Proc. U.S. Nat. Acad. Sci.*, 44, 390 (1958); 45, 709 (1959).
[3] Gillies, N. E., and Alper, T., *Nature*, 183, 237 (1959).
[4] Harold, F. M., and Ziporin, Z. Z., *Biochim. Biophys. Acta*, 29, 439 (1958).
[5] Watanabe, I., Proc. Int. Symp. Enzyme Chemistry, Tokyo and Kyoto, 1957, 418; *J. Gen. Physiol.*, 40, 521 (1957).
[6] Suzuki, K., Sawada, F., and Iwama, Y., *Biochim. Biophys. Acta*, 37, 369 (1960).
[7] Suzuki, K., and Ono, J., *Nature*, 183, 395 (1959).

Host-Range of *Lactobacillus* Bacteriophages

IN 1955, Kiuru and Tybeck[1] isolated a phage specific for 1 strain of *Lactobacillus lactis* and a phage working on 2 strains of *L. helveticus*. These phages were isolated from cultures used in the manufacture of Swiss cheese. In 1958, Meyers *et al.*[2] reported the isolation from saliva of phages active on 7 *Lactobacillus* species. The host-range of these phages was not indicated.

Using the enrichment technique of Adams[3], we have isolated 14 *Lactobacillus* phages. Media employed have been described by Briggs[4]; cultures were incubated at 37° C. in an atmosphere of carbon dioxide. Mixtures of sewage and groups of 12 *Lactobacilli* were used in different experiments. Aliquots were centrifuged daily for 10 days and the supernatant spotted on cultures of the 12 organisms. Lytic activity was never demonstrated before the second and usually only after the sixth day of incubation. The possibility that the phages originated from lysogenic members of the bacilli used for enrichment and not from sewage is being investigated. Phage was purified by picking off a single plaque into a young broth culture of the host organism. After overnight incubation, the culture was centrifuged to clarity and the supernatant titrated by the agar layer method[3] using 1 per cent tomato dextrose agar for the top layer. Repeated single-plaque isolations ensured the purity of the phage suspensions.

Lysates are identified by a number corresponding to that of the *Lactobacillus* host. Phages 300 and 316

Table 1. HOST-RANGE OF *Lactobacillus* PHAGES

Phages	*Lactobacillus* species						
	acidophilus (10)*	*salivarius* (7)	*casei* (11)	*casei* var *rhamnosus* (11)	*plantarum* (10)	*fermenti* (21)	*brevis* (10)
41	0 2	0 0	0 1	0 0	0 0	7 9	1 3
69	0 0	0 0	0 1	0 0	0 0	5 11	1 3
206	0 0	0 0	0 1	0 0	0 0	9 6	1 1
222	0 1	0 0	0 2	0 0	0 0	12 5	1 2
222a	0 0	0 0	0 1	0 0	0 0	12 6	3 1
276	0 1	0 0	0 1	0 0	0 0	6 10	1 1
300	0 0	0 0	2 4	1 4	1 0	1 0	0 0
315	0 0	0 0	2 0	0 0	0 0	10 0	1 1
316	0 0	0 0	4 3	0 8	0 3	0 1	0 0
356	0 0	0 0	1 2	1 0	1 1	0 0	0 0
514	0 0	0 0	0 0	0 0	0 0	3 7	0 2
517	0 0	0 0	0 1	0 0	0 0	7 10	1 1
535	0 0	0 0	0 0	0 0	0 0	11 8	1 3
547	0 0	0 0	0 1	0 0	0 0	4 11	1 3

* Figures in brackets indicate number of strains tested.
Upper figure, number of strains with phage efficiency of plating equal to host strain.
Lower figure, number of strains on which only a lytic drop area was demonstrated.

are active on corresponding *L. casei* hosts; phage 356 is active on a strain of *L. casei* var. *rhamnosus*, and the remaining 11 phages were isolated on different *L. fermenti* strains.

Strains of *Lactobacilli* used were type specimens kindly supplied by Dr. M. E. Sharpe, of the National Institute for Research in Dairying, Reading, England, as well as strains isolated here from human saliva and identified by the methods of Rogosa *et al.*[5].

The host-range of the phages was determined by: (*a*) titration of 0·1 ml. of undiluted, and 10^{-2} and 10^{-4} dilutions of lysates (10^{8} plaque forming particles/ml.) by the agar layer method[3]; (*b*) spotting a large drop of the corresponding dilution in the middle of the plate once the top-layer agar had set. Results are presented in Table 1. Discrepancies are observed in the host-range of phages as determined by the two methods. In many instances an area of lysis is present where the undiluted drop of lysate was placed, but the plaque-forming titre of the phage on the particular organism is zero. This effect, which is specific and reproducible, always extends the intra-species and often the inter-species host-range. Dilution of the lysate before application of the drop in these cases never results in the area of the drop containing individual plaques but simply in the disappearance of the entire lytic area. This phenomenon was investigated by mixing the phage and the organism at 37° C. After a period of 20 min. for adsorption, an aliquot was quickly centrifuged to clarity and the supernatant titrated on the host strain for unadsorbed phage. Simultaneously, another aliquot was titrated for viable bacteria and unadsorbed phage plus infective centres on both the organism under investigation and the host strain. All titrations were completed within 30 min. after mixing. Results of a typical experiment are presented in Table 2. Abortive infection with killing of the organism provides an adequate explanation for the phenomenon. A similar phenomenon has been encountered with *Salmonella* and *Staphylococcus* phages[6], and in this laboratory with *Proteus* phages.

Table 2. INVESTIGATION OF PHAGE 222 WHICH PRODUCES A DROP AREA OF LYSIS ON *L. casei* 316 WITHOUT INDIVIDUAL PLAQUE FORMATION. ADSORPTION 20 MIN. AT 37° C.

Initial concentration *L. casei* 316	$7·0 \times 10^{8}$/ml.
Initial concentration of phage 222	$4·5 \times 10^{8}$/ml.
Multiplicity of infection	0·64
Free phage after adsorption	$5·8 \times 10^{6}$/ml.
Phage adsorbed (per cent)	98·7
Surviving bacteria	$3·6 \times 10^{8}$/ml.
Bacteria killed by phage infection (per cent)	48·6
Unadsorbed phage + infective centres on *L. casei* 316	0
Unadsorbed phage + infective centres on host *L. fermenti* 222	$1·0 \times 10^{7}$/ml.
Infective centres on *L. fermenti* 222	$4·2 \times 10^{6}$/ml.
Killed *L. casei* 316 not yielding progeny phage (per cent)	98·8

Results obtained by both methods of phage-typing serve to confirm some of the serological relationships encountered by Sharpe[7] and Sharpe and Wheater[8]. Thus *L. casei* phages 300 and 316 and *L. casei* var. *rhamnosus* phage 356 all act on different strains of *L. casei*, *L. casei* var. *rhamnosus* and *L. plantarum*. The former two phages also act on various *L. fermenti* strains. The serological relationship which was detected between *L. fermenti*, *L. casei* and *L. casei* var. *rhamnosus* strains may be mirrored in the fact that many of the *L. fermenti* phages also act on *L. casei* strains. Davis[9] includes *L. lactis* in his *L. acidophilus* group and Sharpe[7] found *L. brevis* and *L. lactis* to share a major antigenic component. It is thus of some interest to note that three *L. fermenti* phages acting on *L. brevis* strains also produce abortive infections in four homofermentative *L. acidophilus* strains. While Sharpe[7] has not indicated any serological relationship between the heterofermentative species *L. fermenti* and *L. brevis*, many phages isolated on the former lyse cultures of the latter.

It is too early to decide whether the extended host-range obtained for many phages by employing abortive infection will be desirable when a complete phage-typing scheme, comparable both in elegance and utility to those in use for *Salmonellas* and *Staphylococci*, is evolved for *Lactobacilli*.

This work is submitted with the permission of Prof. C. L. de Jager, honorary director of the Nutrition and Dental Health Research Group of the South African Council for Scientific and Industrial Research.

J. N. Coetzee
H. C. de Klerk
T. G. Sacks

Department of Microbiology,
University of Pretoria,
Pretoria.

---

[1] Kiuru, V. J. T., and Tybeck, E., *Suom. Kemistilehti*, B, 28, 57 (1955).
[2] Meyers, C. E., Walter, R. L., and Green, L. B., *J. Dental Res.*, 37, 175 (1958).
[3] Adams, M. H., "Methods in Medical Research", 2 (Year Book Publishers, Inc., Chicago, 1950).
[4] Briggs, M., *J. Gen. Microbiol.*, 9, 234 (1953).
[5] Rogosa, M., Wiseman, R. F., Mitchell, J. A., Disraely, M. N., and Beaman, A. J., *J. Bact.*, 65, 681 (1953).
[6] Anderson, E. S., and Williams, R. E. O., *J. Clin. Path.*, 9, 94 (1956).
[7] Sharpe, M. E., *J. Gen. Microbiol.*, 12, 107 (1955).
[8] Sharpe, M. E., and Wheater, D. M., *J. Gen. Microbiol.*, 16, 676 (1957).
[9] Davis, G. H. G., *J. Gen. Microbiol.*, 13, 481 (1955).

Association of Pigment with the Cell Envelope of *Serratia marcescens* (*Chromobacterium prodigiosum*)

THE characteristic red pigment of the bacterium, *Serratia marcescens*, is located within the cell. Recently[1] evidence has been presented demonstrating that disruption of the bacterial cell releases pigment that is bound to particles. However, the origin and location within the cell of the particles and associated pigment were not established. The present communication presents evidence that the particulate, pigmented material is associated with the cell envelope of the micro-organism.

The 'Nima' strain of *S. marcescens* was grown at 27° C. for 18 hr. on casein hydrolysate–yeast extract–agar medium[2]. The pigmented organisms were harvested, washed several times in distilled water, and then treated for 20 min. in a Raytheon model *DF* 101 sonic oscillator. Whole cells and large particles were removed from the treated material by centrifugation at 4,000 r.p.m. for 10 min. The supernate was centrifuged at 10,000 r.p.m. for 20 min. to collect cell envelope material. After this treatment both the sediment and supernate remained pigmented. An attempt was made to clarify the supernatant material by centrifugation at 40,000 r.p.m. for 2 hr. The slight amount of pigment remaining in the supernate following this procedure was precipitated by acidifying the fraction to pH 5·0 with 1 *N* hydrochloric acid. This treatment produced a flocculent, light red precipitate and a colourless supernate.

To study the possible association of pigment with cell envelope material, the acetylhexosamine and pigment content of the various sediments and the acid precipitate was measured. The preparations were lyophilized and 25-mgm. of the dried material utilized for the analyses. For hexosamine determinations, the precipitates were treated with lysozyme (400 μgm./mgm. dry material) at 37° C. for 30 min. Acetylhexosamine then was estimated by the Elson and Morgan procedure[3]. Pigment was extracted from the dried preparations by a modification of the alkaline method of Hubbard and Rimington[4], and the pigment concentration of the extract measured in a Klett–Sumerson colorimeter employing the number 42 filter. The same treatments also were applied to dried, whole-cell preparations.

Table 1 presents the results of these experiments. It is readily seen that the hexosamine and pigment values parallel each other. When the hexosamine content is low, so is the amount of pigment, and vice versa. The greatest values are obtained in the 10,000 r.p.m. sediment. Lysozyme treatment of whole cells released some hexosamine, but the amount was almost doubled in the 10,000 r.p.m. material. Similar experiments carried out with colourless cells grown at 38° C. also demonstrated that the greatest concentration of hexosamine was present in the 10,000 r.p.m. sediment. Electron microscopy of the 10,000 r.p.m. fraction showed that the material consisted of many cell envelopes and unidentifiable cell debris with only a very occasional whole cell.

Table 1

Preparation	Pigment	Acetylhexosamine
Whole cells	35	5·11
4,000 r.p.m. sediment	73	6·79
10,000 r.p.m. sediment	151	9·04
40,000 r.p.m. sediment	58	5·71
Acid precipitate	20	0·56

Pigment concentration is expressed as Klett units; hexosamine, as μgm./mgm. dry material.

The results suggest that hexosamine and pigment are present in the same cellular structure. This structure is released by rupture of the cell, and can be collected in greatest quantity in the 10,000 r.p.m. sediment. The cell envelope is such a structure. It has been repeatedly established that the cell envelope contains acetylhexosamine, which can be released by lysozyme treatment[5,6]. The fact that the cell fraction containing the greatest concentration of acetylhexosamine also contains the most pigment suggests strongly the association of the two substances with the cell envelope. The electron microscopic pictures support this conclusion. Additional experiments in which cell envelopes were prepared by the procedures of Salton and Horne[7] and Kandler *et al.*[8] have confirmed that the pigment is associated with cell envelope material. Spectroscopic examination of the 10,000 r.p.m. sediment and cell envelope preparations demonstrated the absence of nucleic acid or other material absorbing at 260 mμ. As pointed out by Work[9], lack of these substances is characteristic of purified cell envelopes.

Few investigations have been carried out to determine the intracellular location of bacterial pigments. Salton[10] has described the pigment of *Rhodospirillum rubrum* as being in the cell wall; but Hickman and Frenkel[11] doubt this observation. The latter investigators suggest that the observation was based upon an incomplete removal of protoplasmic constituents from cell wall fragments. Recently, Mathews and Sistrom[12] have localized the carotenoid pigment of *Sarcina lutea* in the cell or plasma membrane which, together with the cell wall, forms the cell envelope. Their evidence was based on visual and spectrophotometric examination of purified cell-wall material, upon lysozyme preparations of whole cells, and on the enzyme content of disrupted cell fractions. From the results we have presented, we cannot determine whether the pigment is located in the plasma membrane or wall portion of the cell envelope. However, the fact that lysozyme treatment of whole cells results in the release of a clear supernate containing hexosamine suggests that the pigment might be located in the cell or plasma membrane.

This investigation was supported by research grant E-670 from the National Institutes of Health, U.S. Public Health Service, and a post-doctorate fellowship in the Department of Microbiology (M. P.). We wish to thank Dr. J. C. Hampton of the Department of Anatomy for assistance in the electron microscopy.

MIRA PURKAYASTHA
R. P. WILLIAMS

Department of Microbiology,
Baylor University College of Medicine,
Houston 25, Texas.

[1] Taylor, W. W., and Williams, R. P., *Experientia*, 15, 143 (1959).

[2] Williams, R. P., Green, J. A., and Rappoport, D. A., *J. Bact.*, 71, 115 (1956).

[3] Elson, L. A., and Morgan, W. T. J., *Biochem. J.*, 27, 1824 (1933).

[4] Hubbard, R., and Rimington, C., *Biochem. J.*, 46, 220 (1950).

[5] Zilliken, F., *Fed. Proc.*, 18, 966 (1959).

[6] Sharp, J. T., *New York Acad. Sci.*, 79, 344 (1960).

[7] Salton, M. R. J., and Horne, R. W., *Biochim. Biophys. Acta*, 7, 177 (1951).

[8] Kandler, O., Hund, A., and Zehender, C., *Nature*, 181, 572 (1958).

[9] Work, E., *Nature*, 179, 841 (1957).

[10] Salton, M. R. J., "Bacterial Anatomy", 88 (Cambridge Univ. Press, 1956).

[11] Hickman, D. D., and Frenkel, A. W., *J. Biophys. Biochem. Cytol.*, 6, 277 (1959).

[12] Mathews, M. M., and Sistrom, W. R., *J. Bacteriol.*, 78, 778 (1959).

MISCELLANY

Expression of Concentrations of Solutions

It is becoming customary, in the descriptions of histochemical methods, to express the concentration of solutions in terms not of percentage but of molarity. Thus, in one method, it is stated that a 0·004-*M* solution of lead nitrate should be used. Having eventually found a list of atomic weights and the formula of lead nitrate (it has, according to two textbooks, no water of crystallization) and then double-checked my addition, I discovered that in 100 ml. of distilled water I should dissolve 107·7 mgm. of lead nitrate.

But did the author use, as I obviously now do, a 0·1 per cent (0·003723 *M*) solution? If so, the term 0·004 *M* is inaccurate, time wasting and an example of scientific snobbery.

Surely it would prevent wasted effort and occasional inaccuracies if concentrations of solutions were expressed in terms not merely of molarity but also of percentage, particularly where the calculation of the percentage may prove troublesome.

E. H. LEACH

University Laboratory of Physiology,
Oxford.

FORTHCOMING EVENTS

Monday, July 25

Royal Society (at the Royal Institution, 21 Albemarle Street, London, W.1), at 10.15 a.m.—Sir Arnold Hall, F.R.S.: "Trends in Aeronautical Science and Engineering" (Tercentenary Lecture).

Institute of Metals (at the Royal Institution, Albemarle Street, London, W.1), at 6.30 p.m.—Prof. Linus Pauling (California Institute of Technology): "The Structure of Metals and Intermetallic Compounds".

Wednesday, July 27

Society for Endocrinology (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 5.15 p.m.—Prof. Bernardo A. Houssay (Buenos Aires): "An Argentine Trail in Hypophyseal Research" (Annual Lecture).

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer, Grade B, to teach either Mathematics or Physics to G.C.E. Advanced Level Standard—The Principal, Peel Park Technical College, Salford 5 (July 27).

Senior Technologist or Technologist (with H.N.C. or O.N.C. or appropriate City and Guilds qualification in telecommunications, and good experience on the maintenance and construction of electronic equipment and instrument maintenance) at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (July 29).

Assistant, Grade "B" (preferably with teaching and/or industrial experience) in the Chemistry Department—The Principal, Wigan and District Mining and Technical College, Wigan (July 30).

Assistant Lecturer (with a degree in chemistry, biochemistry or agricultural chemistry, preferably with honours) in the Agricultural Chemistry Department—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (July 30).

Lecturer (graduate in science, preferably in physics, with suitable teaching experience) in Education—The Registrar, King's College (University of Durham), Newcastle upon Tyne 1 (July 30).

Lecturer (preferably with an interest in, and practical experience of, hydraulics or soil mechanics) in Civil Engineering—The Registrar, The Manchester College of Science and Technology, Manchester 1 (July 30).

Lecturer (veterinary surgeon) in the Department of Veterinary Pathology, Royal (Dick) School of Veterinary Studies—The Secretary, The University, Edinburgh (July 30).

Research Assistant (with a first- or upper second-class honours degree) in the Department of Agriculture (Crop Husbandry), to carry out sod-seeding experiments—The Registrar, University College of Wales, Aberystwyth (July 31).

Scientific Officer (with at least a good honours degree in geography with subsidiary zoology and/or botany, or in zoology with subsidiary geography) in the Geographical Section, for research in the biogeography of economically important locusts and grasshoppers—The Director, Anti-Locust Research Centre, 1 Princes Gate, Kensington, London, S.W.7 (July 31).

Assistant Lecturer or Lecturer (with qualifications in mining geology or mineralogy) in the Department of Geology—The Registrar, The University, Liverpool (July 31).

Assistant Lecturer, Grade B, in Biology or Chemistry—The Principal, Peel Park Technical College, Salford 5 (August 2).

Assistant Lecturer or Lecturer in Applied Mathematics—The Registrar, The University, Sheffield (August 3).

Assistant Biochemist (with a degree or equivalent qualification in chemistry, experience in, or wishing to take up, clinical biochemistry)—The Secretary, Welsh National School of Medicine (University of Wales), 34 Newport Road, Cardiff (August 6).

Lecturer in Mechanical Engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (August 8).

Senior Lecturer in the Department of Studies in Psychological Medicine—The Registrar, The University, Liverpool (August 13).

Lecturer in Experimental Pharmacology—The Secretary of University Court, The University, Glasgow (August 15).

Lecturers in Botany, Chemistry, Education, Geology, Mathematics, Physics and Zoology at the University College of Townsville, University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 15).

Research Fellow (with at least a good honours degree, and preferably qualifications in both physics and geology) at the University College of Rhodesia and Nyasaland, for a research project in paleomagnetism—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 16).

Senior Lecturer or Lecturer in Mathematics, and a Senior Lecturer or Lecturer in Philosophy at Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 20).

Assistant Lecturer or Lecturer (with special qualifications in either pure mathematics or applied mathematics) in Mathematics—The Registrar (Room 22, O.R.B.), The University, Reading (August 22).

Lecturer or Assistant Lecturer (medically qualified or otherwise) in the Department of Physiology—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (August 22).

Lecturer in Chemistry at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 26).

Senior Lecturer in Biochemistry at the University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (August 29).

Chair of Education—The Registrar, University College of Wales, Aberystwyth (August 31).

Chair of Philosophy in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, August 31).

Lecturer (interested in morphology and systematic botany) in Botany—The Registrar, The University, Hull (August 31).

Senior Lecturer in the Department of Mathematics, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, August 31).

Senior Library Assistant (graduate with library experience) in charge of the Current Periodical Room of the University Library—The Librarian, The Main Library, The University, Birmingham 15 (August 31).

Lecturer (preferably candidate who is a general botanist with research experience in more than one branch of botany) in Botany at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 2).

Reader in Chemical Crystallography at Imperial College—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 14).

Chair of Medicine at Makerere College, The University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 15).

Chair of Psychology at Birkbeck College—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 16).

Administrative Assistant (with a language qualification) in the Section of International Relations, principally for information bureau duties—The Assistant Secretary, The Royal Society, Burlington House, Piccadilly, London, W.1.

Assistant Lecturer or Lecturer (preferably with an interest in climatology) in Geography at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Biochemist, for an interesting research project—The Group Secretary, Rochdale and District Hospital Management Committee, Birch Hill Hospital, Rochdale, Lancs.

Biochemist (preferably with some experience of techniques applicable to muscle or nucleic acids), to assist in a study of the location of ribonucleic acid in muscle by autoradiography—Mr. D. K. Hill, Postgraduate Medical School of London, Ducane Road, London, W.12.

Biologist (preferably 25–35, with experience and interest in lower organisms, particularly protozoa) for collaboration in a programme of research on fine structure, function and morphogenesis—The Director, Medical Research Council Biophysics Research Unit, King's College, Strand, London, W.C.2.

Computer, to work in a small team concerned with interesting research on thermonuclear processes—Prof. D. Gabor, F.R.S., Electrical Engineering Department, Imperial College of Science and Technology, London, S.W.7.

D.S.I.R. Research Student (honours graduate in physics or electrical engineering) in the Department of Electronics, for research into problems associated with microwave generation, electrical noise, electron spin resonance and nuclear magnetic resonance—The Professor of Electronics, The University, Southampton.

Lecturer or Assistant Lecturer in Chemistry—The Registrar, Massey Agricultural College (University of New Zealand), Palmerston North, New Zealand.

Lecturer or Senior Lecturer (with a university degree in medicine, and preferably with an interest in applied pharmacology and therapeutics) in Pharmacology—The Secretary, Charing Cross Hospital Medical School, 62–65 Chandos Place, London, W.C.2.

Lecturer (registered medical practitioner, with some experience of general pathology) in the Department of Neuropathology—Prof. W. Blackwood, Institute of Neurology, The National Hospital, Queen Square, London, W.C.1.

Research Assistant (with a first degree of the University of London and an interest in ultrasonics and electronics) in Ultrasonic Physics—The Principal, Kingston Technical College, Fassett Road, Kingston-upon-Thames, Surrey.

Research Biochemist (with good training in physical chemistry and preferably a knowledge of food technology of fruits and vegetables)—Dept. 4240, National Employment Service of Canada, 61 Green Street, London, W.1.

Research Fellow (preferably with experience in crystal or solid-state physics or in the physics of aerosols) in Experimental Physics, to work in a group investigating the basic physics of cloud and rain-forming processes—Dr. B. J. Mason, Huxley Building, Imperial College of Science and Technology, Exhibition Road, London, S.W.7.

Scientific Director (with three years post-doctoral research experience in nuclear reactions) of the Nuclear Physics Laboratory of the Institute of Physics and Mathematics, to lead research around an operating 800-kV. Cockcroft–Walton accelerator and to lecture on experimental and theoretical nuclear physics at the School of Physics at the University of Chile—Director, Instituto de Física y Matemáticas, Universidad de Chile, Casilla 2777, Santiago, Chile.

Tutorial Assistant (man or woman graduate) in Mathematics—The Registrar, The University, Leicester.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Mathematics, Education and Industry: a Record of a Conference of Teachers, Research Scientists, and Industrialists, held at the University of Liverpool, April 1959. Pp. 156. (London: *Technology*, The Times Publishing Company, Ltd., 1960.) 7s. 6d. [294

Association of British Pharmaceutical Industry. Annual Report and Year Book, 1959–60. Pp. 47. (London: Association of British Pharmaceutical Industry, 1960.) [294

Ciba (A.R.L.), Ltd. Technical Notes, No. 208 (April 1960): Araldite in Napier De-Icing Equipment. Pp. 8. (Duxford: Ciba (A.R.L.), Ltd., 1960.) [294

Flora of Tropical East Africa. Edited by C. E. Hubbard and E. Milne-Redhead. Loganiaceae. By E. A. Bruce and J. Lewis. Pp. 47. (London: Crown Agents for Oversea Governments and Administrations, 1960.) 4s. [294

Biochemical Society. Careers in Biochemistry. Pp. 8. (London: Biochemical Society, 1960. Obtainable from Mrs. R. H. Sherriff, 133–135 Oxford Street, London, W.1.) 8d. [294

Department of Scientific and Industrial Research: Road Research Laboratory. Road Research Technical Paper No. 47: Road Junctions in Rural Areas. By Dr. G. Charlesworth and J. C. Tanner. Pp. iv+9. (London: H.M. Stationery Office, 1960.) 1s. 3d. net. [294

Wet Air—Dry Air. (Humidryer for the removal of unwanted moisture.) Pp. 12. (Aldridge, Walsall: Burnett and Lewis, Ltd., 1960.) [294

Ministry of Agriculture, Fisheries and Food: Department of Agriculture for Scotland. Return of Proceedings under the Diseases of Animals Act, 1950, for the year 1959. Pp. 8. (London: H.M. Stationery Office, 1960.) 6d. net. [294

Sondes Place Research Institute. Pp. 24. (Dorking: Sondes Place Research Institute, 1960.) [294

Sir John Cass College. Report, Session 1958–59. Pp. 26. (London: Sir John Cass College, 1960.) [294

Report of the Committee on Training in Health and Safety to the Authority Committee on Health Safety, United Kingdom Atomic Energy Authority, February 1960. Pp. vi+95. (London: H.M. Stationery Office, 1960.) 5s. 6d. net. [294

The British Institution of Radio Engineers. Report on the Education and Training of the Professional Radio and Electronics Engineer. Pp. ii+31. (London: British Institution of Radio Engineers, 1960.) [294

The Kent Incorporated Society for Promoting Experiments in Horticulture. East Malling Research Station—Annual Report, 1959 (1st October 1958 to 30th September 1959). Forty-seventh Year. Pp. xxvi+144. (East Malling, near Maidstone: East Malling Research Station, 1960.) 17s. 6d.; 2.50 dollars. [35

British Broadcasting Corporation. B.B.C. Engineering Monograph No. 29. A Summary of the Present Position of Stereophonic Broadcasting. By D. E. L. Shorter and Dr. J. G. Phillips. Pp. 27. (London: British Broadcasting Corporation, 1960.) 5s. [35

Ministry of Power. Safety in Mines Research Establishment. S.M.R.E. Bibliography, 1960. Compiled by E. B. Smith. Second edition. Pp. viii+177. (Sheffield: Ministry of Power, Safety in Mines Research Establishment, 1960.) 17s. 6d. [35

University of Reading. Museum of English Rural Life—Report, 1959. Pp. 22 (5 plates). (Reading: Museum of English Rural Life, The University, 1960.) 1s. [35

Institute of Seaweed Research. Annual Report for 1959. Pp. 20. (Inveresk, Midlothian: Institute of Seaweed Research, 1960.) [35

City and Guilds of London Institute. Annual Report, 1958–59—Summary. Pp. 4. (London: City and Guilds of London Institute, 1960.) [35

University of Cambridge: Department of Engineering. Report of the Head of the Department for the year 1958–59. Pp. 11. (Cambridge: The University, 1960.) [35

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 54: The Breeding and Rearing of Calves. Pp. 15. (Belfast: Ministry of Agriculture, 1960.) [45

Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act, 1954, for 1959. North Eastern Division. By H. J. Perrins. Pp. iii+41+6 plates. (London: H.M. Stationery Office, 1960.) 3s. 6d. net. [45

British Medical Bulletin, Vol. 16, No. 2 (May 1960): Symposium on The Thyroid Gland. Pp. 89–174. (London: The British Council, 1960.) 20s. [45

The British Iron and Steel Research Association. Annual Report, 1959. Pp. 156. (London: The British Iron and Steel Research Association, 1960.) [45

The A.B.C. of 'Electronic Brains.' By Leon Bagrit. (A Series of six talks broadcast in the External Services of the B.B.C.) Pp. 46. (London: British Broadcasting Corporation, 1960.) 1s. 6d. [45

Arthur D. Little Research Institute. Annual Report, 1959. Pp. 39. (Inveresk, Midlothian: Arthur D. Little Research Institute, 1960.) [45

University of Nottingham. Report of the School of Agriculture, 1959. Pp. 91. (Sutton Bonington, Loughborough: University of Nottingham School of Agriculture, 1960.) [45

Other Countries

Mitteilungen des Deutschen Wetterdienstes. Nr. 20 (Band 3) Die Fachsitzung "Strahlstromung und Tropopause" in Offenbach a.M. am 7. und 8 Oktober 1959. Pp. 57. 6.10 D.M. Nr. 21. (Band 3): Über Luftspiegelungen der Alpen, gesehen vom Bayerischen Wald. Von Ernst Trautmann. Pp. 30. (Offenbach a.M.: Deutschen Wetterdienstes, 1960.) [35

Board of Grain Commissioners for Canada. Grain Research Laboratory—1959 Report. Pp. vi+84. (Ottawa: Queen's Printer, 1960.) [35

Success in Northern Rhodesia. Pp. 28. (Lusaka: Information Department, 1960.) [35

Organization for European Economic Co-operation. 4th Report on Agricultural Policies in Europe and North America. Vol. 1: Further Problems in Agricultural Policy. (Problems in the Cereal Sector; the Meat Sector. Price Support Systems. Structural Problems. Low Income Farms.) Pp. 352. 18 NF.; 27s. 6d.; 4.50 dollars; 18 Swiss francs; 15.50 D.M. Vol. 2: Problems in Dairy Policy. (Longer Term Problems of the Dairy Sector. Possibilities for Co-ordinating National Dairy Policies.) Pp. 463. 20 NF.; 30s.; 5 dollars; 20 Swiss francs; 17 D.M. (Paris: Organization for European Economic Co-operation; London: H.M. Stationery Office, 1960.) [35

South African Council for Scientific and Industrial Research. Register of Current Scientific Research at South African Universities, 1959. Edited by D. Ryle Masson. Pp. vii+118. (Pretoria: South African Council for Scientific and Industrial Research, 1960.) [35

National Science Foundation. Science and Engineering in American Industry—Report on a 1956 Survey. Pp. ix+117. (NSF 59–50.) (Washington, D.C.: Government Printing Office, 1960.) 70 cents. [35

United States Department of the Interior: Fish and Wildlife Service. Fishery Bulletin No. 171: Determining Age of Atlantic Menhaden from their Scales. By Fred C. June and Charles M. Roithmayr. Pp. iv+323–342. (Washington, D.C.: Government Printing Office, 1960.) 20 cents. [45

The American Philosophical Society. Year Book 1959. Pp. 779. (Philadelphia: American Philosophical Society, 1960.) [45

Smithsonian Miscellaneous Collections. Vol. 139, No. 9: A Long-Range Forecast of United States Precipitation. By C. G. Abbot. Pp. i+78. (Publication No. 4390.) (Washington, D.C.: Smithsonian Institution, 1960.) [45

U.S. Department of Defense. Department of the Navy: Naval Research Advisory Committee. Basic Research in the Navy: Report to the Secretary of the Navy by the Naval Research Advisory Committee. (Report prepared by Arthur D. Little, Inc.) Vol. 1: Pp. xi+69. Vol. 2: Pp. i+102. (Washington, D.C.: Department of the Navy, 1959.) [45

Yale Peabody Museum of Natural History. Postilla. No. 41 (September 15, 1959): Birds from Djailolo, Halmahera. By S. Dillon Ripley. Pp. 8. No. 42 (December 20, 1959): Character Displacement in Indian Nuthatches (*Sitta*). By S. Dillon Ripley. Pp. 11. No. 43 (January 4, 1960): Two new Birds from Angola. By S. Dillon Ripley. Pp. 3. No. 45 (February 15, 1960): Notes on the Embryology and Evolution of the Megapodes (Aves: Galliformes). By George A. Clark, Jr. Pp. 7. (New Haven, Conn.: Yale Peabody Museum of Natural History, 1959 and 1960.) [45

University of California Publications in Botany. Vol. 32, No. 1: Taxonomic Studies in the *Phacelia Magellanica* Polyploid Complex, with special reference to the California Members. By Lawrence R. Heckard. Pp. 1–126+plates 1–14. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1960.) 2.50 dollars. [45

University of California Publications in Geological Sciences. Vol. 36, No. 3: Ohlson Ranch Formation, Pliocene, Northwestern Sonoma County, California. By Charles G. Higgins. Pp. 199–232+plates 18–20. Vol. 36, No. 4: Paleontology and Correlation of the Ohlson Ranch Formation. By Joseph H. Peck, Jr. Pp. 233–242+plate 21. 1.50 dollars (Nos. 3 and 4). (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1960.) [45

World Health Organization. Technical Report Series. No. 187: Expert Committee on Biological Standardization—Thirteenth Report. Pp. 49. 2 Swiss francs; 3s. 6d.; 0.60 dollars. No. 191: Insecticide Resistance and Vector Control—Tenth Report of the Expert Committee on Insecticides. Pp. 98. 3 Swiss francs; 5s. 1d.; 1 dollar. (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) [45

Engineering Outlook, Vol. 1, No. 1 (March 1960). Pp. 4. (Urbana, Ill.: Engineering Publications Office, Engineering Experiment Station, University of Illinois, 1960.) [55

The Imperial College of Tropical Agriculture. Report of the Governing Body and the Principal's Report for 1958–59. Pp. 68. (St. Augustine, Trinidad, and London: Imperial College of Tropical Agriculture, 1960.) [65

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Précis de Phytotechnie des Principales Cultures Industrielles. Par T. Marynen. Pp. 112. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1960.) 100 francs. [65

XII° International Symposium over Fytofarmacie en Fytiatrie, Rijkslandbouwhogeschool, Gent, 26 April 1960. (12th International Symposium on Crop Protection.) Pp. i+184. (Gent: Rijkslandbouwhogeschool, 1960.) [65

Bibliographien des Deutschen Wetterdienstes, Nr. 10: Agrarmeteorologische Bibliographie, 1958. Bearbeitet von Max Schneider. Pp. xiii+235. (Offenbach a.M.: Selbstverlag des Deutschen Wetterdienstes, 1960.) [65

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

SCIENTIST AND TECHNOLOGIST IN ADMINISTRATION

A DEPARTMENT of Science and Technology in the Federal Government of the United States, headed by a cabinet secretary and responsible for a considerable range of scientific and technological activities, has been proposed in several recent Senate bills and recommended in varying forms by administrators of such scientific standing as Dr. L. V. Berkner and Dr. W. R. Brode. Early in January 1960, these proposals were discussed by a group which included Dr. Berkner, Prof. A. H. Dupre, Mr. D. K. Price, Mr. Dael Wolfle and three others. The group agreed in advance to concentrate on the reasons for considering such a department, the alternative forms it might take, and their probable consequences for science and engineering, and for the ability of the Federal Government to carry out its responsibilities in these fields.

The report based on these discussions which Mr. Wolfle was asked to prepare and which has been published in *Science* of May 13 (131, 1407; 1960) has thus an interest for scientists and technologists generally and not simply for those concerned with the relations between government and science in the United States. It makes a genuine attempt to arrive at first principles, and the Group's findings and comments have considerable relevance to the functions of the Minister for Science in Britain and the organization for which he is responsible. The arguments in favour of a Department of Science and Technology are carefully examined, the implications are indicated, and sound criteria are defined which can be applied to any changes in the structure by which scientific advice is brought to bear on problems of government, no less in Great Britain than in the United States.

The first major criterion for judging an organization is its ability to get the assigned jobs done as well as possible, and here the American Group clearly has grave reservations as to how far the proposed Department would offer advantages over the existing arrangements. It does not accept the view that complete elimination of duplication is a valid objective, nor does it consider that co-ordination is necessarily more effective through a single department, as against proper communication between a number of independent departments. Efficient organization is essential, and this applies to any such new department and to existing departments or agencies the activities of which require co-ordination. Both principles are to be kept clearly in mind in considering the activities and interrelations for which the Minister for Science is responsible and also for some, like those in the fields of defence and of education, for which direct responsibility lies elsewhere. It is, in fact, precisely because some recent developments have raised doubts as to the operational effectiveness of the Defence Research Policy Committee and the efficiency of the organization of higher technological education under the control of the Minister of Education and the local authorities, that changes have been suggested for Britain.

Again, the Group rejects the argument that establishment of a Department of Science and Technology would increase financial support for such activities. Such support from public funds, it is rightly pointed out, must come from an increase in public understanding, though the Group accepts as probably sound, though not compelling, the argument that establishment of such a Department would enhance the status of science and technology as a government activity. Here again much depends on effective public relations, and it seems probable that if the existing official research councils in Britain are adequately financed and their activities effectively interpreted to the general public, the Minister for Science should be able to command sufficient public attention and prestige for the activities for which he is responsible. That undoubtedly comes first, for immediately science begins to affect policy, public understanding is imperative.

This appears clearly enough from the fourth criteria which the Group applies to the organization of scientific and technological activity—a capacity to promote the development of sound policy. Scientific and technical activities constitute one of the elements that must be considered in many aspects of broad national policy. At some point in the structure of government there must be means for bringing all the scientific and technological threads together, both from the point of view of establishing policy for research and development agencies and from that of the contributions these agencies make to national policy.

The Group is emphatic that guidance of policy should not mean centralized direction of the work of individual scientists, though it points out that research is not wholly a matter of individual decisions. With the increasing cost of equipment and facilities, it becomes a matter of general policy to decide what new facilities can be afforded, which are likely to make the greatest contributions to science, and which to the attainment of other national objectives. From this aspect of policy-making—the provision broadly for the advancement of science and its practical applications—arises the debate as to how far Britain should engage in space research or nuclear physics research, and the scale of any such effort relative to that, for example, in biochemistry or medical research.

This is the first class of policy problems which the Group distinguishes. The next comprises the contributions that scientific and technical knowledge can make to the solution of other national problems. In illustration the report quotes the ability to detect nuclear explosions, and the bearing of this ability on decisions concerning disarmament and inspection. A third class includes the influence of national needs on science and technology. Political, military and economic needs all help to determine the emphasis given to different technological areas and even to different fields of research.

The report argues that whoever has responsibility for making decisions on these inter-related issues must have opportunity and authority to review the entire research and development effort of the nation, and to give due consideration to other issues of policy; the fundamental question before the Group was whether the proposed Department would provide the means for this, and even ensure a drastic improvement in the capacity of the Federal Government to cope with scientific and technical problems. With this in mind, the reports sets forth the alternative possibilities. It rejects as unworthy of serious consideration any proposal that all the research and development activities of the U.S. Government shall be brought together in one Department. Scientific and engineering activities that are intimately related to the operating responsibilities of an agency belong to that agency: research on military problems, for example, cannot wisely be divorced from the Department of Defence. Again, science and technological development have so much in common and benefit so much from each other, in any particular area, such as nuclear energy, that the two should remain under the same administrative direction.

These two principles appear to have been recognized in at least some of the proposals advanced in the United States. Dr. Berkner, for example, excluded research and development activities which are an integral part of the agencies in which they are at present located—for example, the Departments of Agriculture and Defence—as well as agencies which are primarily responsible by supporting research carried out by others. He would also exclude independent agencies that are already strong and command firm support, such as the Atomic Energy Commission and the National Aeronautics and Space Administration. In the United States this would leave a group of scientific and technical bureaux which Dr. Berkner believes could be moved without detriment to the departments in which they are already located, though there is no obvious title for the new single Department. The main advantage would be that, through the closer contact thus established, the scientific and research activities would be stimulated and the new Department could be given responsibility for the development of new scientific activities. A Department devoted wholly to scientific and technical activities would, he suggests, be more likely to be on the alert to identify areas that need special emphasis, and more eager to secure the facilities that are required.

The proposal was not accepted without modification by the Group. The report that Mr. D. Wolfle has compiled, while agreeing about certain exclusions, suggests that the National Aeronautics and Space Administration should be included, and possibly also the National Science Foundation. None of the proposals for a Department of Science and Technology was regarded as entirely satisfactory, though each helps to reveal deficiencies in the present administrative structure. Dr. W. R. Brode's proposal for a Department of Science, for example, while accepting the general principle that scientific activities essential to the work of an operating agency should be left in that agency, is designed to correct the tendency for authority to engage in basic research in fields that underlie an agency's operating responsibilities, thus supporting an unnecessarily wide range of scientific activities. This was the substance of some serious criticism in Britain of Admiralty research advanced in reports from the Select Committee on Estimates. Dr. Brode's Department of Science, while not removing from agencies such as Defence and Agriculture the research programmes specific to their missions, would include all major segments of science not specifically pertinent to those missions.

Even with the sound principles endorsed by this report, the real difficulties lie in deciding where to draw the line, and in finding the balance of advantages and disadvantages in any change of organization. The Group recognizes very clearly, for example, the value of having alternative means of allocating funds, particularly in fundamental research, as well as the difficult decisions which have to be taken about entering new fields. Here, however, its major emphasis is on the need to watch for new developments, and, whether or not a Department of Science and Technology is established, the report stresses the urgency of achieving greater competency for looking ahead to identify and develop those areas of research that are not yet the responsibility of one of the applied science agencies but that appear likely to produce major advances and applications in return for special support. It might well have been added that closely allied is the no less difficult problem of deciding when to discontinue such support and where the responsibility for continuance or discontinuance should lie.

There is little in all this to point to any need for basic changes in the present structure of Britain's organization for securing that due account is taken both of scientific and technical factors in the making of policy and for securing effective co-ordination of such activities and reasonable allocation of resources for such purposes. Broadly speaking, that is the purpose of the creation of a Ministry for Science, and the report provides substantial reasons for doubting whether that purpose will be better achieved by giving the Minister more executive responsibilities in fields which lie outside his present responsibilities, but not his interest, as in defence research. More is likely to be achieved by strengthening the informal links which at present exist, as between the Advisory Council for Scientific Policy and the Defence Research Advisory Committee, for example, between the several research councils themselves and between them and the universities and industry, and also by positive measures, through the Parliamentary and Scientific Committee and in other ways. In this way it may be possible to create an informed public opinion prepared to provide and maintain the necessary support, competent at least within certain sections to criticize soundly, and one which also sufficiently recognizes the value and significance of science in Government to ensure that the question of status no longer arises.

There are, however, major considerations in this matter of determining overall scientific policy to which the American report directs attention. The limits within which existing or new means of presenting scientific or technological advice can function must also be recognized. Scientific and technological factors are only one element, even if an important one and on occasion the deciding factor in determining national policy. There are financial, economic, social and other factors to be considered, and in this the political element—and frequently the party political element—enters and cannot be excluded. For this reason, as the report points out, in the United States the centre of responsibility for policy must be close to the President, and this would be unaffected by the creation of any new Department of Science and Technology.

What matters is that for the Office of the President to possess the competence to exercise that role wisely, its staff must include men who are highly skilled in the management of scientific affairs, and who can relate scientific matters to all the other considerations that are involved in major decisions on policy. In this connexion it should be noted that the Group stresses the distinction between the position of Special Assistant to the President for Science and Technology and that of the Chairman of the Science Advisory Committee. Even though the two positions may be held by the same man, they are quite distinct. The Committee and its chairman should very properly place first emphasis in their thinking on the scientific and technological needs of the nation and the national implications of scientific and technological developments, and should be free to criticize established or proposed policy if damage to the nation's research and development programme is foreseen. In contrast, the Special Assistant is part of the Presidency, and must always subjugate specifically scientific or technological factors to the total of those involved in making a political decision—that is, a decision on policy. "Whether the chairman and the Special Assistant are the same man or different men, the President needs the best scientific and engineering advice available, and thus needs an Assistant for Science and Technology who can help him to weigh, judge, incorporate, and perhaps override that advice in establishing national policy."

The significance of this observation is obvious. In Britain, the Minister for Science provides the appropriate means for performing for the Prime Minister and in the Cabinet this latter function of the President's Special Assistant for Science and Technology, and it appears to rest with him also to see that through the Advisory Council for Scientific Policy and in other ways he is provided with the advice he needs for doing so. There appears to be no reason to doubt the adequacy of existing arrangements in Britain; but in the United States there seems to be room for improvement in the Federal Council for Science and Technology, and the Group appears to have had the personal factor more particularly in mind. So far as Britain is concerned, it would be difficult to suggest anyone better qualified than the present Minister for Science for presenting scientific and technological factors at ministerial level. Far more important at this level than scientific training is the ability to appreciate a situation as a whole, to work effectively with others and to present the scientific and technical issues clearly and relevantly. It is rather at the level of the advisory committees and councils and at the administrative level in the departments that the question of scientific training and administrative ability arises.

The American report commends for consideration the idea of having within each department an assistant secretary, or officer of similar senior rank, responsible for all research and development activities, and of using these officers as a strong co-ordinating council. Whether such a step would offer any advantage in Britain may be questioned. It would obviously tend to overlap the work of some of the existing advisory committees and councils and possibly to blur responsibilities and functions. Much more important seem to be the quality and the training of administrators in such posts, and the quality of the membership of the advisory councils and committees. This last in turn is linked to the question of status. Men of outstanding ability and experience and judgment will not be found to serve upon them unless the work is seen to be effective and their representations are treated with respect, even when in particular situations other factors may lead to their advice being over-ridden.

On the first problem, however, the question whether scientists rather than administrators as such should occupy more of the key posts in departments concerned with research and development merits more examination than the Government has been disposed to give it. Whether or not such an administrator is primarily a scientist, it is undeniable that it is increasingly impossible for him to be effective unless he has received sufficient scientific training and acquired sufficient scientific knowledge to appreciate the relevance and significance of the scientific or technical advice presented to him. Administrative ability is the primary criteria, but much more could well be done in the Civil Service to ensure that for scientists and technologists with the essential administrative flair there is full opportunity to rise to the highest posts. It does not speak well for the Government's handling of present conditions that there should be signs of such obvious discontent as the simultaneous day's leave taken by eight hundred of the scientific staff at Harwell last March, or the protests voiced at the recent annual conference of the Institution of Civil Servants.

It is true that, as a long article, "Scientists versus Administrators: an Approach towards Achieving Great Understanding", by Mr. Z. M. T. Tarkowski and Miss A. V. Turnbull in *Public Administration* last autumn shows, the Treasury is now giving some attention to this question, and residential conferences for senior scientists and administrators on organization and management have been arranged in the Civil Service for some years in which administrators, scientists and professional staff have been mixed in about equal proportion. The promotion of such understanding, like the promotion of effective co-operation and co-ordination, is, however, largely a matter of providing appropriate conditions, and it might well be worth while for Lord Hailsham to give some attention to this aspect and to the removal of the obstacles to which attention is directed in this article, particularly perhaps to the provision of facilities for scientists to obtain administrative training and experience.

NULLIUS IN VERBA

The Beginning of the Royal Society

By Margery Purver and Dr. E. J. Bowen. Pp. 16+2 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1960.) 2*s*. net.

The Royal Society

Its Origins and Founders. Edited by Sir Harold Hartley. Pp. ix+275+29 plates. (London: The Royal Society, 1960.) 35*s*.; 6 dollars.

A Brief History of the Royal Society

By Prof. E. N. da C. Andrade. Pp. iii+28+14 plates. (London: The Royal Society, 1960.) 10*s*. 6*d*.; 2 dollars.

ONE of the most striking features of the preparations for celebrating the tercentenary of the foundation of "a Colledge for the promoting of physico-mathematicall-experimentall learning" which in 1662 became the Royal Society has been the flood of articles on the history of almost every aspect of this great enterprise and of those activities which were afterwards associated with it. To the three works published during the tercentenary celebrations there will rightly be attached a special importance. To "The Beginning of the Royal Society", which alone of the three does not carry the Society's imprint, there may also be attached a certain notoriety since it unambiguously asserts what "Origins and Founders" implicitly denies, namely, that the Royal Society 'began' in Oxford. Though the adoption of an 'official' version would be wholly at variance with the spirit of the Royal Society, it is the case that three of the four histories of the Society written by its officers—Birch, Weld, and Lyons—all adopted the statement of Wallis against Spratt (the fourth) that the Society's "first ground and foundation" was in London. The authors of this "agonizing reappraisal", in claiming that Sprat "speaks with the voice of the contemporary [1665] Royal Society", do not add that Sprat himself freely admitted that the "objections and cavils" against the Society had compelled him to write of it "not altogether in the way of a plain history but sometimes of apology". The "voice" of the propagandist—whether individual or corporation at a critical moment of its existence—is scarcely likely to be an infallible guide in the establishment of historical truth. In support of their thesis the authors have assembled a great deal of evidence relating to the activities of the 'philosophers' at Oxford before 1660. To me it seems regrettable that this impressive picture of the high significance of Oxford in the growth of the idea which finally took shape in the Royal Society was coupled with the dogmatically presented claim that the Society 'began' there.

"Thoughts," wrote A. N. Whitehead, "lie dormant for ages, and then almost suddenly, as it were, mankind finds that they have embodied themselves in institutions." To me it is the great strength of Prof. D. McKie's long 'leading' article on "Origins and Foundation" that it reveals the Royal Society as the embodiment of a thought which had no beginning, but whose emergence in seventeenth-century England was the final act of a process discernible under various forms in the previous two centuries. The almost "sudden embodiment" was due to a combination of the genius and devotion of a few individuals and a particular historical situation. The latter, in Prof. McKie's judgment, was the influx into London of several influential Royalists (such as Viscount Brouncker and Sir Robert Moray) with a taste and aptitude for "natural philosophy"; the deployment of the former is the concern of the rest of this admirable volume. Of the twenty-one biographies included twelve are those of the men whose recorded decision is the only indisputable 'beginning' of the Royal Society (John Wilkins, Jonathan Goddard, William Petty, Christopher Wren, Laurence Rooke, Robert Boyle, Viscount Brouncker, Paul Neile, William Ball, Abraham Hill, Robert Moray, and Alexander Bruce). The remainder are of men who, though absent from that decisive meeting, were from a very early date associated in the most intimate manner with the Society's well-being: John Wallis, though an infrequent attender at meetings, of international renown and a scholar of the highest calibre and integrity; Thomas Willis and William Croone, pioneers of experimental medicine—the latter also being "named for Register"; Robert Hooke and Henry Oldenburg, without whose complementary talents and devotion the "first fine frenzy" might have evaporated; and John Evelyn, by whose suggestion the Society was granted its Royal title. The two remaining—Kenelm Digby and Elias Ashmole—were indeed less intimately associated with the Society, but their importance for the understanding of the climate of opinion of the times fully justifies their inclusion. There is no space even to name the authors of these biographies, let alone to touch on their several merits. For the sustained enthusiasm which must have been brought to the task—evidently far greater than usually falls to the editor of such a symposium—the Republic of Letters will owe a permanent debt to Sir Harold Hartley: it will be best discharged by following the advice of the printer of Copernicus—*eme, lege, fruere*.

Prof. Andrade's booklet falls into a somewhat different category. His aim is to present a portrait of the Royal Society as a living organism active in the advancement and dissemination of natural knowledge; independent of State control, but ready to enlist State aid for projects likely to promote those ends. Since the life of an organism is determined by its mode of growth, Prof. Andrade has drawn freely on his great knowledge of the commanding figures of the past; but since no chronological sequence is maintained the title might be thought somewhat misleading. This however is a small matter; if the aim is here correctly described, the achievement could scarcely have been bettered.

William P. D. Wightman

GENETICS FOR BEGINNERS

An Introduction to Genetics

By Dr. C. M. M. Begg. (Biological Science Texts.) Pp. xi+292. (London: The English Universities Press, Ltd., 1959.) 35*s*. net.

THIS is a valuable addition to introductory text-books on genetics, suitable for undergraduates and for the reader with some knowledge of biology. It covers a wide range, from formal genetics, population genetics and evolutionary theory to the biochemistry of gene action. It is attractively produced, easy to read and lavishly illustrated with large, clear diagrams which form an integral part of the text.

It is a measure of the rapidity of growth in genetics that the chemical structure of nucleic acids in the chromosomes can now be discussed in an elementary text-book of genetics, and Dr. Begg is to be congratulated on discussing this and other questions which are not yet fully understood, and making it clear to the reader why they are not understood. This is always exciting and provoking in an introductory book. It is therefore surprising that he should have avoided a fuller discussion of the structure of the genetic unit and the nature of mutation and left the reader high and dry over the interrelationship of deoxyribonucleic acid and ribonucleic acid. It is nowhere made clear that ribonucleic acid is found both in the nucleus and cytoplasm nor that proteins always occur with the deoxyribonucleic acid in the chromosomes. This makes it difficult for the reader to effect a synthesis between the first and last chapters.

There are several misprints which may well lead the beginner astray, for example an extra plus sign has appeared in Fig. 97, and it is to be hoped that the problems posed in the references in the last chapter are not an introduction to the stated problems, with solutions, which follow.

It is a pity that small points of editing should have been allowed to mar an otherwise useful book, a book in which a great deal of effort has been made to use genetic examples from man and to emphasize that genetics is of interest to us all.

WILMA GEORGE

IDENTIFICATION OF BLOOD-GROUP ANTIGENS

The Anti-Globulin (Coombs) Test in Laboratory Practice

By Dr. I. Dunsford and Jean Grant. Pp. xiii+120. (Edinburgh and London: Oliver and Boyd, Ltd., 1959.) 12*s*. 6*d*. net.

THE antiglobulin test of Coombs introduced in 1945 was, in fact, a rediscovery, for so long ago as 1908 its principles were worked out by C. Moreschi, an Italian. Dr. Coombs was unaware of this when he introduced his test, but later he duly acknowledged Moreschi's work. The test, as devised by Coombs, Mourant and Race in 1945, is now very extensively used both in routine investigations and in research work.

Many important and substantial advances in blood group serology, that is, the identification of blood-group antigens in the cells, and isoantibodies in the serum (or plasma), would not have been possible without the Coombs antiglobulin test. In selecting blood for transfusion the Coombs test is quite the most reliable compatibility test thus far devised. This test has also proved to be extremely useful as a research instrument and, in particular, has proved invaluable in affording us a better understanding of hæmolytic anæmias. This book, written by two experienced workers, reflects the experience generally not only of the Oxford and Sheffield regional transfusion laboratories but, also, that of other transfusion laboratories. It gives an informative account of the Coombs test, the preparation of antiglobulin sera, the applications of the test, and there is a comprehensive list of references for those who wish to read further on the subject. Certainly this book will be very useful to every pathologist and technician who operates a blood bank.

A suitable account of antigens and antibodies is given, their detection by the Coombs test, and the serological basis of this test. The production, processing, and standardization of anti-human-globulin sera, the behaviour of such sera in tests, the technique and applications of the Coombs test, and the various snags which may arise, are all competently dealt with. The authors point out that antiglobulin sera prepared by heating or by dilution may be adversely affected in that they may be suitable only for detection of γ-globulin coatings. The application of Coombs's test in fields other than blood-group serology, for example in bacteriology, forensic medicine, hæmolytic disease in animals, etc., are briefly but adequately dealt with. This is a useful little book, being compact and concise, and it is to be hoped it will be kept so in future editions which will surely be required.

R. DRUMMOND

EVOLUTION OF MODERN EDUCATION

Studies in the History of Education 1780–1870

By Brian Simon. Pp. 375+24 plates. (London: Lawrence and Wishart, 1960.) 37*s*. 6*d*. net.

THE history of education often lends itself well to a Marxist analysis, and in the case of Mr. Simon's book it has undoubtedly helped to throw fresh light on British social developments in the nineteenth century. What makes this approach exasperating as well as rewarding is its tendency to straight-jacket the material, thereby first illuminating it and then obscuring it—the former by catching it in a sharp focus, the latter by distorting it to fit into a partial pattern of vision.

During 1780–1870 there was indisputably a vast social change, in relationship to which educational principle and practice stood as both cause and effect. Political and economic power shifted from the land-owning aristocracy to the Whig magnates and then, in step with technological invention, to an increasingly prosperous middle-class. This was reflected first in the attack of the Philosophical Radicals on the former establishment in Church and State up to 1832, and secondly in the building up of social institutions in favour of the liberal interest after that date and against the extension of full human rights as yet to the rest of the populace. A trifle tedious in connexion with the first of these phenomena, Mr. Simon's writing seems to catch fire as in Chapters 4 and 5 he describes the response educationally of the still unemancipated section of the nation. Particularly good are his portrait of William Lovett as an educationist and his definition of the links between the educational and more broadly political aspirations of the Chartists.

The following passage on page 223 reveals both the strength and the weakness of the author's arguments: he quotes from the *Northern Star* (1848) a rebuke by the workers to those who in their eyes had betrayed them:

"In our day, the Educationists are still what they were in Cobbett's time—the pretended friends, but the real enemies of the people . . . Ah gentlemen, we see through your craft . . . You would educate us, not, as you sometimes pretend, to fit us for the exercise of political rights, but to make us indifferent to those rights. And you call yourselves 'Philosophical Radicals'."

"This uncompromising statement," comments Mr. Simon, "epitomises the reaction of the most advanced section of the working class to the educational tactics of the bourgeoisie." The author's strength lies in his belief in and capacity for using a partial point of view in order to invest a series of historical events with meaning: his weakness lies in a too doctrinaire use of the viewpoint. Such a phrase as 'the educational tactics of the bourgeoisie' implies the ascription of far too conscious and unitary motives to what was a non-homogeneous and changing stratum of society. It merely serves to conceal the more difficult truth that, as Homyakov expressed it, "Only that is conservative which moves forward, and only that is progressive which does not break with the past". Mr. Simon's carefully documented book with its telling illustrations should help perceptive students of English nineteenth-century educational history to assimilate that paradox. JAMES L. HENDERSON

NUCLEAR MAGNETIC RESONANCE

High-resolution Nuclear Magnetic Resonance

By J. A. Pople, W. G. Schneider and H. J. Bernstein. (McGraw-Hill Series in Advanced Chemistry.) Pp. xii+501. (London: McGraw-Hill Publishing Company, Ltd., 1959.) 104*s*. 6*d*.

AT some stage in the development of almost every specialized physical technique of chemistry there has appeared a text-book which has ultimately become recognized as a standard work on the subject. Such books play a very important part in the practice of chemistry because they invariably provide a convenient source from which the underlying principles of the subject to which they pertain can be mastered. It is therefore most fortunate that the technique of high-resolution nuclear magnetic resonance, which is so obviously destined to be of major importance in chemistry, has acquired a standard text so early in its history, for certainly "High-resolution Nuclear Magnetic Resonance" will admirably fill this role.

This book is the result of a fruitful collaboration of a theoretician and practical spectroscopists, and as such provides a well-balanced account of basic theory, experimental technique, and practical applications. The first part of the book, entitled "Principles", deals with theory and its relation to experiment, and includes brief, but sufficient, descriptions of actual spectrometers. An elementary knowledge of quantum mechanics is necessarily assumed and on this basis the principles of the subject are developed concisely and with considerable clarity. The only serious criticism of Part 1 concerns the generalization made in section 4–8 to the effect that the preferred method of standardizing spectra uses an external reference. Even in 1958 it was more or less recognized that suitable internal references offer considerable advantages.

Part 2 deals with the complete range of applications of high-resolution nuclear magnetic resonance to chemical problems. As the book contains comparatively few references after the first six months of 1958 the real power of proton spectroscopy is not fully indicated. Indeed, it might be argued that the two parts of the book should have been published as separate volumes on the grounds that the contents of Part 2 cannot possibly remain representative of the subject for more than one or two years, and that many private purchasers might have been glad of obtaining Part 1 at a reduced price. Nevertheless, the later chapters of the book contain much which will be of considerable interest and help to both the expert and uninitiated reader.

Such criticisms as have been made above are of minor significance compared with the stimulus which this book is already giving to a rapidly expanding subject. Certainly every worker in the field of nuclear magnetic resonance will need to know and use this book, and those in other disciplines will consult it on numerous occasions. Finally, the authors and publishers are to be congratulated on the uniformity and excellence of the presentation.

L. M. JACKMAN

PRINCIPLES AND PRACTICE OF TELEVISION ENGINEERING

Television Engineering

Principles and Practice. By S. W. Amos and D. C. Birkinshaw. (B.B.C. Engineering Training Manuals.) Vol. 1: Fundamentals, Camera Tubes, Television Optics, Electron Optics (written in collaboration with J. L. Bliss). Pp. 302 (1953). 30*s*. net. Vol. 2: Video-Frequency Amplification. Pp. 270 + 5 plates (1956). 35*s*. net. Vol. 3: Wave-form Generation. Pp. 226 (1957). 30*s*. net. Vol. 4: General Circuit Techniques. Pp. 268 (1958). 35*s*. net. (London: Iliffe and Sons, Ltd.; New York: Philosophical Library.)

THESE four volumes form a comprehensive guide to the principles and practice of television engineering produced by authors who have actively participated in the development of the B.B.C. television services for many years past. The series has been produced from text-books prepared primarily for instruction of the Corporation's own staff, and they are now made available for a wider technical public.

The first volume deals with the fundamental principles of converting a visual scene into electrical signals for transmission to a distant receiver. Considerable space is given to a description of the various types of television camera tubes, and a discussion of the principles of the transmission of light by lenses and mirrors, and of the analogous problems encountered in electron optics. Volume 2 is devoted to video-frequency amplification at both high and low frequencies, with some reference to the sources and nature of noise associated with camera-head amplifiers. In this case, the text is rather more mathematical than in the first volume; but a wide variety of circuits is described, including the use of feedback. Numerical examples are given to illustrate the application to practical equipment.

A somewhat similar presentation is adopted in the third volume, which covers the subject of wave-form generation for television transmission. Separate parts of this book are devoted to the production of waves of sine, rectangular, sawtooth and parabolic form, with details of the various types of valves and circuits suitable for these. The multi-vibrator, in one or other of its different forms, naturally plays a large part in this technique as applied to the reception and analysis of television signals.

The fourth and last volume of this comprehensive work deals with a wide range of circuit techniques, many of which are applicable to the general field of electronics as well as to television engineering. Among the techniques treated are counter circuits, frequency dividers, direct current clamping and restoration, and amplifiers, delay lines and equalizers. Some of these subjects require a mathematical treatment but, in order to facilitate the presentation of the text, many of the mathematical derivations are given in appendixes to the individual chapters.

Altogether these four volumes form a most valuable aid to those engaged in the science and application of the generation and use of television signals, and allied fields of electronics. The texts are very clear throughout and well illustrated by graphs and schematic circuit diagrams. The production of the volumes is of a high standard and is a credit to the publishers as well as to the technical staff of the British Broadcasting Corporation. The work can be confidently recommended as a guide to circuit designers, as a training manual to lecturers and as a general work of reference to the radio and electronics engineer.

R. L. Smith-Rose

UNIFICATION OF ANALYTICAL APPROACHES TO ENGINEERING PROBLEMS

Engineering Systems Analysis

By Prof. Robert L. Sutherland. (Addison-Wesley Series in Instrumentation and Control.) Pp. xii+223. (Reading, Mass.: Addison-Wesley Publishing Company, Inc.; London: Academic Books, Ltd., 1958.) 60s.

THE unification of the analytical approach to engineering problems is an ideal which is sometimes attempted in advanced texts on certain branches of engineering science. It is not, however, very commonly attempted in text-books for undergraduates. Clearly there is a major difficulty in limiting the scope of such a work and in selecting the material to be included. It is, therefore, particularly interesting to find an undergraduate text-book under the title "Engineering Systems Analysis".

The book opens with a study of basic electromechanical analogies and then proceeds to a consideration of mechanical vibrating systems. This is followed by a chapter on oscillations in electrical networks. A section dealing more generally with dynamical systems develops the method of treatment for mixed systems with electrical and mechanical components and explains the use of dimensionless ratios. Dimensional analysis is then treated in considerable detail and its application is illustrated by examples in the field of hydro-dynamics. Thereafter follows a section on the principles of feedback and control and the book concludes with a chapter on analogue and digital computing machines.

With such a wide coverage it might be thought that the treatment would be too superficial to be of real value. In fact the author has succeeded in dealing with a selection of fundamental topics in quite sufficient depth and at the same time in producing a coherent whole. This has in large measure been achieved by the judicious selection of his illustrations.

It would appear from the author's preface that this text-book will meet the needs of certain courses which are being developed in universities in the United States. It is a little difficult to see precisely where this book would fit into the structure of most British undergraduate courses in engineering. None the less, the unification of treatment which is achieved is something of intrinsic value which merits the attention of undergraduates, and the book can certainly be commended as basic reading for both mechanical and electrical engineers. The standard of mathematics involved should be well within the competence of the British undergraduate in his second year.

J. Greig

RUBBER TECHNOLOGY

Introduction to Rubber Technology

Edited by Maurice Morton. Pp. v+547. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1959.) 80s. net.

AN "Introduction to Rubber Technology", edited by Prof. M. Morton, of the Institute of Rubber Research of Akron University, Akron, has first to be compared with the standard work on "Synthetic Rubber" edited by Morton's predecessor, G. S. Whitby. "Synthetic Rubber" is primarily concerned with the preparation and uses of the general purpose styrene-butadiene rubber, with relatively brief mention of chloroprene, nitrile, and butyl rubbers. "Introduction to Rubber Technology" devotes the same fraction of its space to styrene-butadiene rubber as to each of the other rubbers considered. There is no case, therefore, to regard the new book as overlapping seriously the older.

After introductory chapters on the history of rubber technology and polymer chemistry, separate chapters deal with natural rubber, butadiene-styrene, nitrile and acrylate, butyl, polychloroprene, chlorosulphonated polyethylene, polysulphide and silicone rubbers. The various types of rubber additives—plasticizers, antioxidants, and anti-ozonants, accelerators, and fillers—are also treated in separate chapters. Articles on reclaimed rubber, latex and sponge rubber, physical testing, and processing equipment round off a broad survey of modern rubber technology. The only serious omission appears to be of the new polyurethane and polyether foams.

Morton has achieved a large measure of success in welding together the efforts of twenty contributors. The technical level of the articles is uniform and makes for a very readable book. The material is up to date, and presents for the first time in book form much information of value to rubber technologists in

Britain. The quality of printing and of the illustrations is first-class.

The question does arise as to whom this book is directed. It will probably be disappointing to specialists in other fields who seek from the title an introduction to rubber technology within the framework of chemistry and physics. The policy appears deliberate of keeping the scientific matter on a 'popular' level. For example, in the chapter on polymer chemistry, one jumps within a page from atoms and valency to monomers and polymers. Again, in the chapter on vulcanization, the concept of cross-linking is dismissed with reference to the analogy of a fish net of varying size of mesh, and no concept is given of the number of cross-links to monomer units or dependence of properties on the nature of the cross-links, to take only two relevant subjects which should surely be dealt with. The popular approach is also sometimes misleading, as in the equations put forward to describe rubber oxidation.

Rather than an 'Introduction', the various chapters of this book are really self-contained reviews. As such, they include much of interest to practising rubber technologists. The readers of this book will, in general, be already qualified and could with ease have swallowed stiffer doses of the science of their subject from the eminent contributors to this volume. A chemistry and physics of rubber technology still requires to be written. W. F. Watson

MARINE BIOLOGICAL REPORTS FROM DENMARK

Meddelelser frå Danmarks Fiskeri- og Havundersøgelser

Ny Serie, Bind 2, Nr. 23–26. Nr. 23: Investigations on the Quantitative and Qualitative Distribution of Zooplankton in the Southern Part of the Norwegian Sea. By V. K. Hansen. Nr. 24: A Quantitative Investigation of the Echinoderm Fauna of the Central North Sea. By Erik Ursin. Nr. 25: Conditioning *Ostrea edulis* L from the Limfjord for Reproduction out of Season. By I. A. Aboul-Ela. Nr. 26: The Oligochaete Fauna of Three Danish Brackish Water Areas. By I. Dahl. Pp. 292+5 plates. (København: C. A. Reitzels Forlag, 1960.) 47 Danske kr.

The final part of the second volume of the new series of biological reports published by the Danish Institute for Fisheries and Marine Research contains four interesting contributions which carry on the high standards established by the earlier series. The first paper, by V. K. Hansen, "Investigations on the quantitative and qualitative distribution of zooplankton in the southern part of the Norwegian Sea", describes the results of cruises made during several seasons in the area of the off-shore herring fisheries just north of the Iceland–Faeroes–Shetland ridge. Samples were taken with the vertical Hensen net, supplemented by horizontal hauls with small high-speed samplers of the Hardy Indicator type. The catches are described and discussed in relation to movements of Arctic and Atlantic water masses, but conclusions are apparently being kept until the remainder of the plankton community has been described.

Of two shorter papers, one by I. A. Aboul-Ela, on "Conditioning *Ostrea edulis* L., from the Limfjord for reproduction out of season", shows that successful spawning can be induced by higher temperatures. The other paper, by Mrs. Ingerlise Dahl, on "The Oligochaete fauna of three Danish brackish water areas", deals with the systematics and biology of these little-studied animals, which form a surprisingly important component of the bottom fauna in the Danish Fjords.

Most of the volume is taken up by Dr. E. Ursin's comprehensive study, "A quantitative investigation of the Echinoderm fauna of the central North Sea". The author has based his work on most of the Danish material collected since 1922, as well as on a large number of quantitative grab-samples taken from R.V. *Dana* during 1950–55. Full tables are given showing the occurrence of the commoner species at all stations since 1932, and the distribution of both common and rare forms is described in some detail. Reference is made to the accepted bottom fauna communities, but in the main the distributions are considered from the zoogeographical point of view in comparison with other localities, notably Iceland and the Adriatic. Apparently the echinoderms of the southern North Sea have decidedly southern affinities, and the total numbers per unit bottom area are considerably greater than in the northern part. However, the author regards the latter area as the rich area for echinoderms because a larger number of (rarer) species occur there. Many of the species found only in the northern (or north-western) part of the North Sea are distributed to the north of the area (for example, *Leptasterias mülleri*, *Strongylocentrotus droebachiensis*), and would thus be expected to be limited to the northern region because of the generally cooler conditions there during the summer months and the somewhat deeper water which allows the establishment of a thermocline. Other, much fewer, species of southern distribution outside the North Sea (for example, *Antedon bifida*, *Palmipes membranaceus*) are also limited to the same area as the cold-water forms, possibly, it would be expected, because they can better survive the colder months of the year there than farther to the south and east where there are greater extremes of climate. However, the author, after considering such hypotheses, tends to reject most temperature correlations, and instead compares the distributions of the rarer species with the distribution of water masses characterized by the plankton community represented by the chaetognath *Sagitta elegans*.

As one reads the accounts of individual species one gains the impression that the author considers that the presence of "*Sagitta elegans* water" is the predominant environmental factor governing the distribution of echinoderms. Even if the experiments on biological factors in such water are considered conclusive, it is difficult to believe that they can have much influence on non-pelagic larvae or on the adults themselves. Many inconsistencies in distribution in the North Sea would be more intelligible if other environmental factors were considered. Not only temperature but also depth of water, type of deposit and continuity of faunas must be of more direct importance to most species of echinoderms than hypothetical factors associated with water masses. In conclusion, the possibly subjective interpretation must not be allowed to detract from the general importance of this paper, which will form the basis for much future discussion, and zoogeographers will be grateful to Dr. Ursin for his careful compilation of the distributional records.

A. J. Southward

WESTFIELD COLLEGE (UNIVERSITY OF LONDON)

NEW FACULTY OF SCIENCE

SINCE its return to London after the break of the war years, Westfield College (University of London) has been a College in the Faculty of Arts only, except for mathematicians, who have taken either the B.Sc. (Special) or B.A. degree. Previously, the College had a small, but flourishing, Department of Botany, but this was relinquished in 1950 as a result of the difficulties encountered in running one science department in isolation.

In November 1955 the College Council decided to press for the re-introduction of science, but on a wider basis, and the advice of Sir Lawrence Bragg and other eminent scientists was sought and most kindly given. The reasons for the decision probably need no advocacy, but are summed up as follows: "We are convinced that the College would gain immeasurably by the re-introduction of Science: past experience has shown that the contact between students of Science and students of the Arts, living and working side by side, is of the greatest benefit to both, in ways difficult to analyse but none the less real". The original plan was to establish a Faculty of Science "comprising Special Honours Departments of Chemistry, Physics, Botany and Mathematics (already in being), with in addition a two-year Zoology course" (afterwards included as a special honours department) and that these departments should "at the same time cover the requirements of the B.Sc. General Honours Degree". The shortage of science teachers in the schools was kept in view, and it was thought that "there might well be a temporary paucity of properly qualified candidates for Special Honours courses (but) . . . that to have the stimulus of Special Honours Departments is the right policy in the long view". A Faculty of approximately two hundred students was envisaged, though this was increased later in the light of advice from the University. The College possessed its old botany laboratories, equipment and materials, which had been retained, and the botany library, where periodicals and series had been kept up to date. It also had a site for extensions.

In June 1956 a small body of experts appointed by the University went to examine the building plans and confer about staffing and accommodation. Their opinion was that the site proposed was too restricted, and an alternative site allowing for more research facilities as well as possible expansion had to be found. It was also stated by the University when examining the estimates that the original plan was too modest and that if the plan were to be given ultimate sanction the College should think in terms of a building costing about half a million pounds, and also that the building must be ready to accept students in October 1961. The building plan was modified more than once to accord with London County Council requirements and finally it became evident that to obtain a site of sufficient dimensions one of the College residences would have to be demolished.

In all these negotiations the College was helped by the criticism and advice of the inspectors appointed by the University, some of whom afterwards became 'science advisers' to the College and to whom it is deeply indebted, notably Prof. H. T. Flint (then Hildred Carlile professor of physics at Bedford College), Prof. W. S. Bullough, professor of zoology at Birkbeck College, and the late Prof. W. Wardlaw, professor of chemistry at Birkbeck College. After his death in December 1958 his successor, Prof. W. G. Overend, consented to act as adviser in chemistry. In botany no special adviser was sought, since there were some past members of the College who had specialized knowledge. The architects responsible for the laboratories are Messrs. Verner Rees, Laurence and Mitchell. The actual demolition of the property to clear the site began in May 1959, and the official laying of the foundation stone of the new building was performed by Sir John Cockcroft in May 1960. Meanwhile, the intellectual foundations have been laid in the present academic year by the appointment of the first professors and by the recognition by the University of the College as a School in the Faculty of Science.

The appointments are as follows:

PHYSICS. *Prof. E. H. Bellamy.* Dr. Bellamy was educated at Quarry Bank High School, Liverpool, and proceeded to King's College, Cambridge, as a State Scholar in 1941. He obtained a first class in the Natural Sciences Tripos in 1943 and then worked for three years as a scientist in the Road Research Laboratory, Department of Scientific and Industrial Research and at British Insulated Callender's Cables, Ltd. Returning to Cambridge after the War, Dr. Bellamy completed a double-first in the Natural Sciences Tripos in 1948 and thereafter did research work in the Cavendish Laboratory for the Ph.D. degree, which he obtained in 1951. During this latter period Dr. Bellamy made the first measurements in Europe of nuclear spins and magnetic moments using atomic beam techniques. He was appointed to a lectureship at the University of Glasgow in 1951 and rendered valuable help in the development of experimental techniques for utilizing the beam of the 300-MeV. synchrotron which operates there. During the past five years, Dr. Bellamy has made many contributions to our knowledge of photoproduction of π-mesons and has very successfully supervised young research students who have collaborated with him in these and other experimental studies. He is at present on short leave of absence to carry out an experiment on the 1,000-MeV. synchrotron at Frascati. Dr. Bellamy has also taken a full share in departmental teaching and social activities at Glasgow, and has been very popular with undergraduate students.

CHEMISTRY. *Prof. W. Klyne.* Dr. Klyne was educated at Highgate School and New College, Oxford, where he read chemistry. Since then he has worked in

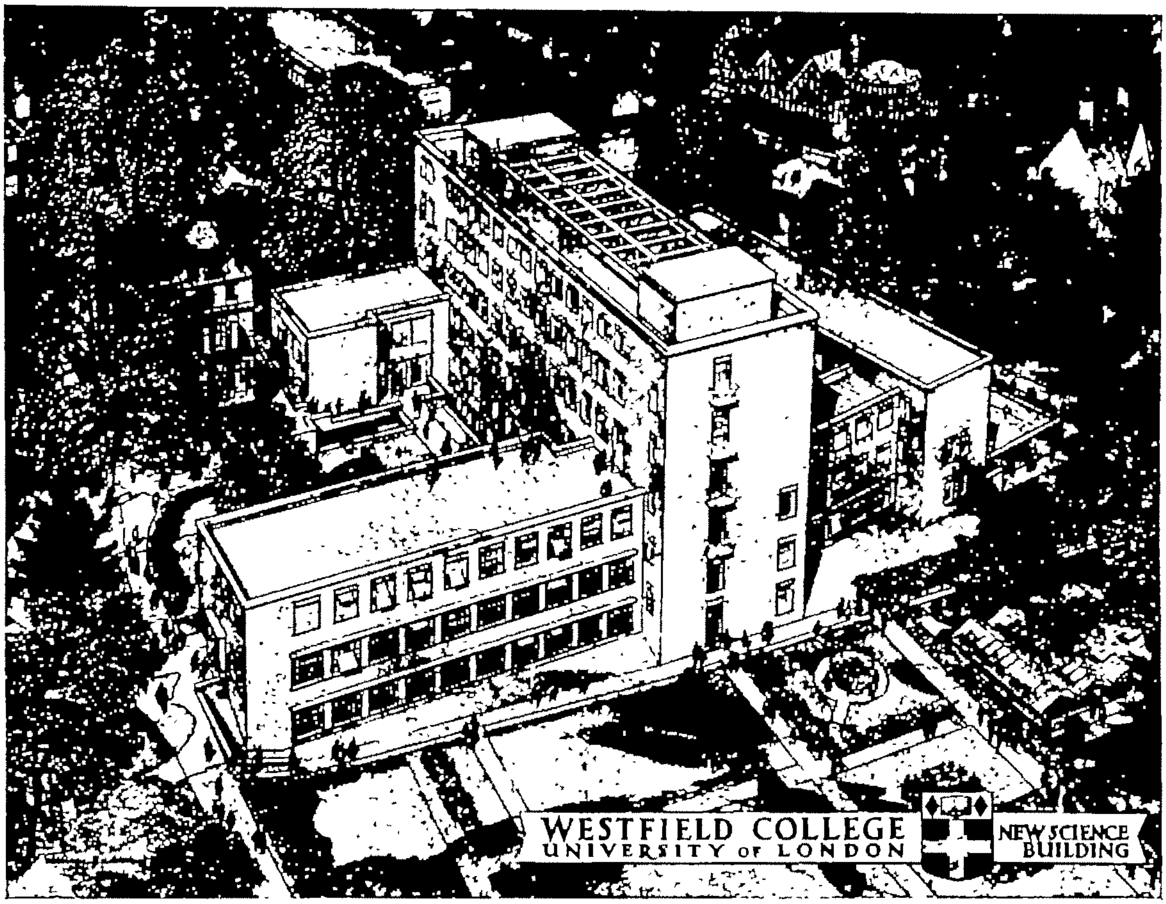


Fig. 1. Photograph of artist's drawing of the new Faculty of Science Building, Westfield College. (Artist: William Suddaby. Photographer: Sydney W. Newbery)

the Department of Medical Chemistry in the University of Edinburgh and in the Department of Medical Pathology at the Postgraduate Medical School of London, where he has been reader in biochemistry since 1952. Prof. Klyne has written "Practical Chemistry for Medical Students", which has been widely used. He is an expert and master of stereochemistry, particularly in regard to the biological steroids and the relation of optical rotation and rotary dispersion to chemical structure. His approach to the subject ranges from biochemistry and organic chemistry to the theoretical aspects of the shape of molecules. His interest in scientific method and his past experience should ensure success for this new department of chemistry.

Botany. *Prof. G. E. Fogg.* Dr. Fogg needs no introduction to most biologists for he is well known as a secretary of the Society for Experimental Biology, as one of the co-editors of the Penguin "New Biology" series and as the author of the book "Metabolism of Algae". Dr. Fogg took his degree in botany at Queen Mary College, London, and went to Cambridge to do his postgraduate research. Since 1945 he has been an invaluable and distinguished member, first as lecturer and now as reader, of the Botany Department in University College, London. Dr. Fogg's research work on the metabolism of algae, involving as it does the growing of algae in pure culture and the use of modern techniques, has been distinguished for its skilful, experimental approach. More recently, he has extended this work to the study of the physiology of phytoplankton in fresh water and the sea. Around this new and expanding field of research, Dr. Fogg will be able to build a sound teaching department at Westfield College.

Zoology. *Prof. J. E. Webb.* Dr. Webb returns to Great Britain after a period of eleven years as head of the Department of Zoology in the University College of Ibadan, Nigeria. After graduating from Birkbeck College, London, he held for a short time a post as research entomologist before taking up a lectureship at Aberdeen. His many publications during this period include important contributions on the morphology and ventilation mechanisms of insect tracheae. The creation and development of a flourishing department at Ibadan and of an attractive and well-stocked zoological garden are a tribute to his energy and powers as an organizer. Under his leadership and guidance the Department has acquired a well-deserved reputation for good teaching and research. Many of his students have graduated with honours degrees under the scheme of special relationship with the University of London and have taken up teaching and research posts in Nigeria; two of them are on the staff of the Department. Prof. Webb, besides playing an active part in the affairs of the University College, as dean of the Faculty of Science and member of the College Council, has established himself as an authority on the systematics of the cephalochordates, and his most recently published work, in the *Philosophical Transactions of the Royal*

Society, includes studies on the geomorphology and ecology of the lagoon systems of Lagos and the adjacent coastline.

All these professors will hold office from October 1960, in order to be responsible for final preparations and for appointment of staff before the first intake of students in October 1961. They will select their first students in November 1960, and the schools have already been circularized.

MATHEMATICS. *Prof. E. H. Sondheimer*. The Mathematics Department is in a different position, since the College never ceased to accept students for the B.Sc. special degree. The Department (about fifty students) is at present directed by a reader, but it had long been decided to apply for a chair in due course. The introduction of the Faculty of Science made it desirable that the change should take place now and the first professor of mathematics is Dr. E. H. Sondheimer. He is, at present, University reader in applied mathematics in Queen Mary College, London, a post which he has held since 1954. Prior to this, he held a lectureship in mathematics in the Imperial College of Science and Technology, to which he was appointed in 1951. This was, in fact, his first teaching post. Dr. Sondheimer has had a varied and interesting career; after taking the Natural Science Tripos at Cambridge in 1943, he joined a small team carrying out war work on experimental studies of the properties of transformer sheet steels. At the end of the War he began research work in the electron theory of metals at Cambridge, to which subject he has made several important contributions. He was awarded a Smith Prize in 1947 and in 1948 elected to a research fellowship at Trinity College which he took up in 1950. In the intervening years he worked first under Prof. N. F. Mott at Bristol and later was in the United States, working with Prof. Slater at the Massachusetts Institute of Technology. Dr. Sondheimer is best known for his work on the anomalous skin effect in metals, which was done in collaboration with G. E. H. Reuter. Later extension of this work paved the way for Pippard's pioneering work on determination of the Fermi surface in metals. Dr. Sondheimer's other important contributions include the first successful solution of the Bloch integral equation, the application of variational methods to conduction phenomena in polar semi-conductors, and a general proof of the validity of Kelvin relations occurring in the theory of phonon drag.

CONTROL OF PRE-NATAL GROWTH IN MAMMALS

By DR. ANNE McLAREN

Agricultural Research Council Unit of Animal Genetics,
Institute of Animal Genetics, King's Buildings, Edinburgh 9

AND

DR. DONALD MICHIE

Department of Surgical Science, University New
Buildings, Edinburgh 8

TO some extent every mammal decides for itself what size it will attain, in the sense that its own genetic constitution sets limits to its growth. However much we feed a Shetland foal it will not grow as large as a Shire horse. But there is evidence that these intrinsic factors exert their main effects in post-natal life, and that pre-natal growth is largely controlled by the intra-uterine environment.

An early indication of this was Walton and Hammond's[1] remarkable demonstration that the new-born foals of Shire mares crossed to Shetland stallions were almost as large as pure Shire new-borns, while the offspring of the reciprocal cross were as small as new-born Shetlands. The presumption was that the uterine environment was responsible, although the possibility of a cytoplasmic effect was not excluded.

Subsequent work with man[2], cows[3], rabbits[4], sheep[5] and mice[6] has confirmed the existence of large maternal effects upon weight at birth, and in the last three cases it has been shown by means of egg transfer that the effects are indeed mainly uterine.

Equally clear evidence of the importance of factors extrinsic to the embryo is the well-known effect of litter-size on weight at birth in polytocous species. According to Healy, McLaren and Michie[7], when the range of litter sizes in mice is artificially increased, differences of more than two-fold in the mean weights of full-term foetuses can be obtained. The classical explanation of such effects is that there is a limited pool of nutriment in the maternal blood for which the foetuses compete[8]. As each draws its ration, so much the less remains for the others.

In this article we review evidence suggesting that this explanation is incomplete, and that most effects of litter size on foetal growth can be given a more plausible explanation in the elementary principles of hydrodynamics to which the flow of blood to the placenta is subject.

In the case of species with a bicornuate uterus, the theory of a limited pool of nutriment predicts that the growth of a foetus in one uterine horn will be just as much retarded by the presence of litter-mates in the other horn as in the same horn. But Eckstein, McKeown and Record's[9] study of guinea pig pregnancies showed this not to be the case. They found that the number of embryos in the same horn was more important than the number in the opposite horn in determining both foetal weight and the weight of the placenta, on which foetal growth in large measure depends. The picture which emerges from their results can be summarized as in Fig. 1.

With regard to the possible mechanism underlying this scheme, Eckstein *et al.* pointed out that since resistance to blood flow through the placenta is low, the pressure at which blood is supplied to each placenta may be inversely related to the number of placentae supplied by the uterine artery on the same side. It can be supposed that the supply of blood, and of its dissolved nutrients, conditions the rate of

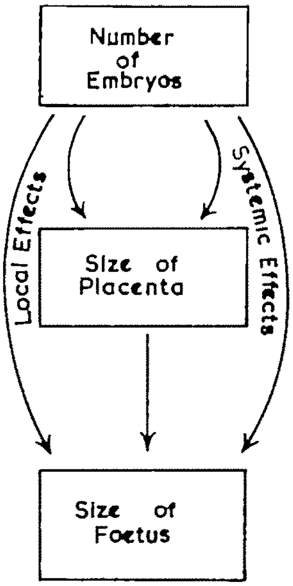


Fig. 1. Scheme showing the pathways by which the number of implanted embryos can affect fœtal growth, as suggested by the work of Eckstein, McKeown and Record (ref. 9). Reproduced by permission of the Royal Society

fœtal growth, both directly, and also indirectly by determining in the earlier part of pregnancy the size attained by the placenta. The local effect of the number of embryos is in this way neatly accounted for, and the authors pointed out that in order to accommodate the residual non-local, or systemic, effect it is only necessary to postulate that changes of blood pressure on one side are to some degree transmitted to the contralateral uterine artery.

In the course of an experiment on the induction of superpregnancy in mice[10], large numbers of full-term fœtuses were weighed, with results[7,11,12] which support this attractive hypothesis. The existence of substantial local effects on fœtal growth was confirmed. The effects, both local and systemic, of embryos surviving into late pregnancy were paralleled by effects of almost equal magnitude exerted by embryos dying in mid-pregnancy. These effects can scarcely be accommodated by the nutritional pool theory, since the nutritional demands of such embryos must be extremely small. But on the hæmodynamic theory the result is reasonable, for by surviving long enough to form a placenta, such an embryo will limit the size attained by the placentæ of other embryos and hence will limit their subsequent growth.

In addition, an extreme test of the theory of competition for a limited nutritional pool was afforded by the induction of superpregnancy in sexually immature females. These animals, as might be expected, show marked signs of nutritional stress[12], yet their full-term fœtuses were not significantly lighter than those of a parallel series of superpregnant adults (*see* Fig. 2).

It seems sufficiently clear that the limited pool theory is inadequate. At the same time, other features of the observations conformed rather well with expectation on the basis of the hæmodynamic theory of Eckstein *et al.*

The supply of blood to each uterine horn of the mouse is derived from offshoots of a main loop artery fed from the abdominal aorta at the top and from the iliac artery at the bottom. In such a system the pressure of blood must be highest in the top and bottom offshoots, decreasing in the offshoots towards the middle. We might consequently expect the larger fœtuses to be at either end of the horn and the smaller ones to be in the middle. This is precisely what has been found[11], with a particular exception which, however, helps to establish the rule. The exception is the topmost fœtus of all, which, especially in crowded horns, is usually supplied by one limb of a bifurcated offshoot of which the other limb supplies the ovary. This fœtus, especially in crowded horns, is on average smaller than its neighbour[7].

The factors controlling fœtal growth which have so far been discussed are summarized diagrammatically in Fig. 3, which is based on the suggested relationship between fœtal growth and uterine blood flow.

Another case of bifurcation relates to the phenomenon of placental fusion[13], where the fœtuses involved also have to divide between them the supply from a single offshoot. Here again, retardation of growth is found. On the other hand, in fused pairs of which one member has died in mid-pregnancy, the survivor presumably enjoys the full output of one arterial offshoot, a circumstance which tallies with the finding that such fœtuses are not significantly retarded relative to their non-fused hornmates.

In general, the hæmodynamic theory seems to account well enough for variations in fœtal growth other than those due to genetic differences between pregnant females.

There is, however, an important exception to which Hammond's concept of limitation of nutrients has a clear application. In some species the young are born at a relatively advanced stage of growth and development, so that their terminal demands upon maternal nutrition are large. One such species is the sheep, in which Wallace[14] has shown that the weight of the young at term, particularly in twin pregnancies, can be drastically altered by varying the plane of maternal

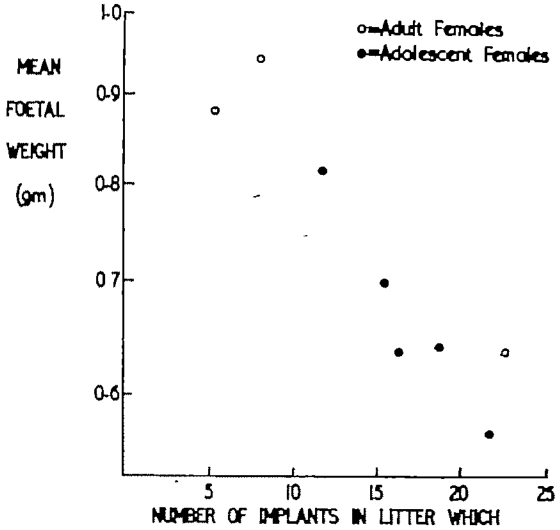


Fig. 2. Mean weights (scaled logarithmically) of 18-day live mouse fœtuses plotted against the mean number of implants surviving beyond day 10. Each point is based on 5–7 superpregnant females. In contrast to the large effect of litter size, effects of maternal age are small or non-existent

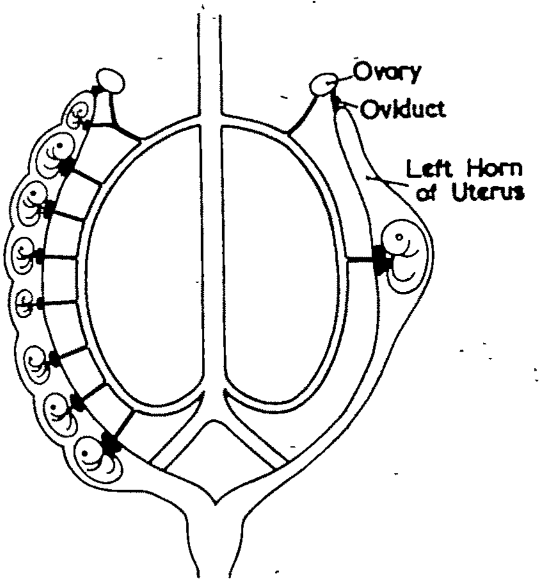


Fig. 3. Diagrammatic summary of various factors controlling fœtal growth. The one-to-one relation between fœtuses and vascular offshoots is an over-simplification. Note retardation of growth caused by (*a*) more fœtuses in the horn, (*b*) position of top fœtus in the horn, and (*c*) increasing distance from the ends of the horn. The correlation between placental and fœtal sizes is also indicated

nutrition during the last 6 of the 21 weeks of pregnancy. No effect could be obtained at earlier stages.

Such results do not, of course, exclude the simultaneous participation of the hæmodynamic mechanisms discussed earlier. That these mechanisms may have application to the human species is suggested by the finding that mothers who smoke give birth to babies weighing, on average, 6 oz. (170 gm.) less than the babies of non-smokers[15]. Since smoking causes peripheral vasoconstriction of about half an hour's duration, it is quite possible that repetition many times a day might restrict the placental circulation sufficiently to affect the growth of the fœtus. It remains to be seen whether such differences in weight at birth as that between the Shire–Shetlands and Shetland–Shires of Hammond and Walton can be accounted for in terms of vascular architecture and the mechanics of fluid flow.

---

[1] Walton, A., and Hammond, J., *Proc. Roy. Soc.*, B, 125, 311 (1938).
[2] Robson, E. B., *Ann. Hum. Genet.*, 19, 262 (1955).
[3] Joubert, D. M., and Hammond, J., *J. Agric. Sci.*, 51, 325 (1958).
[4] Venge, O., *Acta Zool., Stockh.*, 31, 1 (1950).
[5] Hunter, G. L., *J. Agric. Sci.*, 48, 36 (1956).
[6] Brumby, P. J., *Heredity*, 14, 1 (1960).
[7] Healy, M. J. R., McLaren, A., and Michie, D., *Proc. Roy. Soc.*, B (in the press).
[8] Hammond, J., and Marshall, F. H. A., "Marshall's Physiology of Reproduction", third edit., 2, Chap. 22 (Longmans, Green, London).
[9] Eckstein, P., McKeown, T., and Record, R. G., *J. Endocrinol.*, 12, 108 (1955).
[10] McLaren, A., and Michie, D., *J. Exp. Biol.*, 36, 281 (1959).
[11] McLaren, A., and Michie, D., *Mem. Soc. Endocrinol.*, No. 6, 65 (1959).
[12] McLaren, A., and Michie, D., *J. Exp. Zool.*, 141, 47 (1959).
[13] McLaren, A., and Michie, D., *J. Exp. Biol.*, 36, 301 (1959).
[14] Wallace, L. R., *J. Agric. Sci.*, 38, 367 (1948).
[15] Lowe, C. R., *Brit. Med. J.*, ii, 673 (1959).

NATURE OF THE HÆM-BINDING GROUPS IN NATIVE AND DENATURED HÆMOGLOBIN AND MYOGLOBIN

By Dr. JOAN KEILIN
School of Veterinary Medicine, University of Cambridge

HÆMOGLOBIN is very widely but somewhat irregularly distributed in Nature[1,2]. It is found in all vertebrates with the exception of certain bloodless fish living in the antarctic seas, and in many species of different phyla of invertebrates. Its presence has also been demonstrated in a few ciliates among the Protozoa, in certain strains of yeasts and moulds and in the root nodules of leguminous plants.

Although the hæmoglobins, irrespective of their origin, have the same fundamental property of reversible oxygenation and have the same hæm nucleus as their prosthetic group, they differ greatly in their biological, chemical and physical properties[3] such as their affinity for oxygen and its dependence on *p*H, their affinity for carbon monoxide, molecular weight, solubility, ease of crystallization and crystalline form, the amino-acid composition of the protein, the isoelectric point, electrophoretic behaviour, ease of denaturation and immunological properties. Different hæmoglobins have been found within the same species of animals and even in the same individual, and extensive investigations are now being carried out on different genetically controlled hæmoglobins in man, cattle, sheep and other animals[4–6].

One may therefore ask what is the structural peculiarity which must be common to the proteins of all the hæmoglobins, irrespective of their origin and the great diversity of their properties, that imparts to the identical hæm nucleus (protohæm) the remarkable and not easily imitable property of combining reversibly with molecular oxygen, while at the same time protecting its divalent iron from oxidation. This is one of the most important problems which faces all those engaged in the study of hæmoglobin. That this fundamental property depends on the integrity of the protein moiety is clearly shown by the fact that the slightest disturbance in its structure is immediately reflected in the ability of its divalent iron to combine reversibly with molecular oxygen, while denaturation of the protein results in the complete loss of the property of oxygenation. In this respect hæmoglobin is, if anything, more fragile than a number of enzymes.

Although in hæmoglobin, as in other hæmoproteins, it is the entire protein portion of the molecule that influences the properties of the hæm, the first and most convenient approach to the study of this problem is to determine the nature of the groups which link the protein to the hæm iron; these will be referred to as the hæm-binding groups of the protein.

The main object of this article is to evaluate the different views which have recently been put forward as to the nature of the hæm-binding groups and to introduce some new criteria which can be applied to their study, not only in mammalian hæmoglobin and myoglobin but also—a point of great importance—in hæmoglobins of different origins, which differ widely in the amino-acid compositions of their proteins.

Nature of the Group linking the Hæm Iron to the Protein

In considering the nature of the hæm-binding group of globin, the following four possibilities have so far been suggested: (1) the imidazole group of histidine; (2) the carboxyl groups of aspartic and glutamic acids, (3) the sulphydryl group of cysteine; and (4) no specific group.

(1) *The imidazole group of histidine.* The most widely held view is that the iron-linked group of globin is the imidazole ring of histidine. This was at first suggested mainly because mammalian hæmoglobin is rich in this amino-acid; and later this view received strong support from an extensive study of certain physico-chemical properties of hæmoglobin which we owe primarily to Wyman[6] and to Coryell and Pauling[7]. The imidazole ring of histidine as the hæm-linking group has already been discussed on several occasions[4,8,9] and will be dealt with farther on.

(2) *Carboxyl groups.* It was recently suggested by O'Hagan[10] that the hæm iron is bound to a carboxyl group of globin, since the pH stability curves of methæmoglobin obtained by the oxidation of hæmoglobin, or by its reconstitution from native globin and hæmatin, show ionizing groups with pK 4·7. This value lies closer to the pK of the carboxyl groups of aspartic and glutamic acids than to that of the imidazole group of histidine (pK 5·3). This view was also supported by Haurowitz[11].

(3) *Sulphydryl group.* The possibility that the hæm iron is linked to globin through a sulphydryl group of cysteine was at first suggested by Haurowitz[12], who later abandoned this view when myoglobin was found to be free of cysteine[13]. The idea was, however, recently revived by Riggs[14,15], who found that the magnitude of the Bohr effect in mammalian hæmoglobins was proportional to the number of sulphydryl groups which could be titrated by mercuric ions and that the hæm–hæm interaction, which is responsible for the S-shaped oxygen dissociation curve, is abolished when the sulphydryl groups are blocked by p-chloromercuribenzoate. He concluded that the two physiologically important properties of hæmoglobin, the Bohr effect and the S-shaped dissociation curve, are both mediated by sulphydryl groups which link the hæm iron to the globin. He also suggested that much of the physico-chemical evidence presented in favour of the imidazole ring as the hæm-linking group could equally well apply to the sulphydryl group.

(4) *No specific group.* Having discarded the possibility of the sulphydryl nature of the hæm-binding group, Haurowitz and Hardin[16] suggested "that the common feature of all globins is a complementary 'anti-heme' pattern which permits them to approach very closely the flat heme structure", so that the "hemoglobin structure would be maintained by London – van der Waals forces between the molecular surfaces of the heme and the anti-heme pattern of the globin". Since this view does not refer to the protein groups specifically linked to the iron, it may be considered as complementary to each of the previous hypotheses.

For the proper evaluation of these views on the possible nature of the hæm-linked groups in hæmoglobin, it is necessary to consider the reactions of free hæm and hæmatin with different substances, and to determine the requirements for the formation with some of them of the corresponding hæmochromogen and parahæmatin compounds.

Formation of Hæmochromogens by Hæm with Nitrogenous Bases

Hæm, the prosthetic group of hæmoglobin, is a flat molecule consisting of four pyrrol nuclei joined by methene bridges to form a porphyrin ring, with a divalent iron atom occupying the centre. Of the six co-ordination valencies of the iron, four lie in one plane and link it to the nitrogen atoms of the pyrrol nuclei, whereas the remaining two valencies, the fifth and sixth, one on each side of the flat hæm molecule, link it to molecules of water. An alkaline solution of hæm shows two diffuse absorption bands at about 580 and 560 mμ. The addition of pyridine to the hæm solution at once gives a pyridine hæmochromogen compound with two strong absorption bands in the visible region; α at 557 and β at 525 mμ ($\alpha > \beta$). Analogous hæmochromogens can be obtained with a great variety of nitrogenous bases[17,18] such as piperidine, pyrrolidine, nicotine, various amines, imidazole, ammonia, hydrazine hydrate and others. In all hæmochromogens the hæm iron is linked by covalent bonds in positions 5 and 6 to two molecules of the base[19], which replace the molecules of water.

Cyanide, unlike other nitrogenous substances, forms two distinct compounds with hæm: monocyan- and dicyan-hæm. While the general pattern of the absorption bands of monocyan-hæm resembles that of a hæmochromogen, the pattern of the dicyan-hæm spectrum differs from it and is very similar to that of the dihydroxy-hæm compound[20]. Monocyan-hæm has a strong affinity for nitrogenous bases; for example, with imidazole it forms a hybrid imidazole–cyanide hæmochromogen in which one of the two positions around the iron (fifth or sixth) is occupied by cyanide, the other by a molecule of imidazole. Such a hybrid hæmochromogen can also be obtained by treating an ordinary hæmochromogen with cyanide, which replaces one of the two molecules of the base linked with the hæm iron[21]. In this reaction the absorption bands in the visible region of the imidazole hæmochromogen are shifted to longer wavelengths, their positions in the imidazole cyanide hybrid hæmochromogen being α, 560 and β, 530 mμ, while the height (*EmM*) of the α band falls from 0·28–0·32 to about 0·17.

In order to find what chemical groupings in a substance determine its ability to combine with the hæm iron by covalent bonds in positions 5 and 6 to form a hæmochromogen, I have examined a great variety of substances with regard to their reactions with hæm (unpublished work). It was found that hæm formed no hæmochromogens with alcohols, aldehydes, carbohydrates, fatty acids or phenols. Only substances containing a free nitrogenous group (as has been shown earlier) combine with the hæm iron to give the corresponding hæmochromogen compounds. Since not all nitrogenous substances were found to have this property, it is of interest to record here some of the biologically important nitrogenous substances which formed no hæmochromogens with either protohæm or other hæms (hæmatohæm, deuterohæm, mesohæm, coprohæm and urohæm), although the experiments were carried out under a great variety of conditions. The list of nitrogenous substances which failed to give hæmochromogens included urea, guanidine, creatine, creatinine, pyrrol, indol, indolacetate, proline, purines such as adenine, guanine, hypoxanthine, xanthine, uric acid, caffeine, theophylline and theobromine, pyrimidines (cytosine and thymine), adenosine, nucleic acid and its derivatives, and flavine. It is interesting to note that of all the purines and pyrimidines tested, only the unsubstituted free bases, purine and pyrimidine, gave a hæmochromogen.

The divalent iron of hæmochromogens easily undergoes reversible oxidation to the tervalent iron of the corresponding parahæmatins, which have a diffuse absorption band at about 530 mμ with a shoulder at 558 mμ. In a similar way, the oxidation of a hybrid hæmochromogen gives the corresponding hybrid parahæmatin. The formation of this compound was discovered[22] in early work on the inhibition by cyanide of the oxidation of cysteine catalysed by pyridine hæmochromogen. It was shown by Drabkin[23] that this hybrid parahæmatin can be obtained by treating hæmatin with cyanide and pyridine in the ratio of 0·1 to 5,000.

The oxidation-reduction relationship:

$$\text{hæmochromogen} \rightleftharpoons \text{parahæmatin}$$

is analogous to those of:

$$\text{hæm} \rightleftharpoons \text{hæmatin and hæmoglobin} \rightleftharpoons \text{methæmoglobin}$$

Carboxy-hæm and Carboxy-hæmochromogen Compounds

On treating hæm with carbon monoxide, its colour turns from reddish brown to bright red and its very diffuse absorption bands at 580 and 560 mμ are replaced by two strong bands: α, 563, β, 533 mμ (α > β). In this reaction, of the two molecules of water co-ordinated with the divalent hæm iron in positions 5 and 6, only one is replaced by a molecule of carbon monoxide. Similarly, when a hæmochromogen is treated with carbon monoxide, one of the two molecules of the base is replaced by carbon monoxide, giving the corresponding carboxy-hæmochromogen[19] which, as was shown for the first time by Krebs[21], is sensitive to light.

The study of carbon monoxide derivatives is of great importance when considering certain reactions between hæm and proteins. In fact, as carboxy-hæm has a much greater affinity for nitrogenous substances than has free hæm, it was used as well as mono-cyan hæm for the final assessment of compounds as to their ability to combine with the iron of hæm. Moreover, since carboxy-hæm, like mono-cyan hæm, can combine with only one nitrogenous group, it can be used for the study of the reactivity of such a group when, owing to some spatial considerations, its co-ordination with the hæm iron is possible on only one side of the flat hæm molecule.

Hæmochromogen Formation by Amino-acids and Denatured Proteins

The reactions of free hæm with amino-acids and proteins are of special interest for the study of the hæm-binding groups in hæmoglobin as well as in other natural hæmoproteins. It can be demonstrated spectrophotometrically that neither free hæm nor free hæmatin combines with hæmoglobin or methæmoglobin respectively, which indicates that all the available hæm-binding groups of the native globin are already occupied. On mild denaturation, hæmoglobin forms globin hæmochromogen, which resembles the hæmochromogens given by hæm with different nitrogenous bases. When, however, free hæm is added to globin hæmochromogen, the absorption bands of the latter are greatly intensified, showing that denaturation of the globin increases its hæm-binding capacity at least six-fold. Although this property of globin, as well as of other proteins, was known for a long time[24–26], its full significance has not yet been properly appreciated. It was tacitly assumed that denaturation of proteins unmasks several potential hæm-binding groups belonging to different amino-acid residues, but early attempts to demonstrate the correctness of this assumption, by studying the reactions of hæm with free amino-acids, were very disappointing. According to Haurowitz[18], neither parahæmatin nor hæmochromogen could be obtained from hæmatin or hæm, respectively, treated with histidine, alanine, leucine, glycine, cysteine or glutathione, although it had been previously recorded[25] that glycine does give a hæmochromogen compound with hæm. Potentiometric titration[26] of 10^{-4} *M* hæmatin with sodium dithionite in the presence of histidine has shown that the oxido-reduction potential became constant only when the histidine added reached a concentration of 7×10^{-2} *M*. No attempt was made in this experiment to follow the reaction between hæm and histidine spectrophotometrically.

More recently spectrophotometric studies of the reactions between different hæms (protohæm, mesohæm, deuterohæm and urohæm) and amino-acids[18,27] revealed that, given the right conditions, typical hæmochromogen compounds were obtained with practically every amino-acid except proline, which shows that the α-amino group is a hæm-binding group common to all the amino-acids, provided that the hydrogens of the amino-group are not substituted; thus, while alanine gave a hæmochromogen, no hæmochromogen was obtained with N-monomethyl alanine or N-dimethyl alanine.

For the study of the reactions between hæm and proteins it was important to evaluate the hæm-binding properties of other potentially reacting groups of the amino-acids. Such evaluations were obtained from (1) the reactions of hæm with amino-acids in which the participation of the α-amino group was eliminated by being involved in a peptide linkage, or (2) the reactions of hæm with the potentially hæm-binding group either in the free state—for example, imidazole—or forming part of a compound free from other possible reacting groups—for example, the imidazole ring in pilocarpine.

The results of this work (unpublished), carried out with different hæms and their carbon monoxide derivatives, showed that only basic nitrogenous groups of amino-acids can combine with hæms or carboxy-hæms to give the corresponding hæmochromogens or their carboxy derivatives. This eliminates from the list of potential hæm-binding groups in denatured proteins the carboxylic side-chains of glutamic and aspartic acids, the benzene ring of tyrosine and phenylalanine and the sulphydryl group of cysteine. Of the nitrogenous basic groups such as the terminal α-amino group of different amino-acids, the ε-amino group of lysine, the imidazole group of histidine and the indole group of tryptophan, only the first three were definitely established as potential hæm-binding groups. The hæm-binding property of the imidazole group of histidine was supported by the great ease with which free imidazoles, or the imidazole ring of pilocarpine, or of urocanic acid and certain other compounds form parahæmatins and hæmochromogens (unpublished work; see also refs. 18, 31, 32). Strong evidence for the hæm-binding property of the ε-amino group of lysine was obtained from the study of polylysine, which was found to have ten times higher affinity for hæm than free lysine. On the other hand, the side-chains of tryptophan and arginine were eliminated as potential hæm-binding groups by the failure to obtain hæmochromogens with free indole and free guanidine, as well as with denatured salmine and clupeine, which can be considered as polyarginine peptides. It was also found that whereas pyrrolidine gave a good hæmochromogen, free proline failed to co-ordinate with the hæm iron.

The potential hæm-binding groups, which become unmasked by the denaturation of proteins, are therefore limited to the terminal α-amino groups, the ε-amino group of lysine and the imidazole group of histidine. The total number of such groups[13] in whale and horse myoglobins (molecular weight, 17,000) are 32 and 28 respectively, and in horse hæmoglobin (molecular weight, 68,000) there are 76–80, that is, about 19–20 per unit of molecular weight, 17,000. Since the hæm-binding capacity or 'hæm-number' of sperm whale myoglobin is 10 and that of horse hæmoglobin is 6 per unit of protein of molecular weight 17,000 (ref. 27), and since each hæm iron co-ordinates with two nitrogenous groups to form a hæmochromogen, about 62 per cent of all available hæm-binding groups in denatured myoglobin and hæmoglobin are involved in hæmochromogen formation.

The study of hæmochromogen formation by denatured proteins including the globins, which will be fully dealt with elsewhere, has led to the following conclusions:

(1) As the iron atom in hæmochromogens is co-ordinated with two nitrogenous groups lying one on each side of the flat hæm molecule and occupying the fifth and sixth co-ordination positions, the hæm in denatured protein hæmochromogen must lie within the folds of the protein. This is made possible by the unfolding of peptide chains which characterizes denaturation in proteins, that is, the breaking of the bonds of the tertiary structure of the hæmoglobin molecule.

(2) The two nitrogenous groups, one on each side of the protein fold, which are linked to the hæm iron are not necessarily of the same nature; for example, one may be an imidazole group and the other an ε-amino group of lysine, or even an α-amino end-group.

(3) Since two nitrogenous groups, one on each side of the fold, are required for the formation of a hæmochromogen, there must be a certain regularity in their distribution in order to assume a high 'hæm number' which may involve more than 50 per cent of all the potential hæm-binding groups of the protein.

(4) The 'hæm number' of a denatured protein must therefore depend on: (a) the number of free nitrogenous hæm-binding groups; (b) a certain regularity in their distribution; and (c) freedom from steric hindrance by neighbouring side-chains. In this respect consideration should be given to all side-chains not involved in hæm-binding; for example, SH or S—S groups, the guanidine group of arginine, the indole group of tryptophan, the benzene ring of tyrosine or phenyl-alanine, and the carboxylic groups of glutamic and aspartic acids.

Reversible Formation of Hæmochromogen by Native Hæmoglobin

The fact that the iron atoms of hæmoglobin and methæmoglobin are accessible to, and easily combine with, a great variety of ligands some of which, like nitrosobenzene and imidazole, are of an appreciable size, clearly shows that the hæm or hæmatin is well exposed and not buried deeply within the folds of the protein[33–35].

That the hæm is bound to the globin not only by its iron atom but also by its porphyrin ring is indicated by the marked effect that free native globin has on the absorption spectrum of an alkaline solution of free porphyrin, and by the competition of porphyrin and hæm for native globin in experiments on the reconstitution of hæmoglobin from its components[36]. The two carboxyl groups of hæm are probably linked to the guanidine groups of the arginine residues[37].

Since the hæms in hæmoglobin are not buried between the folds of the globin, their iron atoms are linked to the globin by only one iron-protein bond (co-ordination position 5) lying on one side of the flat hæm molecule; on the other side (position 6), the iron is bound to a molecule of water, the presence of which was shown by spectroscopic studies[38] of the effect of low temperatures on alkaline methæmoglobin, and of the effect of drying on hæmoglobin and methæmoglobin.

The molecule of water in position 6 can be replaced in hæmoglobin by oxygen, carbon monoxide, nitric oxide, cyanide, alkyl cyanides or nitrosobenzene, and in methæmoglobin by fluoride, azide, cyanide, sulphide, nitric oxide or imidazole. As under certain well-defined conditions the denaturation of hæmoglobin was found to be a reversible process (unpublished work and ref. 38), it is possible that in the globin hæmochromogen thus obtained one of the two bonds uniting the hæm iron to globin is the original iron-protein bond present in hæmoglobin. The persistence of the original iron-protein bonds of hæmoglobin during the reversible formation of globin hæmochromogen and parahæmatin can be demonstrated by the following experiments.

(1) *Drying of hæmoglobin.* It has been shown that, when hæmoglobin or myoglobin is thoroughly dried, its absorption spectrum is replaced by that of a hæmochromogen[39–41]. On the addition of water, this reverts to hæmoglobin which, in the presence of oxygen, undergoes oxygenation to oxyhæmoglobin. This reversible formation of a hæmochromogen on drying is due to the fact that the molecule of water linked to the iron atom in the sixth co-ordination position is removed and replaced by a nitrogenous group of the protein belonging to the same molecule of hæmoglobin.

(2) *Drying of methæmoglobin.* In a similar way, the drying of acid methæmoglobin converts it reversibly to a parahæmatin[41]. That fluoride and azide methæmoglobin are not changed by drying to a parahæmatin is not surprising, since the fluoride or azide which replaced the water molecule of the methæmoglobin prevents the hæm iron from co-ordinating in position 6 with a nitrogenous group of the globin, brought closer to the iron by drying. The

fact that the absorption spectra of hæmoglobin and methæmoglobin are easily replaced on drying by those of the hæmochromogen and parahæmatin spectra, respectively, suggests that either an imidazole group of histidine or, more likely, an ε-amino group of lysine, must lie in close proximity to the water molecule attached to the iron atom.

(3) *The reaction of methæmoglobin with cyanide.* On treating acid methæmoglobin with cyanide, its colour changes from brown to red and its absorption band at 630 mμ is replaced by a wide band at 540 mμ. Cyan-methæmoglobin, which is one of the oldest known methæmoglobin derivatives[41], was at one time wrongly considered as an irreversible compound because of the very high affinity of cyanide for the tervalent iron of the methæmoglobin. Spectroscopically, it shows a close resemblance to the hybrid cyan-pyridine or cyan-imidazole parahæmatins referred to earlier.

(4) *The reaction of hæmoglobin with cyanide.* Cyan-hæmoglobin can easily be obtained by reducing cyan-methæmoglobin with sodium dithionite[42–44]. While the cyan-hæmoglobin obtained in this way is very unstable and rapidly dissociates into hæmoglobin and cyanide, cyan-myoglobin is sufficiently stable for spectrophotometric studies. It has a characteristic absorption spectrum very similar to that of cyan-pyridine or cyan-imidazole–hybrid hæmochromogens, with two strong absorption bands: α, 562 and β, 535 mμ (α > β). Cyan-myoglobin can be described as cyan-native globin–hybrid hæmochromogen, and its formation requires a high concentration of cyanide at *p*H 9. A compound which is practically indistinguishable from cyan-methæmoglobin was obtained[45] by treating reduced peroxidase with cyanide at *p*H 8·5–9·3. An interesting point was the discovery that cyan-ferroperoxidase and, to a lesser degree, cyan-myoglobin, undergo reversible photodissociation, liberating ferroperoxidase and myoglobin respectively and cyanide[46].

The fact that in these experiments hæmochromogens and parahæmatins were reversibly obtained from hæmoglobin and methæmoglobin respectively, on replacing the water molecule bound to the hæm iron in position 6 by a suitable nitrogenous compound, indicates that in position 5 the hæm iron must be linked to a nitrogenous compound which is the original hæm-binding group of the hæmoglobin. Since this group is a potential hæmochromogen-forming compound, it can only be the imidazole ring of histidine, the ε-amino group of lysine or, less likely, an amino end-group. This eliminates from the list of potential hæm-binding groups the side-chains of all other amino-acid residues, and also dismisses the possibility that the hæm-binding group could originally have been one of the non-hæmochromogen-forming side-chains which was replaced by a hæmochromogen-forming group only when the water molecule in position 6 was exchanged for a suitable nitrogenous substance. In fact, such a process would imply a rapid and reversible displacement of the hæm molecule in relation to the globin; this could scarcely take place, considering (*a*) that hæm is bound to the globin not only by its iron atom but also by the propionate groups and by van der Waals forces between its surface and that of the globin[16], (*b*) that reversible hæmochromogen formation may take place under conditions precluding the denaturation of the hæmoglobin, and (*c*) that cyan-native globin hæmochromogen can be dissociated by light into cyanide and hæmoglobin.

Evidence for the Imidazole Ring of Histidine as the Hæm-binding Group of Globin

Although the hæmochromogen criterion reduces the number of potential hæm-binding groups in hæmoglobin to only three types of basic groups, the imidazole ring of histidine, the ε-amino group of lysine and a terminal α-amino group, it makes no discrimination between them.

Of the views as to the nature of the hæm-binding group which were discussed earlier, the hæmochromogen criterion provides evidence only in favour of the imidazole theory which, as was shown above, was also supported by physico-chemical evidence[6–9], and by the facts that the globins of hæmoglobin and myoglobin are very rich in histidine. It must, however, be remembered that the physico-chemical evidence is largely based on the assumption that the properties of the imidazole ring of histidine which is incorporated in the peptide chain of the globin are quantitatively identical with those of the imidazole ring of free histidine. That this may not necessarily be so is indicated by the fact that the affinities of amino-acids for hæm are greatly enhanced when they form part of a peptide chain[16]. It has also been shown that the formation of a carbamino compound by glycine was increased thirty-fold by condensing two glycine molecules to a dipeptide[9]. Some caution must therefore be exercised in describing certain properties of proteins in terms of what is known of the individual amino-acids.

In spite of certain objections raised against the idea of the imidazole nature of the hæm-binding group in mammalian hæmoglobins and myoglobins[10–12,14,15,33], this theory, unlike any of the others so far proposed, is strongly supported both by the hæmochromogen criteria and by our present knowledge of the properties of hæmoglobin and its derivatives.

More direct evidence in favour of the view that the imidazole group of histidine binds the hæm iron to the globin was obtained from the X-ray analysis of crystals of myoglobin[47]. Indeed, the great advances which were recently made by Perutz and his co-workers[48] in their studies on the structure of hæmoglobin and by Kendrew and his co-workers[47,49] on the structure of myoglobin enabled them to unravel the tertiary structure of a protein molecule for the first time. Their results were based on three-dimensional Fourier syntheses at 5·5 Å. resolution in the case of horse oxy- and met-hæmoglobin[48] and at 2·0 Å. resolution in the case of sperm whale metmyoglobin[47,49].

The myoglobin molecule was found by Kendrew *et al.*[49] to consist of a single polypeptide chain folded in a somewhat complex manner, the straight portions of the chain having the structure of cylindrical tubes consisting of α-helices. The high degree of resolution has also shown that an amino-acid residue strongly suggestive of histidine, arising from the peptide chain adjacent to the hæm disk, is directed towards the hæm iron atom, whereas on the other side of the disk, what appears to be the oxygen of a water molecule lies very close to the iron. The terminal amino-group lies well away from the hæm.

The molecule of horse hæmoglobin was found by Perutz *et al.*[48] to be composed of four sub-units, each consisting of a single peptide chain folded in a very similar manner to that of sperm whale myoglobin. The hæm of each sub-unit is located in a pocket of the folded peptide chain, the four pockets being com-

Table 1. AMINO-ACID CONTENTS, ISOELECTRIC POINTS (I.P.) AND MOLECULAR WEIGHTS (MOL. WT.) OF SOME OXYGEN CARRIERS

Hæmoprotein oxygen carrier	Grams of amino-acid per 100 gm. protein*						I.P.	Mol. wt.
	Hist.	Lys.	Arg.	Trypt.	Tyr.	Cyst.		
Myoglobins								
Sperm whale (ref. 13)	11·12	15·90	2·24	2·00	2·12	0	6 78	17,000
Aplysia (marine mollusc) (ref. 50)	1·22	6·89	4 57	—	1·48	0	4·5	18,000
Hæmoglobins								
Horse (ref. 13)	8·71	8·51	3·65	1·70	3·03	1·01	6 9	68,000
Earthworm (ref. 51)	4 68	1·73	10·07	4·41	3·47	1·41	5 2	2,750,000
Arenicola (marine worm) (ref. 51)	4·03	1·85	10 04	1·64	2·52	4·08	4 5	2,750,000

* The amino-acids selected are limited to those which have been determined in certain invertebrates (ref. 51). In the cases of mammalian hæmoglobin and myoglobin (ref. 13) and *Aplysia* myoglobin (ref. 50), the complete balance sheet is available.

Abbreviations: Hist., histidine; Lys., lysine; Arg., arginine; Trypt., tryptophan; Tyr., tyrosine; Cyst., cysteine.

pletely independent of each other, the iron atoms of the closest pair being 25 Å. apart. The hæm iron on the side where it is linked with a water molecule, both in myoglobin and in hæmoglobin, is freely accessible to ligands of a large size[43] including *p*-iodophenylhydroxylamine[44].

The finding that the molecule of horse hæmoglobin consists of four sub-units each with a structural configuration closely resembling that of sperm whale myoglobin is very interesting and unexpected, considering that the amino-acid compositions of these two hæmoproteins show marked quantitative differences in the case of practically every amino-acid residue[13]. Some of these differences are shown in Table 1.

It was suggested by Perutz *et al.*[45] that "probably the chain, once it is synthesized and provided with a hæm group around which it can coil, takes up this configuration spontaneously, as the only one which satisfies the stereochemical requirements of its amino-acid sequence". This suggestion has direct bearing on the problem of the susceptibility of hæmoglobin to denaturation, which consists primarily in the breaking of bonds leading to the opening or uncoiling of the tertiary structure. Of special importance in this respect are the observations on the reversibility of denaturation in hæmoglobin[46]. It is also known that globin separated from hæm is very unstable, and that the susceptibility of hæmoglobin to denaturation is also affected by the nature of the ligands occupying co-ordination position 6 and by the nature of the bonds which link the hæm iron to surrounding atoms. Thus oxyhæmoglobin is much more resistant than methæmoglobin to denaturation by strong alkali or chloroform. Finally, hæmoglobin is more susceptible to irreversible denaturation than myoglobin. This may be due to the close proximity of the four sub-units in hæmoglobin which, in the partly uncoiled state, may interfere with each other in the proper recoiling of the peptide chain.

Whether or not the structural configuration of the myoglobin molecule is of general significance will be determined only by the study of invertebrate hæmoglobins and myoglobins, the amino-acid balance sheets of which show very great differences from those of the mammalian hæmoproteins[13,50,51] (Table 1). The myoglobin of the marine mollusc *Aplysia* is of special interest in this respect. *Aplysia* myoglobin (molecular weight 18,000), which has been obtained in a pure crystalline state, contains only one histidine residue per molecule, and it differs from mammalian myoglobins and hæmoglobins in the content of all the other amino-acid residues[50]. Considering that, apart from *Aplysia* myoglobin, investigations have been carried out on the hæmoglobins of only very few invertebrates and on material which was incompletely purified and scarcely sufficient in quantity for accurate analysis by the methods then used, it is possible that further work may reveal the existence of a hæmoglobin devoid of histidine. That histidine is not a universally distributed amino-acid is shown by its absence from the proteins of certain strains of viruses[52]. The hæmochromogen criterion has, however, shown that in a hæmoprotein deficient or completely free of histidine, the hæm-binding role of the imidazole ring could be taken over by the ε-amino group of lysine or even by a terminal α-amino group.

Indeed, it is only the study of hæmoglobins and myoglobins of different origins, which show the greatest diversity in their amino-acid compositions and in their physical and chemical properties, that will reveal the nature of the structural peculiarity common to all of them (but not to other hæmoproteins which only undergo oxido-reduction) that confers on the divalent iron of the hæm the property of combining reversibly with molecular oxygen without undergoing oxidation.

I am indebted to the Wellcome Trust for a research grant, to Dr. J. C. Kendrew for crystalline sperm whale myoglobin, and to Dr. C. H. Bamford and Dr. W. E. Hanby for samples of polylysine.

[1] Redfield, A. C., *Quart. Rev. Biol.*, 8, 31 (1933).
[2] Keilin, D., *Acta Biochim. Polonica*, 3, 439 (1956).
[3] Itano, H. A., "Adv. Protein Chem.", 12, 215 (1957).
[4] Ingram, V. M., *Brit. Med. Bull.*, 15, 27 (1959).
[5] Lehmann, H., *Brit. Med. Bull.*, 15, 40 (1959).
[6] Wyman, J., "Adv. Protein Chem.", 4, 407 (1948).
[7] Coryell, C. D., and Pauling, L., *J. Biol. Chem.*, 132, 769 (1940).
[8] Lemberg, R., and Legge, J. W., "Hematin Compounds and Bile Pigments" (Intersci. Pub., 1949).
[9] Roughton, F. J. W., "Harvey Lect.", 39, 96 (1943–44).
[10] O'Hagan, J. E., *Nature*, 183, 393 (1959).
[11] Haurowitz, F., see discussion p. 48 in Conference on Hemoglobin, Pub. 557, National Academy Sciences (Washington, D.C., 1958).
[12] Haurowitz, F., *Hoppe-Seyl. Z.*, 232, 146 (1935).
[13] Tristram, G. R., "The Amino Acid Composition of Proteins", in "The Proteins", 1 A, 181, edit. Neurath, H., and Bailey, K. (Academic Press, New York, 1953).
[14] Riggs, A., *J. Gen. Physiol.*, 36, 1 (1952).
[15] Riggs, A., *Nature*, 183, 1037 (1959).
[16] Haurowitz, F., and Hardin, R. L., "Respiratory Proteins", in "The Proteins", 2 A, 279, edit. Neurath, H., and Bailey, K. (Academic Press, New York, 1954).
[17] Hirsch, M., "Zur Kenntnis der Blutfarbstoffe", doctoral dissertation, Heidelberg (1934).
[18] Keilin, J., "Reactions of Porphyrins and Metalloporphyrins with Nitrogenous Substances and Their Bearing on the Structure of Hæmoglobin", dissertation, Univ. Cambridge (1951).
[19] Hill, R., *Proc. Roy. Soc.*, B, 100, 419 (1926).
[20] Keilin, J., *Biochem. J.*, 45, 448 (1949).
[21] Hill, R., *Proc. Roy. Soc.*, B, 105, 112 (1929).
[22] Krebs, H. A., *Biochem. Z.*, 204, 322 (1929).
[23] Drabkin, D. L., *J. Biol. Chem.*, 142, 855 (1942); 146, 605 (1942).
[24] Anson, M. L., and Mirsky, A. E., *J. Gen. Physiol.*, 12, 273 (1928–29).
[25] Holden, H. F., and Freeman, M., *Aust. J. Exp. Biol. Med. Sci.*, 6, 79 (1929).

[26] Zeile, K., and Gnant, G., *Hoppe-Seyl. Z.*, **263**, 147 (1940).
[27] Keilin, J., *Nature*, **185**, 151 (1960).
[28] Drabkin, D. L., *J. Biol. Chem.*, **158**, 721 (1945).
[29] Rosenberg, L. L., and Clark, W. M., *J. Biol. Chem.*, **205**, 617 (1953).
[30] Barron, E. S. G., *J. Biol. Chem.*, **121**, 285 (1937).
[31] Langenbeck, W., *Ber. dtsch. chem. Ges.*, **65**, 842 (1932).
[32] Cowgill, R. W., and Clark, W. M., *J. Biol. Chem.*, **198**, 33 (1952).
[33] Keilin, D., *Nature*, **171**, 922 (1953).
[34] Kendrew, J. C., and Parrish, R. G., *Nature*, **175**, 206 (1955).
[35] George, P., and Lyster, R. L. J., in Conference on Hemoglobin, 33. Pub. 557, National Academy Sciences (Washington, D.C., 1958).
[36] Hill, R., and Holden, H. F., *Biochem. J.*, **20**, 1326 (1926).
[37] Granick, S., "Harvey Lect.", **44**, 220 (1949).
[38] Anson, M. L., "Adv. Protein Chem.", **2**, 361 (1945).
[39] Zeynek, R., *Wien. Lab.*, **38**, 406 (1926).
[40] Haurowitz, F., *J. Biol. Chem.*, **193**, 443 (1951).
[41] Keilin, D., and Hartree, E. F., *Nature*, **170**, 161 (1952).
[42] Kobert, R., *Jahrber. Fortschr. Tierchem.*, **21**, 443 (1891).
[43] Stitt, F., and Coryell, C. D., *J. Amer. Chem. Soc.*, **61**, 1263 (1939).
[44] Klose, M., and Kasake, H., *Biochem. Z.*, **312**, 121 (1942).
[45] Keilin, J., *Biochem. J.*, **59**, 571 (1955).
[46] Keilin, D., and Hartree, E. F., *Biochem. J.*, **61**, 153 (1955).
[47] Kendrew, J. C., Dickerson, R. E., Strandberg, B. E., Hart, R. G., Davies, D. R., Phillips, D. C., and Shore, V. C., *Nature*, **185**, 422 (1960).
[48] Perutz, M. F., Rossmann, M. G., Cullis, A. F., Muirhead, H., Will, G., and North, A. C. T., *Nature*, **185**, 416 (1960).
[49] Kendrew, J. C., Bodo, G., Dintzis, H. M., Parrish, R. G., Wyckoff, H., and Phillips, D. C., *Nature*, **181**, 662 (1958).
[50] Rossi-Fanelli, A., Antonini, E., and Povoledo, D., in "Symposium on Protein Structure", 144, edit. Neuberger, A. (Methuen, London, 1958).
[51] Roche, J., *Bull. Soc. Chim. Biol.*, **16**, 793 (1934).
[52] Markham, R., and Smith, J. D., "Nucleoproteins and Viruses", in "The Proteins", **2** A, 1, edit. Neurath, H., and Bailey, K. (Academic Press, New York, 1954).

NEWS and VIEWS

Physiology at University College, London: Prof. A. F. Huxley

MR. A. F. HUXLEY, who was recently appointed to succeed Sir Lindor Brown (*Nature*, 185, 733; 1960) as Jodrell professor of physiology at University College, London, is well known internationally for his very distinguished research record. Among his contributions may be mentioned the important part he played in elucidating the mechanism of the nerve impulse and in proving the 'saltatory' nature of propagation in myelinated axons. More recently, he turned his attention to the microscopic structure of muscle fibres and was able to clarify greatly the sequence of the structural changes which occur in striated muscle during activity. Throughout his experimental work, he has tackled difficulties with a remarkable technical ingenuity and mathematical skill, developing important new instruments as well as theories as he went along. A. F. Huxley started at Cambridge and Plymouth, in collaboration with Prof. A. L. Hodgkin, a partnership which proved extremely fruitful and continued for many years. During the Second World War, Huxley was engaged in operational research, first with Anti-Aircraft Command and later with the Admiralty. In 1941, he became a Fellow of Trinity College; his most recent Cambridge appointment was to a readership at the Physiological Laboratory. He was elected to the fellowship of the Royal Society in 1955. Although Huxley's research work is highly specialized, his scientific interests cover an unusually wide range, and many physiologists feel indebted to him for the help they received during the period of his editorship of the *Journal of Physiology*. Those who visit the meetings of the Physiological Society regularly are well aware of Prof. Huxley's ability to penetrate scientific problems of a diverse nature. No doubt, in his new appointment, he will find plenty of opportunities of applying this gift.

The Overseas Civil Service

IN an adjournment debate on the Overseas Civil Service on July 11, Mr. B. R. Braine, Mr. J. Callaghan, and Mr. J. D. Tilney pressed the claims of the Overseas Civil Service. Mr. Julian Amery, Under-Secretary of State for the Colonies, who replied for the Government, said that the strength of their plea was fully justified by the importance of the subject and the urgency of the problem. He agreed that strong, efficient and honest administration had been Britain's greatest contribution to the development of the colonies and that one of our main tasks is to leave a strong local administrative service. This is partly a matter of establishing proper principles governing the local administrative services, of taking them out of politics, and of making appointments the responsibility of public service commissions. It is also a matter of retaining the services of ex-patriates for many years to come, and particularly of discovering ways and means of encouraging them to stay and go on serving now that the Secretary of State, as power is transferred, can no longer offer assurance of a career structure and promotion prospects or guarantee jobs in Britain. There must instead be special inducements to serve, and special compensation for loss of office, if and when it comes. At present there are 15,000 pensionable members of the Overseas Service, including 7,000 in East Africa, 1,500 in Nyasaland and Rhodesia, and 2,000 in West Africa, and in addition more than 10,000 are on contract. It is our duty, he said, as well as our interest, to see that, as these territories move to independence, they have an administrative structure which will enable them to maintain stability and to achieve some economic and social expansion. Mr. Amery said he could not make a statement that night, but he assured the House that the Secretary of State for the Colonies regards the problems raised as of the highest importance and calling for urgent solutions.

British and Foreign School Society and Borough Road College

THE Nuffield Foundation has given £50,000 to the Borough Road College, Isleworth, for a new science block which will house mathematics, biology, chemistry and physics in one building. It will be known as the Nuffield Science Building. This independent College has a long tradition of producing teachers of mathematics and science, and the Foundation has made the grant to enable it to increase the number of specialist teachers of these subjects. Borough Road College belongs to the British and Foreign School Society, which is contributing £75,000 towards the general expansion of the College. With the aid of a capital grant from the Ministry of Education, it will be able to raise the number of students from 320 to 500. The College is one of the oldest teacher-training colleges in the world, and recently celebrated its 150th anniversary.

Science and the Public

IN his foundation oration, "The Diffusion of Knowledge", at Goldsmiths' College, University of

London, on March 17, Dr. Michael Grant, president and vice-chancellor of the Queen's University of Belfast, discussed particularly the extraordinarily increasing activity and problem of making specialized knowledge available to the non-specialized adult public, and especially—since his subject was the diffusion of knowledge—of the printed word rather than the use of television or sound-radio (Pp. 15. London: Goldsmiths' College, 1960). The amount of actual knowledge imprinted on the adult general public by these media remains infinitesimal in comparison with what is gathered from printed books; and Dr. Grant directed attention to the fact that commercial advertisers still spend only 13 per cent of their funds on television and 47 per cent on the Press. The sale of informative paper-backed books, of which first editions of as many as 50,000 might be printed and sold, was further evidence of the existence of a demand for popular knowledge.

Discussing the problems involved in popularization, Dr. Grant referred to the difficulty of simplification but emphasized that good popularization could create the atmosphere for good scholarship, in which before long important new research could arise: diffusion and stimulus could go together. There were also problems of vocabulary and presentation as well as of scholarship, nor was it possible to ignore entirely pronouncements on moral or even social values. Even a smattering of reasonably accurate knowledge, however, would make the non-specialized adult population much less likely to become credulous victims of all the nonsense of which people try to convince them, and the spreading of knowledge by popularization was highly relevant to the problem summed up by Sir Charles Snow as that of the two cultures. That problem could not be left entirely to the universities, though he thought they should study deliberately how to produce the habit of mind which will make its students want, both before and after graduation, to take an open-minded interest in at least something worth while outside their own careers. In conclusion, he appealed to his hearers generally to participate themselves in this extremely difficult, heavily criticized but fascinating task of popularizing knowledge, which was worth doing and had to be done, and was more likely to be done successfully by teachers than by most other people.

New C.S.I.R.O. Sugar Research Laboratory

It is announced that a new Sugar Research Laboratory will be set up by the Commonwealth Scientific and Industrial Research Organization, to form part of the Organization's Chemical Research Laboratories in Melbourne. The decision to establish the Laboratory has come after considerable discussion with representatives of the sugar industry, which is anxious to find new uses for the present surplus in Australian production. The surplus corresponds to about a million tons of sugar cane per year. Australia's biggest sugar producer, the Colonial Sugar Refining Co., Ltd., has agreed to contribute £2,500 per annum towards the running costs of the Laboratory. Dr. H. H. Hatt, previously officer-in-charge of the Organization's Organic Chemistry Section, has been appointed leader of research in the new unit.

The Output of Scientists in Scotland : 1600–1950

In a paper, "The Output of Scientists in Scotland, 1600–1950", published in *The Eugenics Review*, July 1960, R. H. S. Robertson advances evidence that from the beginning of the seventeenth until the middle of the eighteenth century the proportion of scientists born in Scotland who emigrated steadily increased: from then until about 1825 it tended to decrease, and in that year 71 per cent of the scientists selected for his sample died in Scotland, compared with 48 per cent in 1750. From 1825, however, the proportion of scientifically gifted Scots who emigrated has increased at an alarming rate, in spite of a slight evening off in the curve and even a recovery in recent years. Since a high proportion of the net loss of emigrants from Scotland of about 24,000 a year is from the more intelligent classes, Robertson urges that action is imperative if disaster is to be prevented. Scotland, he claims, produces 20 per cent of the British output of scientists and technologists, but only some 3 per cent of British scientific posts are available within her boundaries. Attributing the decline in the number of Scottish posts chiefly to the unequal distribution in Britain of research institutions, he urges that research institutes and posts in Scotland should be increased to about 10 per cent of the British total.

Museum of Applied Science of Victoria, Melbourne

The annual report for 1958–59 of the Museum of Applied Science of Victoria, Melbourne, records the welcome news that tenders have been accepted for building extensions and that it is hoped to complete the work by the end of 1960. As available space will be increased by about 50 per cent, this will be the greatest expansion of the Museum since its foundation in 1870 (Pp. 30. Melbourne: Museum of Applied Science of Victoria, 1960). Major displays include exhibitions celebrating one hundred years of State-operated railways in Victoria, present-day telephones, and a sectioned model of a reactor. The increasing interest in space exploration and upper atmosphere research led to the installation of a working exhibit showing satellites in orbit around the Earth. A working exhibit was also made to demonstrate the behaviour of a low-voltage halogen-quenched Geiger tube and its use for radiation measurement. The circuit includes a counting-rate meter for visual monitoring and a loud-speaker for aural monitoring.

Indexes for Scientific and Technical Reports

An investigation by the Research Department of the Association of Special Libraries and Information Bureaux into the indexing of published reports of scientific and technical conferences and symposia, prompted by an inquiry which cited some examples of unindexed publications of this type, established that half the published proceedings and reports of such conferences are provided with neither subject nor author indexes. Based on a survey of some 205 such publications noted in the British National Bibliography during January 1956–September 1959, inclusive, the survey showed that 59 per cent were without subject indexes and 66 per cent without author indexes, 50 per cent being without both. Publications of 301–400 pages were best provided with subject indexes (66 per cent), whereas 90 per cent of those of up to 100 pages were without, 71 per cent of those with 101–200 pages, 57 per cent of those with 201–300 pages, 54 per cent of those with 401–500 pages and 50 per cent of those with more than 500 pages. The position appears to be worsening, the percentage of publications without subject indexes in 1956 being 47; in 1957, 60; 1958, 61; and in

1959, 68, although the latter year is incomplete. A breakdown into broad subject groups showed that for biological and allied sciences the percentage without subject indexes was 53, and for physics, chemistry, engineering and technology, 60.

The report also notes the considerable time-lag between the holding of a meeting and publication of the report of its proceedings, and points out that publications which took more than two years to prepare were even less likely to contain subject indexes than those issued in the same year as the meeting. About a quarter of the reports were published by the organizers of the conferences themselves, and of these 79 per cent were without; about three-fifths of the remainder were issued by four publishing houses, and for these the percentages without subject indexes were 59, 96, 48 and 33. For the 22 reports issued by commercial publishers, the percentage without subject indexes was 35 per cent, and it is worth noting that all ten issued by one and seven out of eight issued by another had subject indexes. The risk that information sought in such reports may not be found is further illustrated by a more detailed example of a random sample of five publications, but this limited survey could not attempt to examine how far the contents of such reports are published elsewhere or caught up by abstracting organizations.

Leo III

An impressive addition to the field of the automatic office is *Leo* III, a new all-transistor digital computer under development by Leo Computers, Ltd. The machine, which incorporates many of the latest advances in data-processing techniques, makes use of a micro-programming construction and can perform arithmetical operations directly on decimal, sterling or any other desired quantities. The time taken for a typical decimal addition is 44 μsec. Perhaps the most interesting feature is that it is one of the first British computers to incorporate an automatic time-sharing facility. This enables two or more different programmes to be run on the computer at the same time and assists in obviating periods of waiting by (say) the arithmetic unit during the relatively slow operation of the peripheral equipment. Another feature is the large high-speed magnetic core store, which has a capacity of up to 32,768 words of 44 bits each. Further storage is provided by magnetic tape, each tape being capable of holding several million alpha-numeric characters, with a peak transfer speed of 90,000 characters per sec. A wide range of input and output devices is also available, and these include a line-printer with a maximum speed of 850 lines per min.

Radio Frequencies and Space Communications

The increasing demand for frequencies for various applications of radio technique has led to a state of congestion in the radio-frequency spectrum. At its autumn meetings in Geneva, the International Telecommunications Union gave earnest consideration not only to the more orthodox uses of radio-waves, but also to the requirements of radio astronomy and space research; and these must include in the near future the frequencies to be used for communications with and between vehicles in space. For the information of the United States Senate Committee on Aeronautical and Space Sciences, a report, by Edward Wenk, jun., has recently been issued under the title "Radio Frequency Control in Space Telecommunications" (United States. 86th Congress 2nd Session. Legislative Reference Service—Library of Congress. Pp. vii+235. Washington, D.C.: Government Printing Office, 1960). This report explains the dependence of the exploration of space on radio communication, reviews briefly the technical considerations which determine the selection of frequencies for various purposes, and summarizes the history of international agreements on frequency allocation. An outline is given of the organization of the International Telecommunications Union, with its technical advisory body, the International Radio Consultative Committee, and its relationship with the International Council of Scientific Unions, to which are affiliated the International Scientific Radio Union and the Committee on Space Research.

While most of the report is concerned with problems domestic to the United States in the allocation and control of radio frequencies for all purposes, some extensive appendixes include the report of the *ad hoc* Committee on the Peaceful Uses of Outer Space adopted by the United Nations General Assembly in 1959. There is also a world-wide summary of frequencies recorded by the International Frequency Registration Board of the International Telecommunications Union, and a copy of the Radio Regulations and Frequency Allocations adopted by the Administrative Radio Conference of the Union at Geneva in 1959. These appendixes make the U.S. report a very useful work of reference to those interested in international radio matters.

Tectonics of the Gobi Mountains

The aerial and land survey of the fault and fissure zone in the Gobi mountain range, as resulting from the earthquakes of December 7, 1957, and April 7, 1958, is discussed by V. P. Solonenko and N. A. Florensov (*Priroda*, 2, 61; 1960). The disturbed zone stretches almost parallel to latitude 45° N., and extends for almost 300 km. from longitude 99° E. to 102° 20′ E. The zone consists of a number of faults, one with a visible throw of 328 m., enclosing several horsts and rift-valleys, one rift-valley having dimensions 27 km. long and 800 m. wide.

Newly Discovered Rock Shelter Art in Malaya

Why mankind should want to draw and paint in caves and rock-shelters cannot as yet be determined. Probably the reasons are multiple. In the case of palæolithic man, it is likely that sympathetic magic in connexion with food supply was the motive, but such an urge cannot be adduced in the case of the South and Central African rock-shelter art, nor in the case of some newly discovered decorated rock-shelter walls near Ipoh, Perak, Federation of Malaya. These latest discoveries were made by Lieut. R. L. Rawlings, of the Gurka Rifles, and are described in *Man* for January 1960 by J. M. Matthews, curator of museums, Federation of Malaya. Animals, men and designs are depicted in various shades of hæmatite (red), and at least three styles can be distinguished. Most of the caves in Malaya have been dug for cave earth and guano, so there are few undisturbed deposits. No correlation of this new-found art with any known culture is possible. Comparison of drawings made in one area with others elsewhere on stylistic grounds is more than dangerous; most of these drawings are essentially simple, and any conventionalizations are what one might expect to occur anywhere independently. Some day the age of this Malayan art will become known, and also why it was made. In the meanwhile, one must be grateful for the excellent account here given.

The First Forty Years of the Royal Society of London

An exhibition has been arranged at the Science Museum to illustrate the first forty years of the Royal Society of London. The exhibition is mainly biographical, and illustrates the scientific life and work of some twenty men, who were distinguished Fellows during the period 1660–1700. The exhibits consist of a collection of portraits (enlarged photographs of engravings), copies of the Fellows' scientific publications, photographs of early documents of the Society, and a small collection of instruments and apparatus.

British Men of Science

To coincide with the tercentenary of the Royal Society, the preparation of a new series, *British Men of Science*, is announced by Nelson under the general editorship of Sir Gavin de Beer. The series will be designed to provide authoritative but short lives, written by leading scientists and intended for the general reader and university student. So far, twelve volumes are in preparation, but others are being actively planned. They are: "Joseph Black", by Prof. Douglas McKie; "Charles Darwin", by Sir Gavin de Beer; "Humphry Davy", by Sir Harold Hartley; "Edmond Halley", by Sir Harold Spencer Jones; "William Gilbert", by N. H. de V. Heathcote; "William Herschel", by Angus Armitage; "Charles Lyell", by Sir Edward Bailey; "William Henry Perkin", by Prof. John Read; "Joseph Priestley", by F. W. Gibbs; "Ernest Rutherford", by Sir Ernest Marsden; "Michael Scot", by Prof. Lynn Thorndike; "Joseph John Thomson", by Sir George Thomson. The series, which will be fully illustrated, is to be in line and half-tone and will contain a list of books for future reading.

"Non-Enzymic Reactions of Indoles with Coenzyme I"

Prof. S. G. A. Alivisatos, G. A. Mourkides and A. Jibril write: "In a previous communication (*Nature*, 186, 718; 1960) we described certain interactions occurring between indoles and coenzyme I. While recent evidence obtained in our laboratory with a number of other indoles and with the reduced form of coenzyme I confirmed our original observations, pointing towards an interaction of the indole with the nicotinamide moiety of the oxidized form of coenzyme I (probably, a charge transfer complex), the previously reported decrease in absorbancy observed in the ultra-violet region below 310 mμ was later shown to be an artefact produced by stray light when one of the reactants was present at high concentration in the blank".

Announcements

Prof. P. B. Medawar, C.B.E., F.R.S., Jodrell professor of zoology and comparative anatomy at University College in the University of London, has been appointed director of the National Institute for Medical Research, Mill Hill, London, as from August, 1962. Prof. Medawar succeeds Sir Charles Harington.

The following have been elected honorary members of the American Institute of Nutrition: Lord Boyd Orr, Drs. W. A. Aykroyd, F. B. Berry, F. R. Boudreau, R. C. Burgess, F. W. Clements, Dr. D. P. Cuthbertson, V. N. Patwardhan, Prof. E. F. Terroine and Prof. A. I. Virtanen. This is the first occasion on which the Society has elected honorary members.

Dr. J. H. Gerber has been appointed director of the Center for Aging Research of the National Institutes of Health, U.S. Department of Health, Education and Welfare, in succession to Dr. G. Halsey Hunt, who is now chief of the Division of General Medical Sciences, of which the Center is a component.

Dr. J. J. Gilman, of the Research Laboratory, General Electric Co., Schenectady, is to give a lecture on "The Physical Nature of Plastic Flow", under the auspices of the Metal Physics Committee of the Institute of Metals. The meeting will be held at the Institute's headquarters, 17 Belgrave Square, London, S.W.1, on Tuesday, August 16, and from which further information can be obtained.

The Belgian Society of Pharmaceutical Sciences is organizing an International Symposium on Chromatography in Brussels during September 16–17. Further information can be obtained from the Belgisch Genootschap voor Pharmaceutisches Wetenschappen, 11 Archimedesstraat, Brussels 4.

The Universities Federation for Animal Welfare is holding a Summer Congress at Culham College, Abingdon, Berks, during September 16–22. Further information can be obtained from UFAW (Summer Congress), 7*a* Lamb's Conduit Passage, London, W.C.1.

A non-residential summer school on "Numerical Analysis" will be held in Oxford during September 26–October 7. The object of the course is to teach the elements of numerical analysis in the fields of linear algebra and differential equations to users of automatic digital computers in industry, government and university departments. Further information can be obtained from the Secretary to the Delegacy for Extra-Mural Studies, Rewley House, Wellington Square, Oxford.

The fifth International Instruments and Measurements Conference and Exhibition are to be held in Stockholm during September 10–17. The Conference is organized by the Royal Swedish Academy of Engineering Sciences and the Swedish Association of Technical Physicists. Further information concerning the British participation can be obtained from the Chief Press Officer, U.K. Atomic Energy Authority, 11 Charles II Street, London, S.W.1.

The first British Congress on "The History of Medicine and Pharmacy" is to be organized by the Faculty of the History of Medicine and Pharmacy at the Worshipful Society of Apothecaries of London, in co-operation with the Royal Colleges and the Royal Society of Medicine, and held in London during September 29–30. Further information can be obtained from Dr. F. N. L. Poynter, Wellcome Historical Medical Library, The Wellcome Building, Euston Road, London, N.W.1.

As from July 31, the Imperial College of Tropical Agriculture is to be merged into the University College of the West Indies, and the College will be known as the University College of the West Indies, Faculty of Agriculture (Imperial College of Tropical Agriculture), Trinidad, West Indies. The London office of the College is to be closed as from August 31.

DOCTOR RUGGLES GATES AND THE ABORIGINAL AUSTRALIAN

By Prof. A. A. ABBIE
Department of Anatomy, University of Adelaide

DR. R. RUGGLES GATES has recently published two papers on the Australian aborigines. One deals with some genetical aspects of 'race' crossing[1], the other with the homogeneity or otherwise of the aborigines[2]. The first reaction to these papers is of profound admiration that so much could result from so brief a visit and that such far-reaching conclusions could be extracted from such scanty material.

I am not a geneticist but over many years have had close personal contact with large numbers of aborigines in most parts of the continent and it is against that background that Dr. Gates's contributions are considered here.

In the first place it is necessary to point out that Dr. Gates is correct in many of the statements he makes—this is when he is repeating the findings of earlier workers. His paper on the genetics of interbreeding[1] is beyond my competence except to express surprise at the confidence with which Dr. Gates supplies pedigrees when, in truth, aboriginal marriage customs and beliefs render the compilation of a genealogical tree almost entirely a matter of faith (in this connexion, see Abbie and Adey[3]). His second paper is concerned mainly with full aborigines and raises a number of points (some are common to both papers) that deserve further consideration. The most important relate to pigmentation, hair-form, stature and head-form and they will be reviewed in that order.

Aborigines are born pinkish yellow (not white) and darken in a few weeks or so according to the degree of solar exposure. We have never seen a sacral ('mongolian') spot. Darkening of the skin usually stops at a warm medium vandyke, but it may darken further on intense exposure in the desert or in the extreme north. Protection from the Sun, as in fat creases, but more particularly when clothing is worn habitually, causes the skin colour to fade—sometimes almost to the original pinkish yellow—and in the latter case undue exposure may lead to quite severe sunburn[3,4]. Dr. Gates is evidently aware of this work yet he attributes a yellowish shade in some northern Queensland natives to 'Tasmanian' affinities, a fair example of ignoring facts to push a hypothesis. In central Australia particularly, but also in South Australia, many of the children are fair-headed, the colour ranging from completely flaxen to almost rufous brown and darkening with age[3-5]. Dr. Gates appears to support Birdsell's[6] view that this condition appeared first in the south-west of central Australia and is spreading more or less concentrically outwards and especially westwards. In fact, the condition was first described in Western Australia (at New Norcia) in the middle of the last century, and Griffith Taylor's original observations on fairheadedness were also made in Western Australia. We have noted fairheadedness on the south coast at Fowler's Bay; in central Australia it is widespread but with a patchy distribution that does not support the conception of continuous centrifugal spread. But we have also found fairheadedness (though less frequently) in the extreme north of Arnhem Land where the possibility of spread from central Australia is practically zero. In any event, since intertribal breeding was, and still is, virtually unknown except recently on Government Settlements, what mechanism can be adduced to account for the spreading ?

Dr. Gates puts great reliance upon the occurrence of curly or frizzy hair (associated with short stature) to establish the 'negrito' character of some northern Queensland aborigines. Photographs of these people published by Tindale and Birdsell[7] reveal hair-forms from practically straight to deeply curled, and that is what is found normally in all aboriginal groups anywhere in the continent[4,5]. In the extreme north curly-to-woolly hair is commoner than elsewhere but there is some evidence of Indonesian and Melanesian admixture (including blood group B). Also, Dr. Gates does not take into account (although he is aware of the fact) that in the last century some thousands of male 'kanakas' of Melanesian origin were imported into northern Queensland to harvest sugar cane. They were afterwards repatriated but scarcely, one imagines, without leaving their mark on the local aboriginal population. The most tightly curled hair seen by me belonged to a Pitjantjara male in central Australia, about as far away from the coast in any direction as it is possible to get.

Stature Dr. Gates considers diagnostic of the 'negritos' of northern Queensland. For 9 Monamona males he gives a range of 141·5 cm.–161·5 cm., with a mean of 155·8 cm. However, the shortest is an acknowledged dwarf: without him the range is 150·0 cm.–161·5 cm., with a mean of 157·6 cm. Our (unpublished) figures, based upon about 30 adult males in each case, for four areas across the continent are: south (Fowler's Bay): 146·0 cm.–174·0 cm. (mean 163·1 cm.); centre (Pintubi): 152·0 cm.–180·7 cm. (mean 167·1 cm.); (Wailbrai): 159·5 cm.–180·1 cm. (mean 170·3 cm.); northern Arnhem Land (Burera): 150·4–187·3 cm. (mean 169·6 cm.). Clearly there is an enormous overlap and it seems at least possible that had Dr. Gates examined a larger sample he would have been less positive about the pygmoid character of the northern Queensland aborigines. The shortest adult male aborigine so far recorded[8] measured only 135 cm.; he was found in the Peterman Range near central Australia, but short people occur anywhere. Dr. Gates believes that half-castes show heterosis, being larger, better formed and more fully developed; this we cannot confirm.

The shape of the skull is another factor Dr. Gates adduces to support his views on the 'negrito' character of north Queensland aborigines. The range of cephalic indices in his series of 9 was 70·56–81·76, with a mean of 74·48 (the highest index came from the dwarf previously mentioned). Corresponding figures for our groups were: Fowler's Bay: 68·2–79·2 (mean 73·3); Pintubi: 66·2–81·4 (mean 71·5);

Wailbrai: 67·4–84·3 (mean 73·5); Burera: 64·2–80·0 (mean 70·9). Obviously, while the ranges are wider, some of these means are very close to the northern Queensland mean, and many of these heads are much more brachycephalic. Indeed, if the dwarf were eliminated the Monamona mean would not differ materially from any other aboriginal mean. One further point: while Dr. Gates tacitly endorses my view[9] that head-length and head-breadth vary independently, he evidently did not read far enough to gain some insight on brachycephaly. It is true that, *ceteris paribus*, head-length is determined genetically (subject to some environmental modification as Boas has shown) in fully developed adults, but it is not necessary to invoke any involved genetic mechanism to explain short-headedness in pygmoid people. These are in an infantile state of development and their heads betray the characteristically infantile brachycephaly.

There is no space here to mention a number of factual errors in Dr. Gates's papers, and certainly no necessity to follow his excursions into archæology and geology. Perhaps it is best to conclude with one's own views, based upon the examination of several hundreds of aborigines in various, widely separated, parts of the continent.

Aborigines betray a fairly wide range of physical variation, but such variation is intratribal, not intertribal. That is, the tribes, practically anywhere, show a parallelism in the range of variation, and the means for the tribes come out remarkably close to each other. This implies a high level of physical homogeneity throughout the continent—all the more singular because the maximum aboriginal population is said never to have exceeded some 300,000 and such a small number, dispersed in small inbreeding groups throughout an area of nearly 3,000,000 square miles, surely had little chance of achieving such uniformity by interbreeding. On the contrary, genetic drift in what were practically isolates would be expected to produce a wide physical diversity from one end of the continent to the other. The fact that what diversity occurs is but slight points to a few tentative conclusions. It suggests first that the initial aboriginal landing comprised only a relatively small party bringing only a limited genetic pool. The second conclusion is that there had been a minimum of subsequent admixture with other peoples before the advent of Europeans. Thirdly, the aborigines could have occupied Australia for only a relatively short period—certainly not long enough to produce any obvious physical differences from place to place. This last is in harmony with their uniformly mesolithic culture[5] and with carbon-14 datings which, so far at least, cannot certainly be associated with human occupation beyond about 6,000 B.C.

[1] Gates, R. Ruggles, *Act. Gen. Med. Gem.*, 9, 7 (1960).
[2] Gates, R. Ruggles, *Z. Morph. Anthrop.*, 50, 150 (1960).
[3] Abbie, A. A., and Adey, W. R., *Amer. J. Phys. Anthrop.*, 11, 339 (1953).
[4] Abbie, A. A., *The Leech*, 28, 120 (1958).
[5] Abbie, A. A., *Oceania*, 22, 91 (1951).
[6] Birdsell, J. B., *Cold Spring Harbor Symp. Quant. Biol.*, 15, 259 (1950).
[7] Tindale, N. B., and Birdsell, J. B., *Rec. S. Aust. Mus.*, 7, 1 (1941).
[8] Basedow, H., "The Australian Aboriginal" (Preece, Adelaide, 1925).
[9] Abbie, A. A., *J. Anat.* (Lond.), 81, 233 (1947).
[10] Abbie, A. A., *Oceania*, 27, 220 (1957).
[11] Abbie, A. A., and Adey, W. R., *Oceania*, 25, 198 (1955).

HERBICIDES AND THE SOIL

MODERN techniques of herbicidal applications fall into two groups. Direct application may be made to the soil followed by absorption through the roots or applications may be made to the foliage where entry is largely dependent on penetration through the leaves. This distinction is not, however, clear cut, since with foliar applications some of the droplets will fall on the ground while some of the compound may be washed off the leaves by rain. Thus for both types of technique it is of major importance to ascertain how long individual compounds persist in the soil, what are the physical or biological factors which cause their removal or decomposition and what are the effects on the fauna and flora of the soil. It was against this background that the British Weed Control Council organized a symposium on "Herbicides and the Soil", which was held in the Clarendon Laboratory, University of Oxford, on April 7.

The opening speaker was Prof. L. J. Audus (Bedford College, London) on "Microbiological Breakdown of Herbicides in Soils". Before direct investigations on the rate of decomposition of herbicides was undertaken it had been observed in the field that the persistence of some, as judged by the effects on plant growth, was minimal when the soil was moist and warm, conditions generally accepted as being favourable to micro-organisms. Since these conditions could also favour chemical decomposition it was difficult to separate the operative factors except in the laboratory. The fact that breakdown in the soil was largely arrested by autoclaving and that the addition of compounds known to be inhibitory to micro-organisms also slowed down the rate of decomposition pointed to the conclusion that micro-organisms were involved.

If micro-organisms are responsible for the breakdown of a herbicide, then the addition of such a compound to the soil under constant and favourable conditions will not result in immediate breakdown, as in a chemical process, but there will be a lag phase while there is a build-up of the population of the effective organisms.

At Bedford College the perfusion technique has been employed to study the breakdown of substituted phenoxyacetic acids and in every case the existence of a lag phase has been demonstrated. It has also been established that once decomposition has taken place in a soil, then the speed of breakdown of a further addition of the chemical is increased.

In 1950, Audus isolated an organism of the *Bacterium globiforme* group which was able to multiply on an agar medium containing 2,4-dichlorophenoxyacetic acid as the sole source of carbon. This organism, when added to garden soil, immediately accelerated the rate of breakdown of 2,4-dichlorophenoxyacetic acid. Since this original isolation, it has been found that a wide range of bacteria, actinomycetes and fungi are capable of using herbicides as their only source of carbon.

For the substituted phenoxyacetic acids there is no clear correlation between the duration of the lag phase and chemical structure, but it is apparent that the position on the ring of a single chlorine substituent is important; for example, a change of the substituent from the 4 to the 2 position makes the compound much more resistant to attack. In di- and tri-substituted compounds the presence of a 4-chloro substitution overrides the influence of other substitutions. N. Brownbridge, however, sought to discover whether ease of breakdown was linked with the level of phytotoxicity of the chemical to higher plants as judged by the concentration necessary to reduce the rate of growth of cress roots by 50 per cent. Excluding the value for 2-chloro-4 methylphenoxyacetic acid, there was a highly significant inverse correlation. The position of 2-chloro-4 methylphenoxyacetic acid was anomalous; the lag phase was far too long, judged on the degree of phytotoxicity.

If a soil was first treated with 2-chloro-4 methyl phenoxyacetic acid and another substituted phenoxyacetic acid was then added, the breakdown of the second compound was rapid; for example, even after prolonged perfusion 2,4,5-trichlorophenoxyacetic acid is very slowly decomposed but 2-chloro-4 methylphenoxyacetic acid treated soil can break down 2,4,5-trichlorophenoxyacetic acid more readily. Soils first treated with other phenoxyacetic acids did not gain the power to attack other compounds to the same extent.

Prof. W. W. Fletcher (West of Scotland Agricultural College, Glasgow) spoke on the "Effects of Herbicides on Soil Micro-organisms" and emphasized that although a few chemicals did reduce the population of the soil micro-organisms, the net effect was ultimately one of stimulation as one or more species became adapted to use the herbicide as a substrate. Organisms responsible for nitrification and nodulation appear to be more sensitive than other bacteria to a wide range of herbicides including sodium chlorate, 2-chloro-N,N-diethylacetamide and 2-chloro-N,N-diallylacetamide when applied at normal rates in the field. There is a general agreement that 2-chloro-4 methylphenoxyacetic acid, 2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid at the normal rates employed in agriculture have no adverse effects on the total number of micro-organisms, and it would appear that 2,2-dichloropropionic acid augments rather than depresses the general soil population.

The species of one genus may vary greatly in their response to chemicals. For example, 3,5-dinitro-*o*-cresol inhibited *Rhizobium lupini* at 198 p.p.m., whereas *R. meliloti* and *R. leguminosarum* required 1,980 p.p.m. for inhibition.

Dr. G. S. Hartley (Chesterford Park Research Station) spoke on the "Physico-chemical Aspects of the Availability of Herbicides in Soils". Beginning with a simple theoretical model, Dr. Hartley defined his problem within the system—soil particulate structure–air–water–herbicide.

In the simplest case, if the water content is at 'field capacity' and a non-volatile water-soluble herbicide is applied uniformly to the soil surface, then as long as the system remains undisturbed the herbicide can move only by diffusion in the water phase. The rate of this movement can be calculated and for molecules of the size of herbicides 1 per cent of the applied chemical will move rather more than 2 ft. downward in three years. The presence of solid matter in such a system as well as air locks reduces the 'expected' rate of diffusion. When corrections for these obstacles are applied to the theoretical figure it is apparent that 1 per cent of an applied soluble herbicide might take twelve years to reach a depth of 2 ft. It must therefore be concluded that the downward movement of herbicides in the field is not by diffusion alone.

Again in an ideal uniform system, and assuming field capacity to be 25 per cent v/v, 10 cm. of rainfall would sweep a readily soluble herbicide to a depth of 40 cm., where it would be localized in a narrow band. In the field where a soil is heterogeneous the herbicide will move unevenly downwards. This unevenness is especially marked if rainfall is heavy, when the herbicide is washed down the larger channels or cracks in the soil. Dr. Hartley suggested that the difference between observed and calculated rates of movement could be largely explained in terms of the heterogeneity of the soil system.

Attempts to measure the rates of movement of herbicides downwards have all departed from field conditions by applying 'rainfall' at extremely heavy rates and thereby introduced large errors. Relatively insoluble herbicides go into solution slowly; for example, a sphere of trichloroacetic acid 5μ in radius might dissolve in seconds, whereas a sphere of simazine of identical size would take 30 hr. Therefore, unless rainfall is prolonged, the more insoluble substances may resist leaching due to their failure to go into solution, although sufficient water *in toto* may be applied to take all herbicides into solution.

Upward movement of a herbicide in the soil is induced by the evaporation of the soil water. Evaporation will take place almost entirely from the surface of a wet soil, but as the capillary conduction system breaks down the rate of loss of water falls sharply. This upward movement of herbicides will accentuate a tendency for herbicides to be concentrated near the surface of the soil in dry weather.

Even at a rate of application of 100 gal./acre the sorption of a spray solution into the capillaries of a dry soil lump can be quite pronounced and subsequent release of the chemical from such places is by the slow process of diffusion. The only way to counter this appears to be spray when the soil is wet. The development of granular herbicides promises to overcome some of these difficulties since the amount of rainfall necessary to extract the herbicide from the granule is probably sufficient to ensure thorough wetting of the easily accessible sites in the soil before the granules release their active content. A simple experiment using a freely soluble dye added to plaster-of-paris columns showed that the extraction of the dye passing through the columns was far more complete and far quicker if the columns were first wetted with water.

Dr. W. van der Zweep (Wageningen) contributed to the meeting a consideration of the practical use of herbicides in relation to their persistence in the soil. Frequently, the rate of application and the chemical used are determined by the persistence that can be tolerated by the following crops. In certain cases control and not eradication of weeds is a penalty that must be accepted if a following crop is to be safeguarded. Mechanical incorporation of a chemical into the soil increases the persistence if the chemical has a high vapour pressure. In other cases incorporation improves the effectiveness of the chemical and also assists subsequent breakdown so that a following crop may be sown with increased safety. Persistence may be varied according to the formulation of the chemical used. Dr. van der Zweep brought his contribution to an end by appealing for information on the half-life of herbicides, a half-life determined in the first instance in standardized laboratory tests. Such a system could be extended to field studies where the variation would be apparent and could be measured.

The full proceedings of the meeting together with reports of the discussion which followed each paper will be published by Blackwell Scientific Publications, Ltd., later this year.

COLLOID AND POLYMER SCIENCE

CONTINUING earlier seminars[1] in the Department of Chemistry of University College, London, nine lectures were given during February 25–March 18. Drs. C. H. Bamford and J. A. Kitchener summarized work (some of which has been published[2,3]) on calculation of free-radical reactivity and stability of colloidal model suspensions. Prof. J. A. V. Butler discussed some flow properties of dilute solutions of deoxyribonucleic acid in 0·2 *N* sodium chloride, the rate of shear being varied in the range 0·5–30,000 sec.$^{-1}$. At the high rate of shear no permanent change of the solute occurred, but some disentangling of networks. Using the theories of Kuhn and Kuhn[4] and Cerf[5], for the results obtained at low rate of shear, it appears that the deoxyribonucleic acid molecule is somewhat flexible. Dr. P. W. Allen described the grafting of methylmethacrylate polymers on natural rubber latex using hydrogen peroxide, together with a polyethylene amine, as initiators. Under these conditions the graft co-polymer is mainly formed on the surface of the latex. If oil-soluble initiators are used, polymerization of methylmethacrylate occurs inside the latex. Dr. C. Robinson reviewed recent work[6] on liquid crystals of synthetic polypeptide and described a new effect: if a concentrated solution of poly-γ-ethyl-L-glutamate is illuminated with white light, brilliant iridescent colours are reflected. This is explained as an optical analogue of an X-ray powder diagram. There are indications that deoxyribonucleic acid solutions can also form liquid-crystals.

Prof. A. Katchalsky discussed the application of the thermodynamics of irreversible processes[7] to the study of colloid–chemical phenomena. The treatment of entropy production as the sum of the products of generalized forces and conjugated flows was outlined. Sufficiently slow flows are linearly dependent on all the forces operative in the system, through a set of phenomenological equations, the coefficients of which obey Onsager's law[8] and constitute a symmetrical matrix. The phenomenological equations provide a convenient formal framework for the description of electrokinetic phenomena[9], and permit the establishment of the classical Saxen relations on a thermodynamic basis. A similar treatment[10] of polyelectrolyte solutions leads to new correlations between transport phenomena, such as diffusion, sedimentation and conductance. The thermodynamic approach is useful in the analysis of membrane permeability[11–13]: contradictions inherent in the conventional equations do not occur and a consistent set of equations is obtained, suitable for the description of the transport of electrolytes and non-electrolytes through membranes[14]. The coefficients of these equations were transcribed in terms of frictional forces and distribution coefficients, which characterize the interaction of the permeant solutes with the membrane. In the last lecture, Prof. Katchalsky discussed some fundamentals of mechanochemistry[15].

---

[1] *Nature*, **182**, 762 (1958).

[2] Bamford, C. H., Jenkins, A. D., and Johnston, R., *Trans. Faraday Soc.*, **55**, 418 (1959).

[3] Schenkel, J. H., and Kitchener, J. A., *Trans. Faraday Soc.*, **56**, 161 (1960).

[4] Kuhn, W., Kuhn, H., and Buchner, P., *Ergeb. exakt. Naturw.*, **25**, 1 (1951).

[5] *C.R. Acad. Sci. Paris*, **243**, 1875 (1956); **244**, 456 (1957).

[6] Robinson, C., *Trans. Faraday Soc.*, **52**, 571 (1956). Robinson, C., and Ward, J. C., *Nature*, **180**, 1183 (1957). Robinson, C., *Faraday Soc. Discussions*, **25**, 19 (1958).

[7] See Prigogine, I., "Étude thermodynamique des phénomènes irreversibles" (Desoer, Liège, 1947). de Groot, S. R., "Thermodynamics of Irreversible Processes" (North Holland Pub. Co., Amsterdam, 1951).

[8] Onsager, L., *Phys. Rev.*, **37**, 405 (1930); **38**, 2265 (1931).

[9] Mazur, P., and Overbeek, J. F., *Rec. Trav. Chim. Pays-Bas*, **70**, 83 (1951).

[10] Katchalsky, A., Alexandrovith, Z., and Kedem, O., "Adv. Chem. Phys." (in the press).

[11] Staverman, A. J., *Trans. Faraday Soc.*, **48**, 176 (1952).

[12] Kirkwood, W., in "Ion Transport across Membranes", 119 (Acad. Press, New York, 1954).

[13] Spiegler, K. S., *Trans. Faraday Soc.*, **54**, 1409 (1958).

[14] Kedem, O., and Katchalsky, A., *Biochim. Biophys. Acta*, **27**, 229 (1958).

[15] Katchalsky, A., Lifson, S., Michaeli, I., and Zwick, M., "Size and Shape Changes in Contractile Polymers" (Pergamon Press, London . New York) (in the press).

EFFECTIVENESS IN INDUSTRY

THE presidential address of Mr. W. E. Bargett to the Institution of Metallurgists, though specifically directed to that profession, had much of direct interest for other technologies. In discussing the training of both graduates and juniors he pointed out the necessity of realizing that the former, though 'educated', have still to receive a 'training' even if during this period they can give little immediate return for their salaries. Equally, "the inefficient utilization of junior people's time is out of keeping with the demands of industry for greater numbers of well-qualified technologists and must be eliminated through sheer economic necessity". It is a general experience that a bright junior is quickly frustrated when called upon to do repetitive work which provides little experience and makes no particular intellectual demand. The interesting suggestion was made that a solution of this problem might be found by employing older people who may have had no special training, but who have sufficient intelligence to learn all that is required to carry out specific operations, appreciating not only what to do but also why it is done in a certain way. Experience has shown that there is no difficulty in filling posts of this kind very successfully. They have, indeed, a certain attraction for a particular type of man who is satisfied to continue doing a routine job.

Mr. Bargett, though appreciating the temptation to look for rapid solutions of industrial problems, expressed his strong belief that the effort expended would be more efficiently used in gaining a fuller understanding of the problem itself, that is to say, in finding the best, rather than the quickest, solution. Concluding with a few examples drawn from his own work to illustrate the points made, he mentioned the search for an answer to the urgent problem of overcoming the service-cracking at elevated temperatures of a low carbon steel containing $\frac{1}{4}$ per cent molybdenum. The suggestion that the trouble was due to grain-boundary effects which might be eliminated by the addition of 0·002 per cent of boron proved successful, but also, as a most unexpected by-product, led to the yield-point of the steel being doubled and the tensile strength being raised by 50 per cent. Further work led to the production of a weldable steel with a tensile strength of 70 tons per sq. in. in the air-cooled condition.

HEALTH SERVICES IN THE U.S.S.R.

IN October 1958, twenty-three individuals from twenty-one countries and territories were invited by the World Health Organization to visit the U.S.S.R. to study its health services. Some of the members of the group were public health administrators, others were medical specialists, and all were engaged in medical or health work in their own countries. An extensive itinerary was planned by the Government of the U.S.S.R. in order to allow the group to see as much as possible of the country's health services during their stay of a little over five weeks. On their return, the members of the group prepared a report which has recently been published*.

The health services in the U.S.S.R. are organized to meet the requirements of a specific social system and philosophy, and are designed to provide comprehensive medical care for the whole population through the integration of curative and preventive services at all levels of administration. The basic health philosophy in the U.S.S.R. is one of 'prophylaxis' by health protection, and it places the responsibility for the health of the people on the State. The Soviet Government has recognized the part played by health in the economy and development of the country, and the fact that certain population groups (children, workers, etc.) require specialized medical attention.

The existing health services of the U.S.S.R. are the result of development during a period of forty-years research. The complicated structure evolved in this way consists of a number of institutions and functional units so interlocked that the result is a unified system embracing all health disciplines and reaching into every locality in the fifteen constituent republics, to the smallest and most remote villages and farming areas. The basic principle of this structure is highly centralized planning and supervision, coupled with almost complete executive and operational decentralization, permitting about 90 per cent of problems to be dealt with at local levels, without disturbing the general and basic pattern in any way.

The various units constituting the organizational structure of the health services of the U.S.S.R. may be classified into six groups, each group representing a defined function. The six functional groups are: (1) the directing, planning and supervising group; (2) the academic and scientific group; (3) the advisory group; (4) the educational group; (5) the executive group; (6) the operational group.

The health services of the U.S.S.R., both preventive and curative, are available to the whole population free of charge, regardless of social and economic status. The services of health workers, whether highly trained medical specialists or trained *feldschers*, reach every home even in the most remote and isolated localities. This is possible because of the 'State' character of Soviet medicine, and although private practice is not forbidden, it is so restricted that it exercises no influence whatever on the general set-up of health services in the country. The State character of Soviet medicine is further illustrated by the structure of the health budget for the Union. The health budget for 1958 makes provision for an expenditure of more than 40 billion roubles. This means that approximately 200 roubles will be spent for every member of the population in one year. But this does not represent the total expenditure for health in the Union, for apart from the official budgets, other bodies and institutions are also required to budget for additional expenditure on health.

The collective farms provide the buildings and equipment, and bear most of the cost of maintenance of their own health units and maternity homes; the health authorities are only responsible for the salaries of medical and para-medical staff. The same applies to industrial concerns. Furthermore, only part of the capital cost of buildings comes from the official health budget. Finally, certain medicines prescribed for ambulatory patients have to be paid for by the patients themselves.

The Soviet concept of health has resulted in a realignment of services which appears to be unique. There are three main medical fields in the U.S.S.R.: (*a*) adult medicine, (*b*) child medicine, (*c*) hygiene and sanitation.

Soviet scientists feel quite strongly that a child is not just a miniature adult: it is a different being with its own specific physical and physiological functions, and therefore requires a specific medical approach. Paediatrics is therefore not a post-graduate speciality of general medicine, but rather a separate study which begins during the undergraduate period. A medical student must choose at the beginning of the third year of his course whether he wants to become a doctor for adults, or a doctor for children, and, depending on the choice, will follow a different line of study.

The third medical field is that of hygiene, which produces graduates known as 'hygienists'. Preventive medicine is divided into (*a*) personal preventive services, which are integrated into the respective fields of adult and childhood medical studies, and (*b*) non-personal services (including environmental and occupational health), which constitute the major subjects at the undergraduate faculties of hygiene. Hygienists staff the sanitary and epidemiology stations and may further specialize in nutrition, municipal hygiene, and industrial hygiene. It appears that, in many respects, the medical hygienists of the U.S.S.R. fill the posts usually occupied by sanitary engineers in other countries.

---

* World Health Organization. Public Health Papers, No. 3: Health Services in the U.S.S.R.: Report prepared by the Participants in a Study Tour organized by the World Health Organization. Pp. 58. (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) 2 Swiss francs; 3s. 6d.; 0.60 dollar.

Scientific research is a most important function of all medical units in the U.S.S.R. Research is planned and co-ordinated, however, and it includes basic, clinical, applied and operational aspects. The system of special research institutes and advisory councils, together with the hierarchical structure of research units, ensures the proper utilization of funds and directs research towards the more pressing problems of the nation.

All heads of divisions and departments of the medical services are medical graduates. Even those departments which deal with sanitary engineering, nursing and para-medical training are headed by doctors. There is no nursing council as such, and the post of sanitary engineer is non-existent. Engineers are attached to departments dealing with buildings and construction, but their task is that of a constructional engineer rather than of a specialized sanitary engineer. The lay sanitarian or sanitary inspector, as known in other countries, is unknown in the U.S.S.R., and his task is performed by doctors, assisted by *feldschers*. Nor are the posts of social workers and social anthropologists known in the U.S.S.R.

The number of doctors in the U.S.S.R. is high, there being about one doctor to every 570 of the population, and in some regions, such as Georgia, as many as 1 in 400. The ratio of male to female doctors is about 50 : 50, but in some areas 70 per cent of practising doctors are women. The total number of medical graduates in the U.S.S.R. in 1957 was 360,000, a striking increase over the figure for 1913, which was 23,000. It is estimated on the basis of existing facilities for medical education that, by the end of the new 'seven-year' plan in 1965, there will be 490,000 doctors in the country, which will give a ratio of one doctor to every 460 inhabitants.

There were also 99,921 mid-wives working in the U.S.S.R. in 1957, as well as 71,151 *feldscher*-mid-wives and 14,714 *feldschers*. It is estimated that by 1965 there will be 1,470,000 qualified nurses in the country, or 3 qualified nurses to every doctor.

BIOLOGICAL EFFECTS OF ATOMIC RADIATION

IN 1956, a report with this title was published by the U.S. National Academy of Sciences. It contained the findings and recommendations of six committees dealing with genetics, pathology, meteorology, oceanography and fisheries, agriculture and food supplies, and disposal and dispersal of radioactive wastes. During the intervening years these committees have continued to collect information in their separate fields, and they have now published their findings and conclusions in the same form as before[*]. The report is shorter than the first one, in which much space had to be devoted to explanations of fundamental scientific facts and principles. The presentation is again admirably clear and as free from technicalities as possible; the main points are condensed into a separate, concise and easily understood "Report to the Public". Several appendixes bring more detailed information and calculations; technical reports are in preparation. The following are some of the more important statements.

At present, delayed fall-out from the stratospheric reservoir is the major source of airborne artificial radioactivity and will remain so unless large-scale testing is resumed. There is a non-uniform distribution of strontium-90 in fall-out, with a maximum at lat. 40–50° N. Fall-out is greatest in spring and is mostly brought down by precipitation. The half-residence time of radioactive debris in the troposphere is about 2–4 weeks; in the stratosphere it depends on the latitude at which the debris was injected. For injections in equatorial regions, the half-residence time is 2–5 years; for injections in temperate and polar zones it is less than 1 year. If there are no further additions to the atmospheric burden, most of the remaining radioactivity in the atmosphere will have settled down by 1962–63; the ground concentration will then be about twice that of November 1958. It is certain that all living things, man included, now have a radioactive body burden higher than in the pre-atomic era, and although the present levels in foodstuffs are low, the cumulative and retained isotope burden in man must be considered.

The estimate of genetical radiation damage has gone up as a result of the recent increase in fall-out and the previously unconsidered contribution to it of carbon-14. On the other hand, the finding that in spermatogonia and oocytes—but not in mature spermatozoa—of mice and *Drosophila* a given dose of radiation produces fewer mutations when administered at low than at high intensity may mean that previous estimates of genetical radiation damage have erred on the high side. In the absence of more information on the effects of dose-rate and dose-fractionation, the committee continues to recommend that for the general population the average gonadal dose accumulated during the first 30 years of life should not exceed 10 r. of man-made radiation, and should be kept as far below this as practicable. In human tissue cultures, doses of 25 r. produce detectable chromosome breakage in a significant proportion of cells. A slight, but statistically significant, deviation from the normal sex-ratio was observed among children of survivors of the Japanese atom bomb explosion; possibly this might be due to the action of sex-linked mutations affecting prenatal viability.

In animals, a shortening of life-span through radiation has been observed not only for the irradiated individuals themselves, but also for their progeny. In man, shortening of life has not been demonstrated after small doses, but is expected to occur after substantial doses of whole-body irradiation. Part of

[*] National Academy of Sciences–National Research Council. The Biological Effects of Atomic Radiation: Summary Reports from a Study by the National Academy of Sciences. Pp. xi+90. A Report to the Public on the Biological Effects of Atomic Radiation based on the 1960 Summary Reports of the National Academy of Sciences Committee on the Biological Effects of Atomic Radiation. Pp. iii+19. (Washington, D.C.: National Academy of Sciences–National Research Council, 1960.)

this expected decrease in life-span will be due to leukæmia, which is known to affect over-exposed individuals with more than average frequency. The question whether diagnostic X-radiation during pregnancy increases the incidence of leukæmia in the children cannot be decided on the available evidence. Neither can it be decided whether there is a lower threshold to the production of tumours and leukæmia by irradiation, but the sub-committee dealing with hæmatological effects thinks it prudent to assume that for leukæmia no threshold exists. Mammalian embryos are readily affected by low doses of ionizing radiation. One of the most sensitive known indicators of chronic biological damage is the gradual reduction in number, motility and viability of sperm, resulting from small chronic radiation over-exposure. In dogs, effects on sperm have been observed at chronic dose-rates of only ten times the maximum permissible value for human occupational exposure.

Considerable space is devoted to recommendations for future research, especially in the field of genetics. The need for basic research is stressed, and the relevance of mutation research on all forms of life, including bacteria and viruses, is pointed out. On the other hand, attention is directed to problems that arise in human populations and have no counterpart in animal societies. Thus: "human society depends upon a diversity of performance among its members and on very high mental qualities among a few of them. A human civilization might collapse by becoming qualitatively inadequate, even though reproductive selection of certain kinds were acting at high intensity and the number of individuals in the population remained at a level that was previously optimal". These sentences have an obvious relevance to the questions discussed in the leading article "Evolution of Mankind" in *Nature* of February 13.

C. Auerbach

MODERNIZATION OF THE STOCKHOLM CYCLOTRON

In two papers published during 1952, H. Atterling and G. Lindström described the initial performance of the fixed frequency 225-cm. cyclotron at the Nobel Institute of Physics, Stockholm (*Arkiv för Fysik*, 4, 559; 1952, and *Nature*, 169, 432; 1952). A more detailed description of the machine, which has operated reliably and stably for several years producing internal beams of protons, deuterons, alpha-particles and heavy ions (carbon, nitrogen, oxygen and neon ions), is given in two recent articles in *Arkiv for Fysik* (15, 483 and 531; 1959). The oscillator-frequency used recently is 8·1 Mc./s. and with this frequency the machine accelerates ions to a nominal energy of about 11 MeV. per nucleon at a radius of 90 cm. Internal beam currents of approximately 300 μamp. of 22-MeV. deuterons are obtained.

In March 1958, the cyclotron was shut down and taken to pieces for remodelling. Previously it had been run exclusively with internal beams, but when the dees were designed provision was made for the subsequent mounting of an internal d.c.-deflector in one of the dees and during the reassembly of the dees the deflector is being installed.

The machine is housed in an underground hall, resting directly on rock and surrounded on all sides by rock, clay and earth. On the top it is shielded by a water pond two metres deep. The control room is in a three-storey building above ground, and the connexion between the building and the cyclotron hall is via a stairway or a lift to the bottom of a shaft from which a corridor leads to the hall. A removable 150-cm. concrete thick wall partly closes the corridor, leaving an opening 140 cm. broad which can be closed by a concrete door weighing 35 tons. The first article contains full details together with drawings and photographs of the building; the magnet; the radiofrequency tank and dee systems; and the ion-source of the cyclotron. In the second article the techniques used in the work on heavy-ion acceleration in the cyclotron together with some results of the investigation of the energy-distribution for $^{12}C^{4+}$ ions are outlined. It is shown that the distribution contains a low-energy component in addition to the higher-energy peak of the ions. Other applications of the accelerated heavy-ions, in particular for the production of transuranium elements, are briefly mentioned.

DAILY FOOD CONSUMPTION BY SOUTH AFRICAN UNIVERSITY STUDENTS

It has been the practice of the Department of Physiology of the University of the Witwatersrand to request students, as part of their physiological training, to keep a daily record of their food consumption over a defined period of time. The records from one year's class form the basis of a preliminary report by Sonia E. Walker; but it is hoped that data accumulating over several years will afterwards be analysed, and will give some indication of the dietary trends in this student section of the community (*South African J. Med. Sci.*, 24, December, 1959).

The food consumption-levels of the students investigated are similar to those reported from other parts of the world. In a survey of dietary levels of households in the United States, the average consumption per person per day was found to be 2.760–3,260 calories, 87–115 gm. protein and 133–161 gm. fat. The share of total calories derived from carbohydrate was 43 per cent, from protein 13 per cent, and, from fat, 44 per cent. A more recent report based on the estimation of apparent civilian consumption *per capita* per day in the United States gives mean daily intakes of 3,160 cal., 96 gm. protein, 378 gm. carbohydrate and 144 gm. fat. In the United Kingdom a similar estimation of food consumption per head of civilian population per day gave 2,890 cal., 380 gm. carbohydrate, 112 gm. fat, and 90 gm. protein.

The mean daily fat intake of the male group of South African students was 110 gm. This is considerably less than the average American intake, but similar to the daily intake in Britain. The mean protein consumption of the male medical students is 102 gm. per day, which is higher than that found in the United States or Britain.

For practical purposes, the majority of the medical students could probably be classed as sedentary workers, as a large part of their day is spent in sitting in lectures and in dissecting rooms, or in doing laboratory work. Recommended daily allowances for young males doing sedentary work range from 2,400 cal. and 70 gm. protein according to American standards to 2,250 cal. and 66 gm. protein according to British standards.

The present study showed a marked sex difference in food intakes between the male and female students. This is in agreement with observations made on college men and women in the United States, where the men were found to consume more meat, milk and cereals than the women students.

The calorie intake of the Johannesburg women students was slightly less than that found in a group of American students of comparable age, body-weight and height.

DISTRIBUTION OF ATMOSPHERIC OZONE; A PRELIMINARY ANALYSIS OF SOME INTERNATIONAL GEOPHYSICAL YEAR OBSERVATIONS

By J. MacDOWALL

Royal Society International Geophysical Year Expedition, c/o The Royal Society, Burlington House, London, W.1

THE three years of total atmospheric ozone observations at Halley Bay (75° 31′ S., 26° 37′ W.) do not fit into the world-wide picture of the ozone distribution first measured by Dobson[1] from 68° N. to 44° S. Maximum amounts of ozone are not observed until the equivalent of 2–3 months after the seasonal maximum in high northern latitudes, and the highest values observed in the southern hemisphere are lower than in the north.

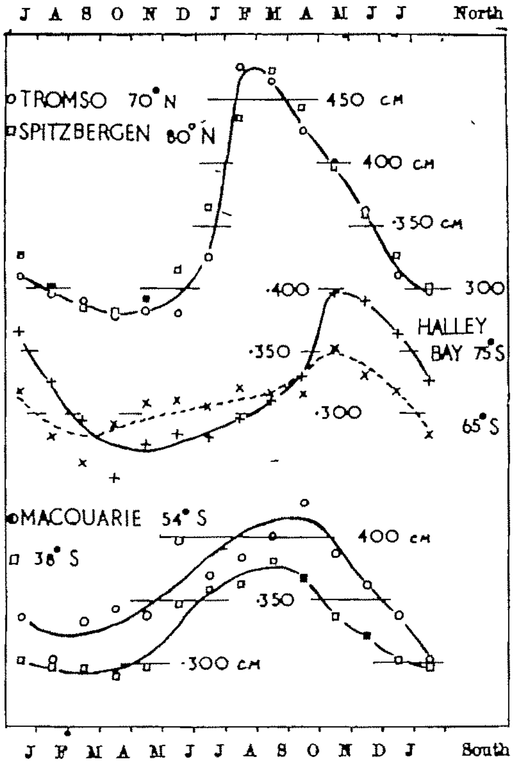


Fig. 1. Shows that the type of seasonal variation of total ozone at Halley Bay is also discernible at Argentine Islands (65° S.), and the seasonal variation at both stations differs greatly from the variation found at high-latitude northern stations

Fig. 1 shows that the type of seasonal variation at Halley Bay is also present, but much less definite, ten degrees to the north at Argentine Islands; the seasonal variation of ozone at both stations differs greatly from the variation found at high-latitude northern stations. International Geophysical Year observations of total ozone at Macquarie Island, Melbourne, and Brisbane show a more 'normal' seasonal variation.

The International Geophysical Year observations from twelve northern and five southern stations are used in Fig. 2 to illustrate the marked difference

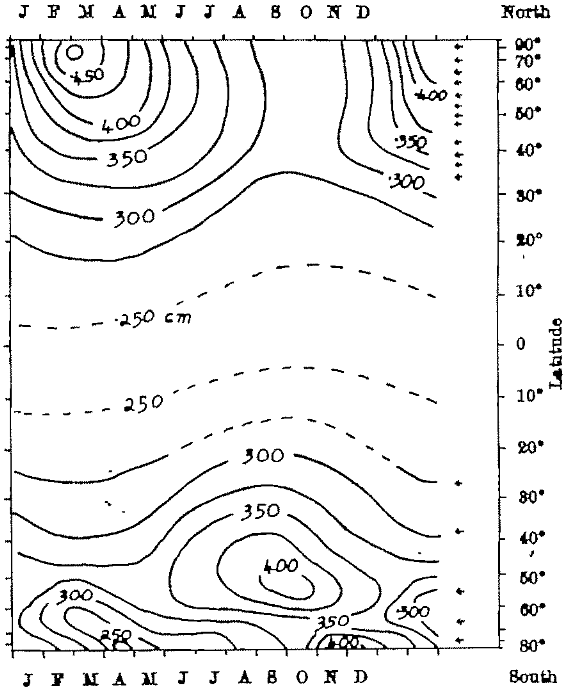


Fig. 2. Smoothed monthly mean results of ozone measurements from seventeen stations illustrating the marked difference between the hemispheres in the seasonal variation of the total quantity of atmospheric ozone

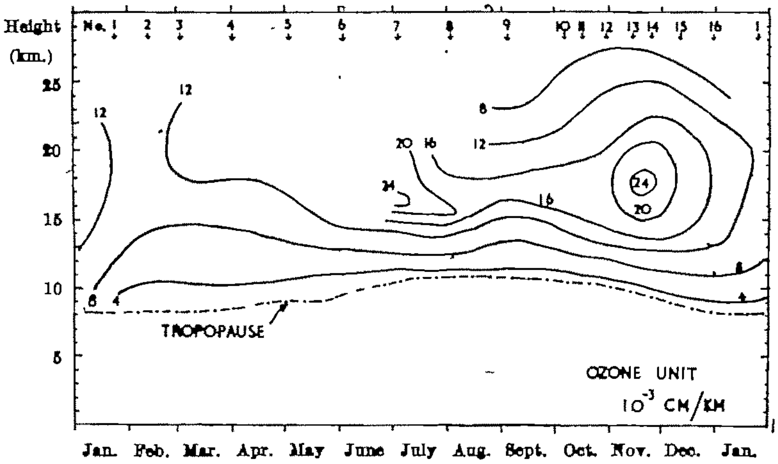


Fig. 3. Smoothed results of sixteen ozone sonde ascents showing the seasonal change in the form of the ozone layer over Halley Bay

between the hemispheres in the distribution of atmospheric ozone at latitudes higher than 55°. The small arrows on the right of the diagram indicate the latitude of the seventeen stations; ozone values for low latitudes, shown by dotted lines, are chiefly due to the work of Normand[2]. There is a close similarity between the hemispheres in low latitudes, but south of 55° S. completely new features of the ozone distribution are revealed, particularly during July–September (compare with the ozone distribution during January–March in the north). In these early spring months the amount of ozone in the north increases very rapidly with latitude, but in the south least ozone is found at high latitudes.

Upper air conditions are well known to be related to the total amount of ozone[3]. Short period fluctuations of 3-day mean values about the 10-day running mean of air temperature and pressure are related to short-period fluctuations of ozone at Halley Bay, but they are less closely related than in south-east England. However, at Halley Bay, 10-day running mean of air temperature and pressure are found to bear little or no relation to the total amount of ozone, whereas in south-east England these measurements are closely related.

During 1958 a series of sixteen chemical ozone sondes were flown from Halley Bay; the sonde was designed by Dr. A. W. Brewer[4] at the Clarendon Laboratory, Oxford, to fit on a standard Kew type radio sonde as used by the Meteorological Office, London. The results of these flights are used in Fig. 3 to draw a smoothed height/time cross-section of ozone concentration over Halley Bay. Apart from the intrinsic interest of these soundings it is of importance to notice at the moment how they confirm the lateness (compared with high northern latitudes) of the ozone maximum at Halley Bay. The great success in the operation of this somewhat temperamental instrument was largely due to the skill of Mr. J. A. Smith, who joined the Meteorological Group at Halley Bay for 1958.

I take this opportunity to thank my colleagues at the Royal Society Base for their co-operation which made the ozone work successful, Mr. J. Farman of the Falkland Island Dependencies Survey, for provisional International Geophysical Year daily values of total ozone at the Argentine Islands, and Dr. G. M. B. Dobson for the great benefit of his advice.

This work formed a part of the programme of the British National Committee for the International Geophysical Year; a full discussion of the results will be published in due course[5,6].

[1] Dobson, G. M. B., *Proc. Roy. Soc.*, A, **129**, 411 (1930).

[2] Normand, C. W. B., Sci. Proc. Int. Assoc. Met., Tenth Assembly, Rome (1954).

[3] Normand, C. W. B., *Quart. J. Roy. Met. Soc.*, **79**, 39 (1953).

[4] Brewer, A. W., and Milford, J. R., *Proc. Roy. Soc.*, A, **256**, 470 (1960).

[5] MacDowall, J., *Proc. Roy. Soc.*, A, **256**, 149 (1960).

[6] MacDowall, J., in "The Royal Society I.G.Y. Antarctic Expedition, Halley Bay, Coats Land, Falkland Island Dependencies, 1955–1959", **3** (1961).

THEORY OF AURORAL STRUCTURES

By E. R. HARRISON*

Atomic Energy Research Establishment, Harwell

THE varied structures of the visual auroræ present problems in many branches of physics. In this discussion the subject is simplified to some extent by ignoring so far as possible such questions as where the auroral streams come from, how they gain their energy, and what are the excitation mechanisms. On the other hand, the present treatment collects together some of the properties, such as stability, peculiar to beams guided by the geomagnetic field prior to their entry into the denser regions of the atmosphere. It turns out that stable beams are possible provided they are thin in cross-section. The break-up of arcs into rayed structures can, it appears, be explained by the conditions governing the growth of electrostatic oscillations in the streams. It seems reasonable that quiescent arcs and rays are equilibrium structures, free at least from any gross forms of instability, whereas many of the transient effects of auroral phenomena are the result of unstable streams.

Auroral displays[1] often begin with quiet, homogeneous arcs extending distances of several thousand kilometres along parallels of geomagnetic latitude. A striking feature of many of the arcs is their thinness; Elvey[2] reports that on one occasion an arc had an estimated thickness of 0·25 km. Frequently several arcs are close together and as many as six have been observed in a distance of 25 km. along a geomagnetic meridian. Later in the display the arcs tend to brighten and then disrupt into rayed structures. Later still, the display may change to pulsating

* Temporarily on leave at CERN, Geneva.

surfaces and flaming auroræ. Apart from the amorphous and relatively transient forms of auroræ, the two basic types of structure in any display are the arcs and the rays[3]. They occur either independently or together in various combinations. Both types extend upwards along the geomagnetic lines of force. Arcs extend vertically for approximately 50 km. and seldom more than 100 km. Rays, however, can have heights of several hundred kilometres, and also diameters of less than 0·5 km. Doppler shifted hydrogen lines are observed in homogeneous arcs[4] (but so far not in rays) and indicate maximum incoming proton velocities of at least 3×10^8 cm.sec.$^{-1}$. In the arcs it seems that the excitation is produced partly by protons, whereas in rays the excitation is primarily by electrons[5].

Commencing with the idea that the beams responsible for producing the auroræ may consist of streaming plasma, one finds that in the absence of electric fields the electrons are rapidly eliminated and the plasma is converted into an ion beam. Let H_0 be the geomagnetic field strength where the plasma is injected at an initial temperature T_0. With no collisions, the magnetic moments are invariant, and the mean transverse kinetic energy increases as $kT_0 H/H_0$ at the expense of the longitudinal kinetic energy, as the particles approach the Earth. In a streaming plasma the electrons have a relatively small kinetic energy and they are therefore brought to rest more quickly than the ions. Thus, if kT_0 is of the order of 10 eV., and protons have initially an energy of 10^5 eV., the electrons are arrested when $H \simeq 5H_0$, and the protons when $H \simeq 10^4 H_0$. Assuming that injection occurs at a distance of 10 Earth radii, the plasma is converted into a proton beam at 6 Earth radii, and at the Earth's surface the protons (assuming no collisions) have lost 10^4 eV. When, however, the plasma is density-modulated into bunches, either by spatial or time growing oscillations (see below), the associated electric fields do not have to be large to trap and drag along some of the electrons and increase their transverse kinetic energy at the expense of the energy of the protons. This mechanism may account for some of the energetic electrons found in the auroral zones[6] and in the outer Van Allen belt[7], particularly if the initial transverse energy is larger than that assumed above.

The beams producing the quiescent arcs and rays are evidently guided in a rigid manner by the geomagnetic lines of force. An analysis of the problem shows that there is lateral stability when the Maxwell stress tensors of the geomagnetic field exceed the stress tensors of the self-fields and of the beam itself[8]. Neglecting for the moment the self-fields, this requires that:

$$H^2/4\pi > n_b^+ m_b^+ v^2 \qquad (1)$$

where n_b^+ is the number density and m_b^+ the mass of the ions in the beam, and v is the velocity component parallel to the geomagnetic field H. When the 'tension' of the geomagnetic lines of force is greater than the 'negative tension' of the momentum flux, as given by (1), the beam is hydromagnetically stable. The upper atmospheric density is comparable with or greater than the beam density, and when (1) is not satisfied the Alfvén phase velocity has complex values and the beam is unstable against transverse perturbations[9].

From (1) it follows that the stress tensors of the self-magnetic field components are small compared with $H^2/4\pi$ provided the beams which produce the rays have a radius d, and the beams which produce the arcs a semi-thickness d, given by:

$$d < \delta_b \qquad (2)$$

where $\delta_b = (m_b^+ c^2/4\pi n_b^+ e^2)^{1/2}$ is the collision-free penetration depth of an electromagnetic field for the beam ions. In the case of protons $\delta_b = 2 \times 10^2 n_b^{-1/2}$ km.

Condition (2) is also necessary if the Larmor radius of the beam ions in the transverse self-magnetic field is to exceed the beam radius. This has been shown elsewhere[10] for cylindrical beams in terms of Budker's parameter $\nu = (d/2\delta_b)^2$, and it seems that for non-relativistic speeds (2) is necessary for a streaming type motion, whereas $d > \delta_b$ applies for plasmas in which the relatively small drift motions are maintained by electric fields. For constant-speed ions the ratio d/δ_b varies at most by $\sqrt{2}$ in any beam following the geomagnetic flux lines; thus if (2) is true at one point, it is also approximately true for all points of a constant speed beam. In spite of both (1) and (2) instabilities may still occur, particularly in arcs, due to transverse force fields producing drift motions[11]. For example, it has been suggested that drift motions are responsible for the folding of arcs into draperies[12].

Using the plasma parameter β, defined as the ratio of the thermal and magnetic pressures, (1) is equivalent to $\beta < 2kT/m_b^+ v^2$. Beams with energy sufficient to penetrate only to a magnetic field strength H are initially stable if $\beta < H_0/H$, provided the magnetic moments are invariant. One notices that the beam ions have a mean Larmor radius in the geomagnetic field of $\delta_b \beta^{1/2}$.

We first consider the possibility that the incoming proton beams proceed directly from a large-scale source or stream external to the geomagnetic field. If a stream of particles is incident on regions of the geomagnetic field of strength H_0, and we assume that the convergent flux lines are parallel to the stream velocity, then by Busch's theorem[13] it is found that if (1) is satisfied, then (2) is also satisfied. In one particular model one imagines that tongues of plasma from the solar wind are injected into the unstable outer surface of the geomagnetic field[14]. One might tentatively extend such a model by suggesting that the outer Van Allen belt contains the particle injections which have failed, due to beam instabilities, to produce an immediate auroral effect; such instabilities could be responsible for the energetic electrons found in the belt. It has been suggested[15] as an alternative possibility that auroral beams originate from regions within the Earth's magnetic field, as, for example, the outer Van Allen belt mentioned above. The difficulty with this suggestion is that there is no evidence[7] of the trapped energetic protons at distances of several Earth radii which are at least necessary for the quiet arcs.

So far what has been said applies more or less equally for the beams which produce both the ray and arc type structures. However, the possibilities are strong that the situation is different when one turns to the subject of electrostatic oscillations in beams passing through a plasma. Because of the long-range Coulomb forces, initial density fluctuations under certain conditions can grow into bunches, and the coherent interactions lead to a rapid loss of momentum from the beam[16]. In the present treatment it is sufficient to consider only those coherent interactions in the beam which occur high above the auroral display. These interactions will determine whether the beam survives to contribute to the auroral display, and whether the beam will produce an arc or a ray. At lower altitudes, approaching the ionosphere, the electron density rises to a value which makes it extremely unlikely that any non-relativistic beam of electrons or protons larger in radius than a few metres is stable. As a result the energy of the incident streams is converted into fluctuation and drift energy of the atmospheric electrons. Radio studies of the aurora[17] have shown for some time that there are electron density fluctuations having in some cases the form of bunches elongated along the magnetic field. These fluctuations have been attributed principally to atmospheric turbulence. In the present discussion it is suggested that the coherent bunching observed in the ionospheric and auroral regions are possibly the result of incoming particle streams.

From the electromagnetic equations, the equations of motion and continuity, we have:

$$\nabla_{\perp}^2 E_z + k_z^2 \varepsilon E_z = 0 \qquad (3)$$

$$1 - \frac{\omega_b^2}{(\omega - k_z v)^2} - \frac{(\omega_e^+)^2 + (\omega_e^-)^2}{\omega^2} = \varepsilon$$

where E_z is the longitudinal component of the electric field, $k = (k_z^2 + k_{\perp}^2)^{1/2}$ is the wave number, and ω_b and ω_e are the plasma frequencies for the beam and plasma, respectively. It is assumed that only longitudinal oscillations occur. Interactions between the beam and the stationary atmospheric electrons is complicated by the fact that there is momentum transfer and the moving electrons in turn interact with the atmospheric ions. Comparing the rates of momentum transfer (Ohkawa, T., privately communicated) one finds by an approximate treatment that the electrons are dragged along at a speed of $v n_b / n_e$, which is of the order of 10^4 cm.sec.$^{-1}$. But this method neglects Landau damping due to the thermal motion of the electrons and the velocity spread of the beam. It has been shown[18] that an electron stream interacts with stationary ions when it has a velocity exceeding its mean random speed, or in this case when $v n_b / n_e > (2kT/m^-)^{1/2}$. This requires an electron thermal energy of less than 10^{-3} eV. The thermal energy is certainly greater and at high altitudes might be as large as 10 eV., and in this case beam interactions with the electrons can be neglected.

Consider first the case of short transverse wave-lengths, given by $k_{\perp} d > 1$. Using the dispersion equation obtained from (3) one finds that there are spatially growing waves (k_z is complex) for $k_z < k_{\perp}$, and time growing waves (ω is complex), when:

$$k_{\perp} < \frac{1}{v}\{\omega_b^{2/3} + (\omega_e^+)^{2/3}\}^{3/2} \qquad (4)$$

and there is no velocity spread in the beam. At distances of several Earth radii the atmospheric ion density is possibly of the order 10^3 cm.$^{-3}$, and the beam density is, say, of the order 1 cm.$^{-3}$, and therefore $\omega_e^+ > \omega_b$. It follows from (4) and the assumption that $k_{\perp} d > 1$ that a sufficient condition that there are no instabilities is:

$$d < \frac{v}{c}\,\delta_e^+ \qquad (5)$$

where $\delta_e^+ = c/\omega_e^+$. For $v/c \sim 10^{-2}$ the beams must have a semi-thickness or radius of $d < 0 \cdot 2$ km. When this condition is not fulfilled the beam loses its momentum in a distance:

$$L \simeq \frac{\lambda}{2\pi}\left(\frac{\omega_e}{\omega_b^+}\right)^{2/3} \ln \Lambda \qquad (6)$$

where λ is the wave-length of the disturbance, and the logarithmic term has a value between 10 and 100 and depends partly on the mean square fluctuation $[(\Delta n/n)^2]$. The effect of a large velocity spread[18] in the beam is difficult to assess without some knowledge of the distribution function. The growth-rate of instabilities will be reduced and possibly there will be a relaxation in the stability condition (5).

Condition (5) is sufficient for stability when $k_{\perp} d > 1$. If we regard the transverse standing waves as dividing the beam into raylets of diameter $k_{\perp} d = 1$, then (5) is the necessary condition for stability in each raylet. At low altitudes the electron interaction cannot be neglected and the stability condition becomes:

$$d < \frac{v}{c}\,\delta_e^- \qquad (7)$$

and for $n_e^- \sim 10^6$, this gives $d < 5$ cm. Thus, practically all beams lose energy due to coherent interaction as they approach the ionosphere.

For long wave-lengths the electric fields are no longer confined to the beam and the appropriate boundary conditions must be used for solving (3). As a result, the frequencies are reduced by $(k_z^2 d/k_y)^{1/2}$ for sheet beams which produce arcs when $k_y d < 1$ (where k_y is in the transverse direction along the geomagnetic longitude), and approximately by $k_{\perp} d$ for cylindrical beams which produce rays when $k_{\perp} d < 1$. The conditions that there are no time and space growing waves, and therefore the beams are stable, are:

$$\begin{aligned} &\text{(arc)} \qquad d < \frac{v}{c}\,\delta_e^+ (k_y d)^{1/2} \\ &\text{(ray)} \qquad d < \frac{v}{c}\,\delta_e^+ \left\{\frac{2}{\ln(1/k_y d)}\right\}^{1/2} \end{aligned} \qquad (8a,\ b)$$

For ray beams (8*b*) is sensibly the same as (6) with the exception of the logarithmic dependence on $1/k_y d$. Arc beams, however, are always unstable for sufficiently long transverse wave-lengths. Thus, when an arc beam becomes unstable the transverse standing waves grow rapidly, and for short transverse wave-lengths for which $k_y d \rightarrow 1$ the stability is eventually determined by the ray condition (8*b*).

There are, therefore, a number of elementary conditions necessary for the stability of auroral beams which are broadly covered by (1), (2), (5) and (8*a*, *b*). Presumably, in the early stages of an auroral display the beams have a low density and there is no serious growth of coherent interaction at high altitudes. A diffuse source ejecting particles towards the Earth will produce thin homogeneous arcs extending along the geomagnetic latitudes. During the auroral display the beam density apparently increases and the arc beams become unstable; there is then a loss of beam energy. Transverse density variations in the arc beams, however, can lead to the formation of ray beams, which are more stable. According to this treatment the arc is the more fundamental of the two types of structure, and the presence of rays must indicate that arc type beams are arrested in regions possibly high above the auroral display. In these regions there are considerable fluctuations which modulate the down-coming rays, and at lower levels these fluctuations grow spatially, as in a travelling wave amplifier, due to an increase in the density and a reduction in the temperature of the atmospheric electrons. The oscillations in the ray beams may account for their luminous length, the loss of proton energy due to the atmospheric electron drag is possibly a reason why no hydrogen lines are observed, and the increased energy of the electrons[19] which are excited or dragged down by the beams may also explain the electron impact excitation which predominates in ray structures.

Acknowledgments are gratefully made to Tihiro Ohkawa for a number of informative discussions on plasma and beam oscillations, and to Lloyd Smith for discussions and comments on the treatment outlined in this paper.

---

[1] See review articles. Hsiang, L., "The Aurorae" (Wiley, New York, 1951). Ferraro, V. C. A., "Adv. Phys.", 2, 265 (1953). Chamberlain, J. W., and Meinel, A. B., "The Earth as a Planet", ed. G. P. Kuiper, Ch. 2 (University Press, Chicago, 1954). Störmer, C., "The Polar Aurorae" (Clarendon Press, Oxford, 1955).

[2] Elvey, C. T., *Proc. U.S. Nat. Acad. Sci.*, 43, 63 (1957).

[3] Chamberlain, J. W., "Theories of Auroras", Sandia Corporation Rep. 77 (1959).

[4] Meinel, A. B., *Astrophys. J.*, 113, 50, 583 (1951).

[5] Fan, C. Y., *Astrophys. J.*, 119, 294 (1954).

[6] Meredith, L. H., *et al.*, *Phys. Rev.*, 97, 201 (1955). Van Allen, J. A., *Phys. Rev.*, 99, 609 (1955). Anderson, K. A., *Phys. Rev.*, 111, 1397 (1958).

[7] Vernov, S. N., *et al.*, *Dokl. Akad. Nauk. S.S.S.R.*, 125, 304 (1959).

[8] Finkelstein, D., and Sturrock, P. A. (unpublished).

[9] Harrison, H. B. (to be published).

[10] Lawson, J. D., *J. Nuc. Energy*, Part *C*, 1, 31 (1959).

[11] Rosenbluth, M. N., and Longmire, C. L., *Annals of Phys.*, 1, 120 (1951).

[12] Alfvén, H., "Cosmical Electrodynamics" (Clarendon, Oxford, 1950).

[13] Pierce, J. R., "The Theory and Design of Electron Beams" (Van Nostrand, New York, 1949).

[14] Parker, E. N., *Proc. Inst. Rad. Eng.*, 47, 239 (1959); "Phys. of Fluids", 1, 171 (1958).

[15] Van Allen, J. A., *et al.*, *J. Geophys. Res.*, 64, 271 (1959).

[16] Buneman, O., *Phys. Rev.*, 115, 503 (1959).

[17] Booker, H. G., *J. Atmos. Terr. Phys.*, 8, 204 (1956); *J. Geophys. Res.*, 61, 673 (1956). Kaiser, T. R., "The Airglow and the Aurorae", ed. Armstrong, E. B., and Dalgarno, A. (Pergamon, London, 1955). Nichols, B., *Proc. Inst. Rad. Eng.*, 47, 245 (1959).

[18] Chamberlain, J. W., *Astrophys. J.*, 126, 245 (1957).

[19] Winkler, J. R., *et al.*, *Phys. Rev.*, 108, 903 (1957); *ibid.*, 110, 1221 (1958).

INFRA-RED SPECTRA OF AMINO-ACIDS AND RELATED SUBSTANCES IN WATER

By PROF. FRANK S. PARKER and PROF. DONALD M. KIRSCHENBAUM

Department of Biochemistry, State University of New York, Downstate Medical Center, Brooklyn, New York

ADVANCES both in infra-red instrumentation and in the availability of barium fluoride windows for the manufacture of infra-red cells to contain aqueous solutions stimulated us to undertake a systematic investigation of infra-red spectra of various small molecules of biological importance, including amino-acids and related amines. Until recently, most infra-red spectrophotometric measurements on compounds of biological interest have been made in mulls, in films, in organic solvents, or in potassium bromide pellets[1]. However, following Coblentz's[2] early work with water, Gore *et al.*[3], Blout[4], and others have used aqueous solutions for infra-red studies of certain materials. The present article contains some of the results of our work on amino-acids and derivatives.

Infra-red spectra were recorded as described in a previous publication[5]. Concentrations are recorded in the legends to the figures.

Fig. 1 shows the spectrum of water between 950 and 1,600 cm.$^{-1}$, and typical examples of solubility effects in the aliphatic amino-acids. It is seen that saturated solutions of glycine and alanine have distinctive spectra. The solubility of glycine[6] is 25 gm. per 100 gm. of water at 25°; the solubility of L-alanine is 16·5 gm. per 100 gm. of water at 25°. These amino-acids still show distinctive spectra at 5 per cent concentrations in water; thus glycine still shows distinctive absorption bands at 1,404, 1,319 and 1,124 cm.$^{-1}$; and alanine at 5 per cent concentration still shows the distinctive bands at 1,408, 1,351, 1,299, 1,212 and 1,105 cm.$^{-1}$, among others.

Fig. 2 shows, however, that saturated solutions of valine, leucine and isoleucine have very few distinctive absorption bands, as one would expect from their solubilities. The solubility of DL-valine is 7·1 gm. per 100 gm. of water at 25°; the solubility of L-leucine is only 2·2 gm., and the solubility of L-isoleucine is only 4·1 gm.

Fig. 3 shows the spectra of proline, serine, threonine and hydroxyproline. The effects of changing the structure from a primary hydroxy compound, serine, to a secondary hydroxy compound, threonine, can be seen. Zeiss and Tsutsui[7] have shown that in alcohols with a saturated chain, a band appears between 1,075 and 1,010 cm.$^{-1}$ for primary alcohols. On the other hand, in secondary alcohols the band

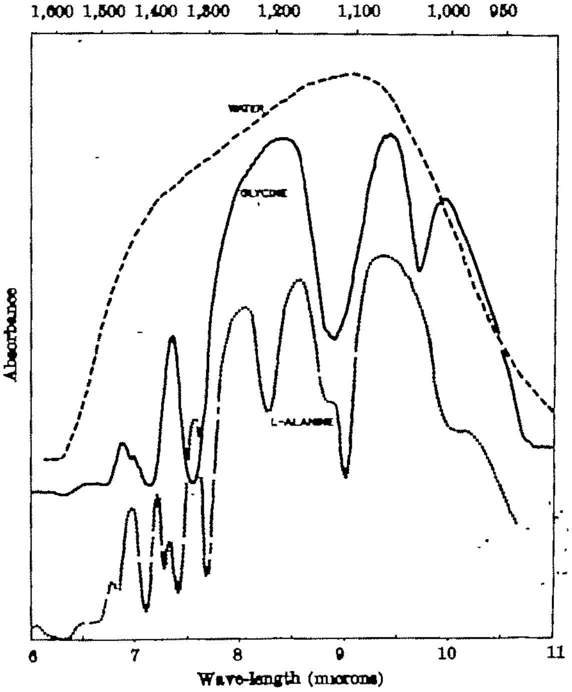


Fig. 1. Spectra of water, glycine and L-alanine. The amino-acids were in saturated solutions. Barium fluoride cell, 0·05 mm. thickness

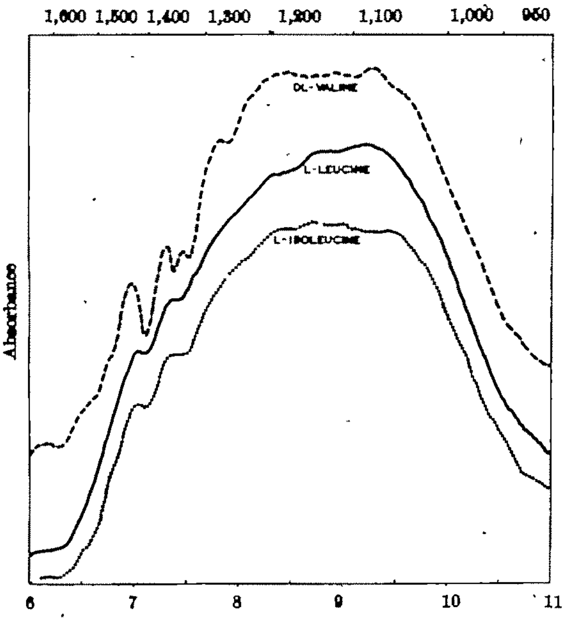


Fig. 2. Spectra of DL-valine, L-leucine and L-isoleucine in saturated solutions

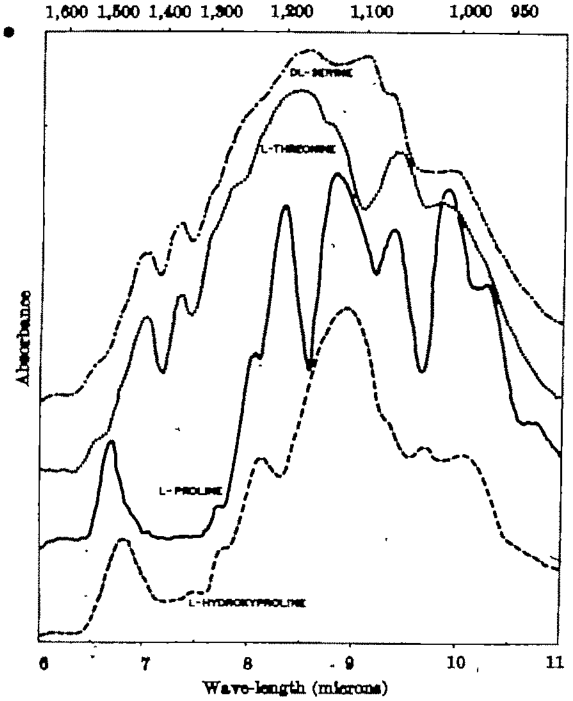


Fig. 3. Spectra of DL-serine (5 per cent solution); L-threonine (5 per cent solution); L-proline (saturated solution); and L-hydroxyproline (saturated solution)

appears between 1,119 and 1,105 cm.$^{-1}$. It is of interest, therefore, that serine has an absorption band at 1,020 cm.$^{-1}$, which is in the range for primary alcohols; and threonine absorbs at 1,100 cm.$^{-1}$, which is in the range for secondary alcohols. However, hydroxyproline, which contains a secondary —OH group on a cyclic imino-acid, does not show absorption where one would expect a secondary alcohol to absorb, namely, from 1,105 to 1,119 cm.$^{-1}$; rather, there is a band at 1,205 cm.$^{-1}$.

It is of interest to note the distinctive differences between the spectra of the imino-acids proline and hydroxyproline, particularly the band in proline at 1,163 cm.$^{-1}$. These differences can perhaps be used to advantage in the examination of the conversion of proline to hydroxyproline, an important process in the biosynthesis of collagen[8]. Although saturated solutions of proline and of hydroxyproline were used, 5 per cent concentrations of these amino-acids can still be differentiated.

Aspartic acid is known to undergo decarboxylation of either the α- or the ω-carboxyl group to form

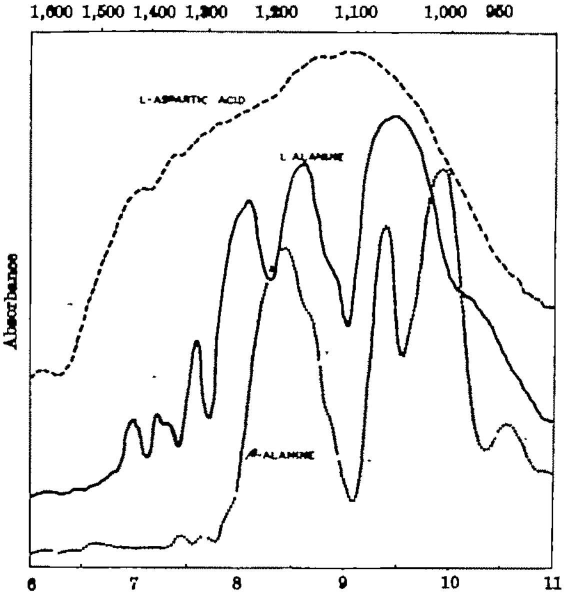


Fig. 4. Spectra of L-aspartic acid, L-alanine and β-alanine in saturated solutions

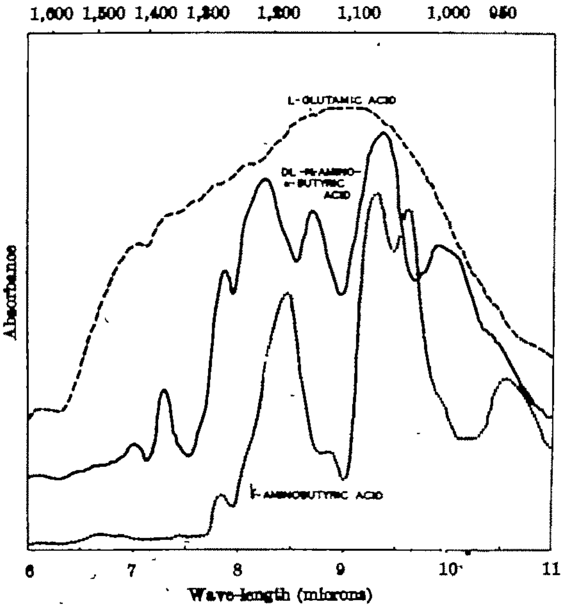


Fig. 5. Spectra of L-glutamic acid, DL-α-aminobutyric acid, and γ-aminobutyric acid in saturated solutions

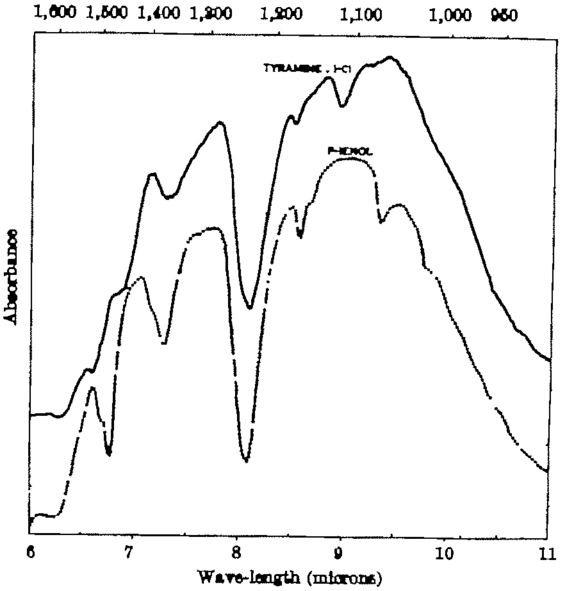


Fig. 6. Spectra of tyramine hydrochloride (10 per cent solution) and phenol (7 5 per cent solution)

either β-alanine or alanine. Examination of Fig. 4 shows that it may be possible to follow such changes using infra-red techniques. There are distinct differences between the spectra of aspartic acid, L-alanine and β-alanine. Infra-red techniques would thus permit one to deduce which end of aspartic acid has lost its carboxyl group. Similarly, in Fig. 5 are shown the spectra of L-glutamic acid, DL-α-aminobutyric acid and γ-aminobutyric acid. Either of the aminobutyric acids can be obtained by decarboxylation of glutamic acid. It is thus possible to distinguish between glutamic acid and either of these decarboxylation products by their infra-red spectra.

With the aromatic and heterocyclic amino-acids, the problem of low solubility of the dipolar ionic form again appears and this renders the demonstration of distinctive spectra difficult. However, the decarboxylation products display distinctive spectra; for example, tyramine (Fig. 6), which is the decarboxylation product of tyrosine, displays a distinctive spectrum as the hydrochloride. Comparison of this spectrum with that of phenol shows that the main absorbing group in tyramine between 950 and 1,600 cm.$^{-1}$ is the phenolic moiety. Tyrosine was too insoluble to study.

The absorption characteristics of many other amino-acids, related homologues and decarboxylation products are being investigated in our laboratory and will be reported elsewhere[9].

A preliminary report of this work was presented before the American Society of Biological Chemists in Atlantic City, New Jersey (*Fed. Proc.*, 18, 299; 1959).

---

[1] Bellamy, L. J., "The Infra-red Spectra of Complex Molecules", second edit. (Methuen, London, 1958).

[2] Coblentz, W. W., "Investigations of Infrared Spectra", 56 (Carnegie Inst., Washington, 1905).

[3] Gore, R. C., Barnes, R. B., and Petersen, E., *Anal. Chem.*, 21, 382 (1949).

[4] Blout, E. R., *Ann. N.Y. Acad. Sci.*, 69, 84 (1957).

[5] Parker, F. S., *App. Spectroscopy*, 12, 163 (1958).

[6] Meister, A., "Biochemistry of the Amino Acids" (Acad. Press, Inc., New York, 1957).

[7] Zeiss, H. H., and Tsutsui, M., *J. Amer. Chem. Soc.*, 75, 897 (1953).

[8] Gould, B. S., *J. Biol. Chem.*, 232, 637 (1958).

[9] Parker, F. S., and Kirschenbaum, D. M., *Spectrochim. Acta* (in the press).

A HYPOTHESIS OF CONTRACTION IN STRIATED MUSCLE

By Dr. M. SPENCER and Dr. C. R. WORTHINGTON

Medical Research Council Biophysics Research Unit, Wheatstone Laboratory, King's College, London

WE wish to suggest a mechanism by which the system of sliding filaments in striated muscle, proposed by H. E. Huxley and Hanson[1] and by A. F. Huxley and Niedergerke[2], might be caused to exert a contractile force during excitation. The mechanism is probably also applicable to those smooth muscles which have a double array of filaments[3]. It relies on electrostatic forces between sites on the actin and myosin filaments, and does not necessarily require mechanical linkage between them. It does not involve contraction or folding of the filaments, and thus differs from previous models using electrostatic forces[4].

The mechanism was suggested by the results of recent work by one of us[5] on X-ray diffraction from striated muscle fibres. The results showed that, in addition to orders of the previously observed axial spacing of 410 Å. attributed to actin, orders of an axial spacing of 435 Å. could be seen which were attributable to myosin. The arguments on which this assignment is based have been presented elsewhere[5]. The spacings are significantly different, and can be observed together in the same X-ray diffraction pattern, and in both the wet and the dry state. Work on living muscle is in progress in this Laboratory.

Basic Assumptions

Let us assume that excitation of a striated muscle is ultimately transferred to the actin filaments where they meet the Z-lines. (There is evidence that excitation is transferred from the surface membrane to structures called triads in the sarcoplasmic reticulum[6]. In frog muscle the triads lie opposite each Z-line; in certain other muscles there are two per sarcomere, displaced from the Z-line by a quarter of the sarcomere length.) The terminology is illustrated in Fig. 1. Suppose also (in common with Szent-Györgyi[7]) that the actin and myosin filaments are, prior to stimulation, mutually repelling each other. The repulsion is assumed to be between sites on the filaments which carry like electrostatic charges. The sites are assumed to be spaced at 410 and 435 Å. along the actin and myosin filaments respectively. It seems likely that the sites on either the actin or the myosin filaments, or on both, are really projections from them. Electron micrographs of striated muscle show 'cross-bridges'

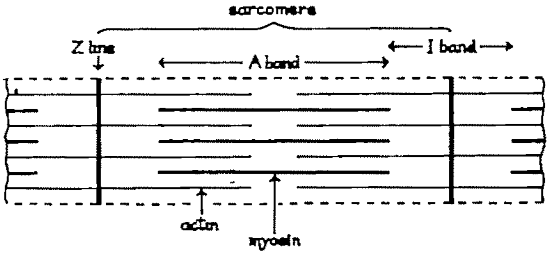


Fig. 1. Diagram of the arrangement of molecular filaments in a striated muscle fibre, according to Hanson and Huxley During contraction the actin and myosin filaments slide past each other

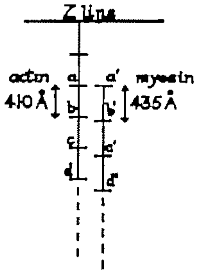


Fig. 2. Diagram of two filaments in a sarcomere, showing proposed sites of electrostatic charge. The difference in spacing has been exaggerated. Sites on the actin filaments are regularly spaced along their length at 410 Å. apart; myosin sites are spaced at 435 Å.

spaced at about 400 Å. which appear to originate from projections on the myosin filaments[7].

Let us now suppose that the excitation transmitted across a Z-line sets off a pulse of charge reversal which travels down the actin filaments so that successive sites on each filament are momentarily given an opposite electrostatic charge. (The idea that some change in properties is propagated down the filaments is not new.) The mechanism by which this could happen is, of course, quite hypothetical at present. We believe that it might be a charge transfer of the type envisaged by Szent-Gyorgyi[8]. A rough parallel may be drawn with the passage of a pulse down an electrical transmission line. Each site carrying a reversed charge would be attracted to whichever sites on the adjacent filaments were nearest to it.

Consequences of the Hypothesis

(*a*) ***Free contraction.*** Consider the effects on only two filaments, one of actin and one of myosin, of a pulse of charge-reversal travelling down the actin filament (Fig. 2), when the myosin is free to move relative to the actin. Assume, for the sake of argument, that the first charged site a' of the myosin lies initially in register with a site a on the actin. When the charge on a is reversed, there will be no axial force on the myosin filament. However, when the charge-reversal is transferred to b there will be an axial force, upwards in the diagram, on site b'. This would also be true for reversal at sites c and d. If the myosin filament was prevented from responding to the upward force, the charge-reversal at sites farther down the actin would give an opposite force. Since, however, the myosin is free to move, reversal of charge on b will cause movement of the myosin until b and b' are in register. The distance between c and c' is then the same as that originally separating b from b'. If the movement is repeated at each transfer of charge, there will be a continuous upward movement of the myosin. If a and a' are not initially in register, the first movement may be downwards, but all subsequent movements will be upwards. This movement in one direction only may be compared with that occurring in a unidirectional synchronous electric motor.

(*b*) *Contraction under load.* We do not suggest that, except possibly under conditions of zero load, the contraction of muscle involves the synchronous motion just described. The speed of contraction of a muscle varies with its load, and to explain this with a synchronous mechanism one would need to postulate that the speed of propagation of the charge-reversal was controlled by the rate of contraction. However, a study of the actual arrangement of filaments in striated muscle shows that there is no need to invoke such a process, and we shall proceed on the assumption that the speed of propagation is constant.

We know from structural studies[1,3,7] that each myosin filament in a striated fibre is overlapped by actin filaments at both ends. Consider what happens when pulses travel simultaneously from two successive Z-lines in a myofibril. We assume that the speed of propagation of the impulse to the beginning of each actin filament is much greater than that of the pulse of charge-reversal down each filament (we shall examine this assumption later). An exact prediction of the sequence of events is impossible without a knowledge of the electrostatic field at all points between the filaments. The analysis which follows describes one possible sequence. It is based on the assumption that, if the pulse arrives simultaneously at a and z (Fig. 3a), the myosin filament will adjust its position so that the distance a–a' is the same as z–z'. There will, in the example shown, be a net force pulling the two actin filaments together. Assume, however, that there is 'slip' so that the position is reached later on where the attracting sites on the actin filaments are midway between pairs of sites on the myosin. Sites c and x in Fig. 3a illustrate this condition. If the myosin filament remained stationary while the pulses moved on to sites d and w, there would afterwards be a force pushing the actin filaments apart again. However, when the pulses are at c and x, the equilibrium of the myosin filament will be an unstable one; the filament will tend to jump into one of two positions so that c and x on the actin are in register either with b' and x' (Fig. 3b) or with c' and y' (Fig. 3c). Subsequent transfer of the pulses to

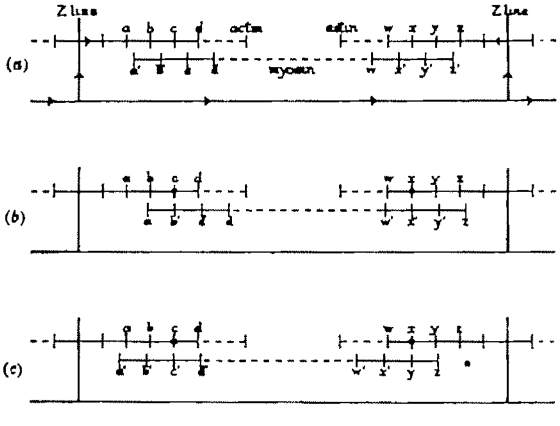


Fig. 3. Three stages in the contraction of a possible model. For explanation see text

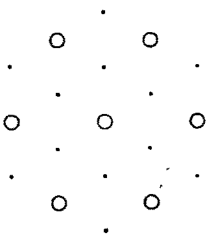


Fig. 4. Arrangement of molecular filaments in a cross-section of the *A* band of a typical striated muscle, as deduced from electron microscopy (ref. 7). Actin filaments are represented by dots and myosin filaments by larger circles

d and *w* will then give rise to forces which still favour drawing together of the actin filaments. We thus see that, provided the myosin is free to make the 'jump' referred to, almost every step in the propagation of the pulses down the actin filaments favours drawing together of the actin filaments. Furthermore, the process is independent of the rate of slip, so that the muscle would exert a tension at all speeds of contraction.

As well as in the special case described above, it can in general be shown that the 'jump' of the myosin filament is essential to the theory; if there was only a steady relative motion of actin and myosin, there would be no net force. However, there is reason to believe that each myosin filament is, in fact, free to move independently. Cross-sections of striated muscle in the *A*-band[7] show that each myosin filament is surrounded by six actin filaments, and is isolated from adjacent myosin filaments (Fig. 4). On the other hand, the fact that every actin filament is adjacent to three others could ensure that the six actin sites which might act on every myosin site were always in register.

(*c*) ***Effect of multiple filaments.*** It is clear from the above description that an individual set of filaments will exert a tension which varies with time. It will at certain instants be zero and, under certain conditions, it may even be negative for part of the cycle. However, a large number of filaments in parallel will, if their jumps are spread out in time, exert an even tension. There is insufficient evidence to decide whether or not all the filaments in a given sarcomere will act in unison. It is not necessary to assume that all the myosin filaments in a sarcomere are identical. A variation among the myosin periods in a typical muscle of only ± 0·5 per cent would spread out in time the jumps of different myosin filaments. The variation of ± 0·5 per cent is less than the experimental error of 1 per cent in measuring the average myosin spacing from a diffraction pattern.

General Properties of the System

A detailed consideration of the expected length-tension and force-velocity curves[10,11] will not be given now. We may, however, note the following properties of the system; some of them are possessed by other possible schemes as well, and have been discussed by previous authors.

(*a*) The maximum tension which the muscle can develop depends on the number of molecular filaments in any one sarcomere, that is, it depends only on the total cross-section of the muscle.

(*b*) The maximum velocity of contraction of the muscle varies as the number of sarcomeres along its length. There is evidence[8,9] that muscles intended for rapid movement often have closely spaced sarcomeres.

(*c*) The isometric tension developed will fall as the muscle is stretched beyond its normal length, because the number of myosin sites overlapped by actin sites will decrease. This means that the number of site interactions per second will also fall (for a given rate of stimulation), and the average force will decrease. A reduction in length will also lead to a fall in tension, for two reasons: first, displacement of fluid by the sliding filaments may increase their separation, and therefore reduce the attraction between sites; secondly, reduction in length will ultimately produce sarcomeres in which the actin filaments have run into each other[7]; this will again result in a drop in the number of interacting sites, and a fall in the tension.

(*d*) The application of an increasing load to the system will lead to an increasing amount of 'slip' from the synchronous motion described, until it just balances the contractile force. It follows that the force-velocity curve must show a decrease in velocity with increasing load.

Thus, qualitatively at least, the expected behaviour of the model is in accord with observation. We have constructed an electromagnetic model which, though crude in that it has only two myosin filaments, illustrates the type of behaviour we have described. It uses coaxial coils to represent the ring of actin filaments around each myosin filament; the latter is represented by a tube containing spaced soft-iron cores. The coils are energized in turn to simulate the passage of the pulse of charge-reversal down the actin filaments.

Discussion

A number of calculations may be made to test whether the assumptions made in the theory are consistent with observations *in vivo*. Examine first the assumption that the passage of the pulse of charge-reversal down each filament takes place at a speed much less than that of the exciting impulse. One way to test this is to compare observed and calculated values for the maximum rate of contraction of a muscle. One would expect that, if our scheme were correct, the maximum rate of contraction of a muscle would correspond with the synchronous motion mentioned earlier. If the velocity of the charge-reversal is v cm./sec., the maximum rate of contraction per sarcomere can be shown to be about 0·12 v cm./sec. In a typical muscle of length 1 cm., having sarcomeres of length 2·5μ, the maximum rate of contraction of the whole muscle will then be 500 v cm./sec. Taking an observed maximum velocity of 2 cm./sec. per cm. length of frog sartorius muscle at 0° C. (ref. 12), the value of v must be about 0·004 cm./sec.—much less than the observed velocity of propagation of the action potential along a fibre, which in many cases exceeds 100 cm./sec. (ref. 13). The assumption that there was this large difference in velocities has not therefore led to a prediction which conflicts with experience. We may note here that the average interval between charge transfers from one site to another will be about 10^{-3} sec.

We may also test whether the calculated value of velocity down the filaments is consistent with the observed frequencies of excitation of muscles *in vivo*. One would expect that, for maximum output from a muscle, the frequency of excitation would be such that one impulse arrived just as the previous pulse of charge-reversal reached the end of the actin filaments. If the frequency was higher than this, the superposition of two pulses on the same set of filaments might lead as often to cancellation of their effects as to reinforcement. (It is of interest to note here that the rate of repetition is in some cases observed to fall when maximum output is not required[13].) If the actin filaments had lengths of 1μ, the time taken for a pulse to travel down them at 0·004 cm./sec. (the velocity calculated above) would be 0·025 sec. The maximum frequency at 0° C would then be 40 impulses/sec. This value is of the right order of magnitude. Calculations based on results obtained at higher temperatures give a higher frequency.

We do not suggest that the nerve impulse transmitted into each *z*-line supplies the energy needed to bring about contraction. We believe that the impulse must trigger a series of reactions which convert chemical energy, perhaps stored in adenosine triphosphate, into electrostatic energy. The theory offers no direct evidence on the reactions involved, and therefore provides no estimate of the heat liberated during contraction.

An important question is whether the theoretical electrostatic attraction between sites can account for the observed tensions developed by living muscle. A typical maximum tension for frog sartorius muscle[10] is 2 kgm./cm.^{2} cross-section. This means that the average force exerted by each myosin filament must be about 3×10^{-5} dyne. If this force is shared between six sites, each of which is opposite an actin site, the average force at each site must be about 5×10^{-6} dyne. The effective force between a myosin site and an actin site is the axial component of the attractive force between them. The component will be zero when the sites are in register. At a large axial separation the component will approach the value of the total force but, due to Debye-Hückel screening, it will be small. Between these two extremes it will rise to a maximum in a way which cannot be predicted without knowing the exact distribution of charges and the ionic conditions in the intervening fluid. In addition to this, there may be large deviations from the simple Debye-Hückel theory under very intense fields. We can, however, make certain assumptions and calculate the maximum component of attractive force between point charges at a given separation.

The most favourable calculation possible is made by neglecting Debye-Hückel screening and assuming a dielectric constant of unity; there are grounds for believing that the relevant dielectric constant may not be as high as that of water. Two sites carrying unit electronic charge would then exert a force of 6×10^{-6} dyne (the average force required) at a separation of about 20 Å. If there were (say) ten electronic charges per site, the separation would be 200 Å. The least favourable calculation is made by assuming the dielectric constant to be that of water, and assuming the Debye-Hückel theory[14] to apply at all separations. The ionic strength, which determines the magnitude of the Debye-Hückel screening, has to be given an arbitrary value; we assume it to be 0·15, a value close to that of human blood serum. The 'thickness' of the ionic double layer[14] will then be about 8 Å. The calculated separation at which unit electronic charges exert the required force on each other is then about 2 Å. This value is, however, so small that the assumptions on which it is calculated cannot be valid, and it is clear that the scheme could not work under these conditions. If, however, there were ten charges per site, the required separation of charges would be 15 Å. This is more of the right order of magnitude, though still somewhat low. For the scheme to be correct we would expect the forces to have appreciable magnitude at distances greater than 25 Å.

It is clear from these calculations that the scheme cannot at present be ruled out on theoretical grounds alone. We may also note that an exact calculation would have to consider the dynamic nature of the process; the attractive force at the beginning of each charge transfer might be greater than that calculated for static conditions, due to the finite time required for equilibrium to be established in the surrounding fluid.

There is one important consequence of the theory which we have not so far discussed. It is that, at any instant during contraction, only a very small percentage (perhaps 4 per cent) of the actin and myosin sites are attracting each other. This implies that the proportion of the biochemist's 'actomyosin' present in contracting muscle will be similarly small, since it seems likely that actomyosin is essentially actin combined with myosin by electrostatic forces. On the other hand, inducement of a charge-reversal of all sites on either actin or myosin would probably cause the filaments to draw together so that they were locked in position by interpenetration of their projections. It seems very likely that such an overall charge-reversal is brought about by removal of adenosine triphosphate from the system[8], since muscles in rigor and glycerol-extracted muscles show the rigidity we have described. The plasticizing role of added adenosine triphosphate and pyrophosphate follows from this idea.

One obvious need in verifying the hypothesis is to extend to the present problem the theoretical work already available on electrostatic forces between charged sites in ionic media[15]. There is, equally, a need to test whether the suggested transfer of charge down the actin filaments does in fact take place. The work of Szent-Györgyi and his associates has shown that this type of process may be vital to many biological systems.

We are indebted to Dr. E. M. Deeley for advice during construction of the electromagnetic model. We would also like to thank Dr. J. Lowy, Dr. J. Hanson and Mr. G. F. Elliott for discussions on the results of muscle research; Dr. M. E. Fisher for advice on theoretical matters; and Prof. J. T. Randall and Dr. M. H. F. Wilkins for encouragement and helpful criticism.

[1] Huxley, H. E., and Hanson, J., *Nature*, 173, 973 (1954).
[2] Huxley, A. F., and Niedergerke, R., *Nature*, 173, 971 (1954).
[3] Hanson, J., and Lowy, J., in "Structure and Function of Muscle", 1 (Academic Press, 1960).
[4] Morales, M. F., *Rev. Mod. Physics*, 31, 426 (1959).
[5] Worthington, C. R., *J. Mol. Biol.*, 1, 398 (1959).
[6] Huxley, A. F., *Ann. N.Y. Acad. Sci.*, 81, 446 (1959).
[7] Huxley, H. E., *J. Biophys. Biochem. Cytol.*, 3, 631 (1957).
[8] Szent-Györgyi, A., "Bioenergetics" (Academic Press, 1957).
[9] Szent-Györgyi, A., "Chemistry of Muscular Contraction" (Academic Press, 1951).
[10] Hill, A. V., *Proc. Roy. Soc.*, B, 126, 136 (1938).
[11] Wilkie, D. R., "Prog. in Biophysics", 4, 288 (1954).
[12] Ritchie, J. M., and Wilkie, D. R., *J. Physiol.*, 143, 104 (1958).
[13] Hoyle, G., "Comparative Physiology of the Nervous Control of Muscular Contraction" (Camb. Univ. Press, 1957).
[14] Verwey, E. J. W., and Overbeek, J. Th. G., "Theory of the Stability of Lyophobic Colloids" (Elsevier, 1948).
[15] Rice, S. A., *Rev. Mod. Phys.*, 31, 69 (1959).

MELANIN GRANULES AND MITOCHONDRIA

By Dr. RUTH V. BAKER
Department of Pharmacology, University of Oxford
M. S. C. BIRBECK
Chester Beatty Research Institute; Institute of Cancer Research: Royal Cancer Hospital, London
Dr. H. BLASCHKO
Department of Pharmacology, University of Oxford
Prof. T. B. FITZPATRICK*
Department of Biochemistry (Radcliffe Infirmary), University of Oxford
AND
Dr. M. SEIJI*
Department of Biochemistry (Radcliffe Infirmary), University of Oxford

ALTHOUGH the chemical structure of the melanin pigment naturally occurring in mammals is not known[1], much information is available on the mechanism of its formation. Our present knowledge is derived from a study of homogenates or particulate fractions prepared from mammalian pigment cells[2] as well as from histochemical observations on intact cells, with both radioactive and non-radioactive pigment precursors[3]. These studies have established that in mammals melanogenesis is the activity of a specialized type of cell, the melanocyte, which is characterized by the presence of a copper-containing oxidase, tyrosinase, a catalyst responsible for the aerobic oxidation of L-tyrosine, the precursor of melanin, to 5,6-dihydroxyindole. The monomeric 5,6-dihydroxyindole then polymerizes to form a compound of large molecular weight[1]. The melanin polymer is believed to be attached, through its quinone linkages, to amino or sulphydryl groups of the protein matrix of the pigment granule.

Localization of tyrosinase in suspensions of cell particles was first reported by Herrman and Boss[4] in preparations of the ciliary body of the bovine eye. In addition to a "specific catalyst for dopa oxidation", these suspensions also contained two enzymes characteristic of mitochondria, succinic dehydrogenase and cytochrome oxidase. In a study of the Harding–Passey mouse melanoma by differential centrifugation, tyrosinase activity was also reported in the particulate fraction, but the structural elements were thought to be "microsomes or particles the size of microsomes which were formerly part of larger aggregates that were dispersed during the experiments"[2].

In 1949, DuBuy, Woods, Burk and Lackey[5,6] reported that preparations of granules isolated from the Harding–Passey mouse melanoma contained, in addition to melanin, cytochrome oxidase, succinic dehydrogenase and cytochrome *C*, and that they also had tyrosinase activity. These workers arrived at the conclusion that the melanized cytoplasmic particles in the mouse melanomas, which in addition to tyrosinase activity also possessed cytochrome oxidase and succinic oxidase and dehydrogenase activities in considerably varying degree, represent one of several modified forms of mitochondria, but generically mitochondria in any event.

In recent years, several authors have studied the morphology of the melanin granules from various sources in electron micrographs[7]. The melanin granules in human hair bulb appear as dense ovoid or rod-shaped bodies, varying in length from 0·4 to 1·0μ, and in breadth from 0·1 to 0·5μ. In the melanocyte there occurs, distal to the nucleus, an area which contains numerous filamentous mitochondria together with many small vesicles. The centre of this area is believed to be the region where the melanin granules are formed. It is free from melanin granules; but in its periphery there occur structures the size of melanin granules made up of concentric shells upon which variable amounts of dense material are formed; these are considered to be early stages of formation of melanin granules. Both Dalton[8], using Cloudman *S*91 melanoma cells, and Birbeck and Barnicot[7], using human hair bulbs, have concluded that melanin granules and mitochondria differ in size and internal structure. Woods[9] maintains that the melanin granules are melanized mitochondria because of "their high specific activity for enzymes characteristic for mitochondria, their oxygen-dependent staining with janus green B, and the inverse relationship between them and the number of amelanotic mitochondria in the same cells". The need for clarification of this problem is emphasized by Dalton[8], who makes a plea for correlating electron micrographs and chemical data on both melanin granules and mitochondria after centrifugation.

Such an investigation has now been carried out and a separation of mitochondria from melanin granules has been accomplished by the density-gradient

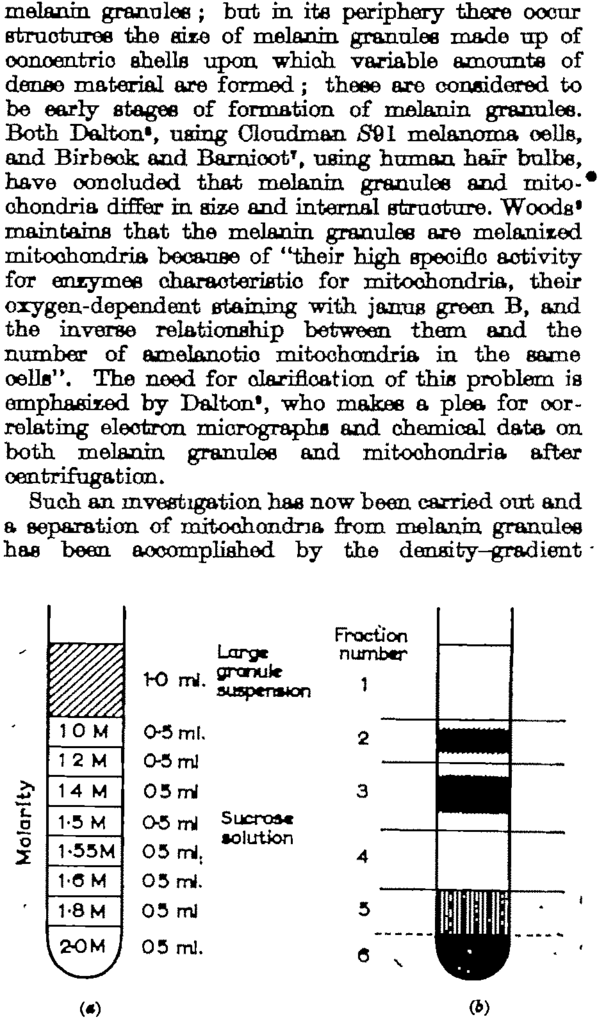


Fig. 1. *a*, Gradient tube before centrifugation; large-granule suspension (in 0·3 *M* sucrose) was added immediately before centrifugation. The gradient was prepared 18 hr. earlier; *b*, gradient tube after ultracentrifugation at 103,000 *g* for 1 hr. The three opaque regions are shown diagrammatically. The places where the tube was cut are also indicated. Fractions numbered 1 to 6

---

* Present address: Department of Dermatology of the Harvard Medical School at the Massachusetts General Hospital, Boston 14, Massachusetts.

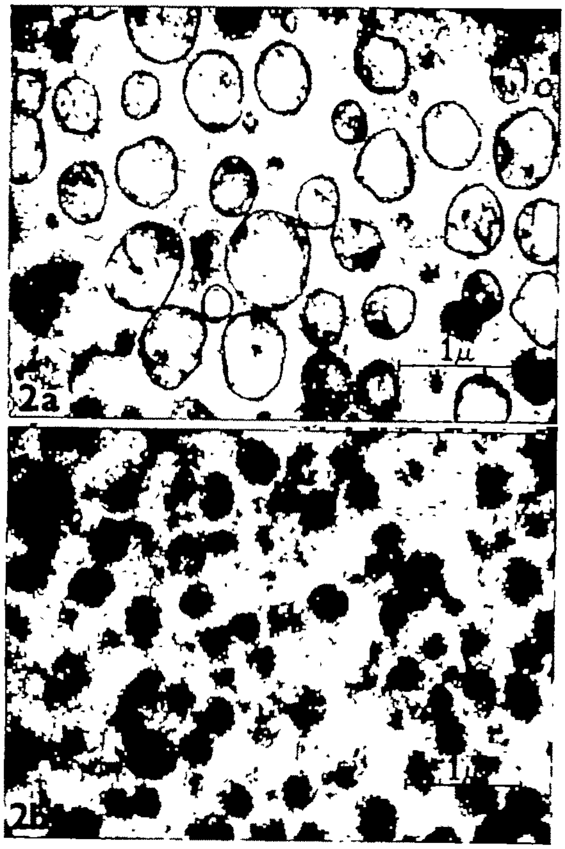


Fig. 2. *a*, Electron micrograph showing elements of fraction 3 (mitochondrial fraction) isolated by gradient density centrifugation. Fraction 3 is a pure preparation of mitochondria quite free of melanin granules. (Sections of fixed embedded fraction; × 16,000.) *b*, electron micrograph showing fraction 6 (pellet after centrifugation at 103,000 *g* for 1 hr.), isolated by gradient density centrifugation. Fraction 6 is a pure preparation of melanin granules. (Section of fixed embedded fraction; × 16,000)

method of centrifugation; the particle fractions thus obtained have been studied by electron microscopy and by biochemical methods. The centrifugation separated two morphologically distinct structures, one of which, the mitochondria, contained succinic oxidase, whereas the other contained the melanin as well as the enzyme tyrosinase.

The 'large-granule' fraction from a Harding–Passey mouse melanoma was isolated by a low-speed centrifugation at 700 *g* for 10 min., followed by a high-speed centrifugation at 11,000 *g* for 10 min. of the low-speed supernatant fluid; the sediment obtained was washed once and suspended in isotonic sucrose solution (0·3 *M*). It was then placed above a density gradient, similar to that used for the separation of mitochondria from amine-carrying granules[10,11]. The gradient used in the present work is shown in Fig. 1*a*. The gradient tubes were centrifuged for 1 hr. at 103,000 *g* in the swinging bucket rotor *SW 39L* of the Spinco ultracentrifuge.

The appearance of the tubes at the end of the centrifugation is shown in Fig. 1*b*. Two narrow bands could be seen, one at the top of the gradient (fraction 2) and a second grey turbid band (fraction 3) between this layer and a relatively clear zone below (fraction 4); near the bottom of the tube a black suspension of particles (fraction 5) and a black pellet could be distinguished. The tubes were cut, using the centrifuge tube cutter kindly presented to the Department of Pharmacology, Oxford, by Dr. E. H. J. Schuster some time ago; a cutter, based on this instrument, has recently been described in a review article by de Duve, Berthet and Beaufay[12]. The positions at which the tubes were cut are indicated in Fig. 1*b* by horizontal lines.

Electron micrographs showed that fraction 2 consisted mainly of cell debris; fraction 3 was an almost pure preparation of mitochondria (Fig. 2*a*). Fractions 5 and 6 contained predominantly melanin granules (Fig. 2*b*). It is apparent that in the density-gradient tube the melanin granules had been separated from the mitochondria; the melanin granules had accumulated in a region of much higher density.

We have determined tyrosinase, succinic oxidase and protein nitrogen content of the various fractions as well as of the large-granule fraction from which they were derived. Tyrosinase was estimated using a 10 : 1 mixture of L-tyrosine and L-dopa as substrates (1·77 μmoles)[13], succinic oxidase by a manometric method[14]. Of the total tyrosinase activity, 94 per cent was recovered in fractions 5 and 6. No tyrosinase activity was found in the mitochondrial layer (fraction 3). Of the succinic oxidase activity, 68 per cent was recovered in fraction 3, 7 per cent in fraction 5, and 4 per cent in fraction 6. Total recovery of succinic oxidase was 83 per cent.

The results of this experiment are given in Table 1. They show that fraction 6 (melanin granules) contains twice as much tyrosinase per milligram of protein nitrogen as the large granules, and that fraction 3 (mitochondria) contains seven times as much succinic oxidase per milligram of protein nitrogen as the large-granule fraction (Fig. 3).

These experiments show that in the Harding–Passey melanoma there exist granules that have the typical appearance of mitochondria in the electron micrographs and contain a high concentration of succinic oxidase, a typical mitochondrial enzyme; these granules are found in the gradient tube in a density layer characteristic of all mitochondria studied whatever their source. In addition, the tumours contained denser granules; these had the typical appearance of melanin granules and they contained the bulk of

Table 1. DISTRIBUTION OF TYROSINASE, SUCCINIC OXIDASE AND PROTEIN NITROGEN AFTER CENTRIFUGATION (AT 103,000*g* FOR 1 HR.) OF LARGE-GRANULE SUSPENSIONS OVER DENSITY GRADIENT OF HYPERTONIC SUCROSE

Fraction	Protein nitrogen			Tyrosinase			Succinic oxidase		
	mgm./ml.	Total mgm.	Recovery (per cent)	Specific activity μl. O_2/hr./mgm. N	μl. O_2/hr.	Recovery (per cent)	Specific activity μl. O_2/hr./mgm. N	μl. O_2/hr.	Recovery (per cent)
Large granules	5·2	15·6	100	166·8	2,604	100	270	4,218	100
1	0·64	1·47	9	0	0	0	0	0	0
2	0·72	1·51	10	0	0	0	57	84	2
3	0·88	2·64	17	0	0	0	1,896	2,862	68
4	0·24	0·62	4	184·8	112·2	2·5	168	104	2
5	0·96	3·65	23	186·0	678	26	76	277	7
6	1·92	5·76	37	307·8	1,770	68	28	159	4

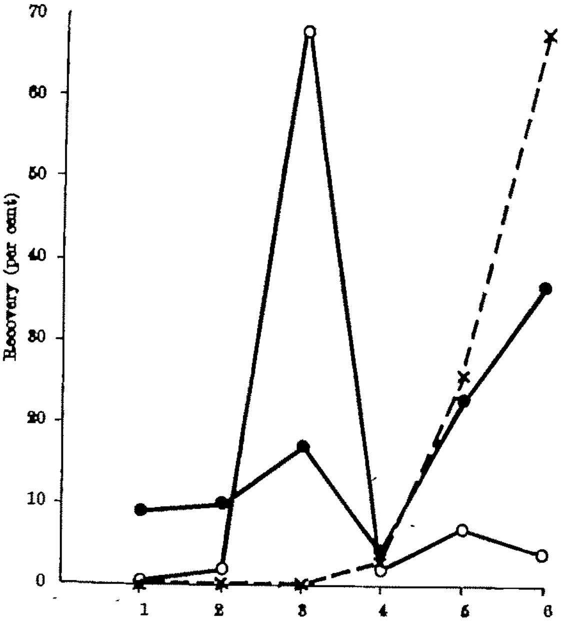


Fig. 3. Contents of fraction 1–6 from density gradient experiment. Percentages are calculated in terms of the amounts recovered in all the fractions. Total recoveries, in terms of contents in large-granule fraction, were: tyrosinase, 96·5 per cent; succinic oxidase, 88 per cent; and protein nitrogen, 100 per cent
×, Tyrosinase; ●, protein nitrogen; ○, succinic oxidase

the tyrosinase activity; they had negligible succinic oxidase activity.

We conclude from our experiments that melanin granules and mitochondria of the Harding–Passey mouse melanoma are distinct cytoplasmic constituents of the melanin-forming cell; each of these constituents is equipped with its own typical enzymes. The method employed does not, by itself, exclude the possibility that melanin granules are derived from mitochondria, but in view of the cytological evidence quoted we see no reason for assuming that such a relationship exists between the two types of structure here described.

We wish to acknowledge support given by a Research Grant from the National Cancer Institute, U.S. Public Health Service, to Drs. Seiji and Fitzpatrick, and by a grant-in-aid from the Royal Society to Dr. Blaschko. In addition, we express our gratitude to J. R. P. O'Brien, head of the Department of Biochemistry (Radcliffe Infirmary), for use of the facilities in his Department.

[1] Mason, H. S., in "Pigment Cell Biology", edit. by Gordon, M., 563 (Academic Press, Inc., New York, 1959).

[2] Lerner, A. B., and Fitzpatrick, T. B., *Physiol. Rev.*, **30**, 91 (1950).

[3] Fitzpatrick, T. B., and Kukita, A., in "Pigment Cell Biology", ed. by Gordon, M., 489 (Academic Press, Inc., New York, 1959).

[4] Herrman, H., and Boss, M. B., *J. Cell. and Comp. Physiol.*, **26**, 131 (1945).

[5] DuBuy, H. G., Woods, M. W., Burk, D., and Lackey, M. D., *J. Nat. Cancer Inst.*, **9**, 325 (1949).

[6] Woods, M. W., DuBuy, H. G., Burk, D., and Hesselbach, M. L., *J. Nat. Cancer Inst.*, **9**, 311 (1949).

[7] Birbeck, M. S. C., and Barnicot, N. A., in "Pigment Cell Biology", ed. by Gordon, M., 549 (Academic Press, Inc., New York, 1959).

[8] Dalton, A. J., and Felix, M. D., in "Pigment Cell Growth", ed. by Gordon, M., 267 (Academic Press, Inc., New York, 1953).

[9] Woods, M. W., in discussion in "Pigment Cell Growth", ed. by Gordon, M., 274 (Academic Press, Inc., 1953). Dalton, A. J., *ibid.*, 275.

[10] Blaschko, H., Hagen, J. M., and Hagen, P., *J. Physiol.*, **139**, 316 (1957).

[11] Baker, R. V., *J. Physiol.*, **142**, 563 (1958).

[12] De Duve, C., Berthet, J., and Beaufay, H., *Prog. in Biophys. and Biophys. Chem.*, **9**, 325 (1959).

[13] Miyamoto, M., and Fitzpatrick, T. B., *Science*, **126**, 449 (1957).

[14] Umbreit, W. W., Burris, R. H., and Stauffer, J. F., "Manometric Techniques and Related Methods", revised edition, 173 (Burgess Publishing Co., Minneapolis, 1949).

CRITICAL ENERGY BARRIERS IN THE EXCRETION OF SODIUM

By Prof. E. J. CONWAY, F.R.S.

Department of Biochemistry, University College, Dublin

THE secretion of sodium is considered here chiefly with respect to such large-scale secretion of sodium ions as occurs when frogs' sartorii are immersed in Ringer–Conway fluid containing 120 m*M* sodium and then re-immersed for 2 hr. at room temperature in similar fluid containing 104 m*M* sodium and 10 m*M* potassium[1,2]. It was found under such conditions that the re-immersed muscles lost in the average about 20 m.equiv. sodium per kgm. of the muscle before re-immersion, the average concentration after the first soaking being approximately 59 m.equiv./kgm. (ref. 4).

This type of experiment will for convenience be referred to here as the 120/104/10 procedure, and there will be occasion to refer to others such as the 120/120/10, 104/104/10 and the 120/120/30 procedures.

It was found that there was no significant secretion of sodium using the 104/104/10 procedure[3,4], which was in marked contrast to the results of the 120/104/10 procedure[3]. As a tentative hypothesis it was considered that the over-night immersion in fluid with sodium-level of 120 m*M* in some way stimulated the activity of the sodium pump in the subsequent 2-hr. re-immersion period. But it was found also that the 120/120/10 procedure resulted in no significant excretion of sodium, and this was interpreted in the sense that though the pump was here likewise stimulated, there was an entrance of sodium in the re-immersion period which about balanced the excretion. With such procedure the hypothesis was tested by inhibiting the excretion of sodium either by 2 m*M* iodoacetate or by ouabain (10^{-4} *M*) (Conway, Kernan and Zadunaisky, unpublished work), which had been shown[4] to inhibit fully, or practically so, the net secretion of sodium when using the 120/104/10 procedure. With sodium secretion so inhibited it could be expected that sodium would increase within the muscle, in about corresponding amount. But no appreciable increase of sodium was observed at the end of the 2-hr. period.

It was also shown that the explanation did not lie with osmotic pressure differences in the fluids used

It was then decided to test another hypothesis, namely, that the cause of the marked difference in secretion resulting from the use of the 120/104/10 and the 104/104/10 procedures could arise from the

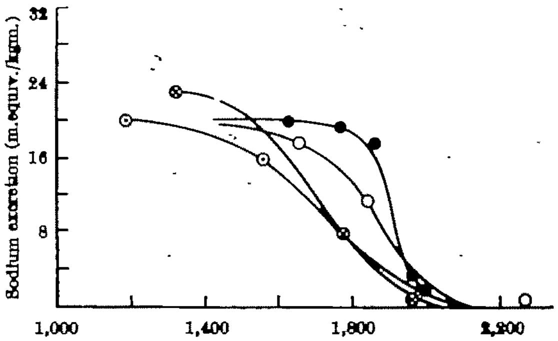


Fig. 1. ●, for series 120/120/10, 120/115/10, 120/104/10, 120/80/10 ; ○, for series 104/104/10, 104/80/10, 104/104/30 ; ○, for anaerobic series, 120/120/10, 120/104/10, 120/104/30 ; ⊗, for 120/120/30, 120/120/60

existence of a critical energy barrier under the conditions. The energy barrier to the secretion of sodium may be written:

$$\frac{dG}{dn} = RT\ln\frac{[Na]_e}{[Na]_i} - E_mF \qquad (1)$$

where n is the number of moles of sodium excreted and $[Na]_i$ and $[Na]_e$ are the concentration of sodium in the fibre water and in the external fluid, E_m being the membrane potential (but the numerical value of $-E_mF$ is positive). If one includes associated movements of potassium or chloride ions, the same equation will result from principles already established[2]. One can lower the energy barrier, therefore, either by reducing the concentration of the external sodium or by increasing the concentration of external potassium, which in turn lessens the membrane potential.

In order to calculate the energy barriers, the membrane potential E_m must be known. Approximate values of E_m were obtained using the Graham and Gerard technique[3] on fibres of the sartorius after about 15–30 min. after the second immersion. Such potential measurements are necessarily inexact for the purpose because of changing conditions. None the less, it is to be expected that they will not be much in error and they are useful data in the present context.

In Fig. 1 the secretion results are plotted against the calculated energy barriers. The occurrence of a critical energy barrier is clearly evident from the graph. This critical energy barrier for the conditions described is of the order of 2,000 calories per equivalent of sodium. But the magnitude of the barrier may be expected to change when the conditions are much different, as mentioned below. Among other things, the graph shows that when the 104/104/10 and 120/120/10 procedures (giving no significant excretion of sodium) are changed to 104/104/30 and 120/120/30 procedures, a large excretion of sodium occurs.

Here it may be noted that when excretion occurs on reducing the external sodium concentration some fall in membrane potential occurs.

Oxygen Uptake as affected by the Critical Barrier and Sodium Excretion

A number of experiments were conducted in which the oxygen uptake was determined by the Warburg technique for the second immersions in the 104/104/10, 120/120/10 and the 120/104/10 procedures. The results are summarized in Table 1. As there was no apparent difference in oxygen uptake or sodium secretion between the 120/120/10 and the 104/104/10 procedures with respect to the secretion of sodium ions or the uptake of oxygen, these experiments were grouped together. Table 1 gives the medians as the most representative values. Fuller details will be published in a paper by Conway, Kernan and Zadunaisky. The number 63 refers to the excretion of sodium as previously established[4], the other numbers to experiments of the present series, each experiment being conducted on three sartorii, and companion muscles being in nearly all cases used for comparison with the 120/104/10 procedure.

It will be seen then from Table 1 that with this series of experiments the 120/104/10 procedure shows a marked excretion of sodium ions, in contrast to the other procedures. (Here the mean value of the excretion is somewhat higher than in the groups previously described.) At the same time, the oxygen uptake is considerably increased throughout this secretion, and the average ratio of the milli-equivalents of sodium excreted to millimoles oxygen gas taken up is 3·84 or close to 4·0. It is to be noted that the increased oxygen uptake here occurs with the same concentration of external potassium.

Further, in a series of 35 experiments carried out with the 120/104/10 procedure, there is, as usual, a rather wide distribution in the amount of sodium secreted in each single experiment. At the same time there is a very significant correlation (0·68 ± 0·1) between the sodium excreted and the oxygen uptake.

Here it may be mentioned that Keynes and Maisel[6] investigated the relation between oxygen uptake and sodium excretion from frogs' sartorii with the muscle sodium somewhat increased by immersion for 30 min. in potassium-free Ringer's fluid. The excretion was measured by isotopic exchange. These measurements at the time appeared quite satisfactory, but it is now known that due to exchange diffusion they can differ widely from the real extrusion[7,4].

Table 1. SODIUM EXCRETION, AEROBIC AND ANAEROBIC, FROM SODIUM-RICH SARTORII

The numbers in brackets refer to the number of experiments (each with three sartorii). The number 63 for the first two results listed refer to experiments from Carey, Conway and Kernan (ref. 4)

Procedure	Sodium excreted (m.equiv./kgm.)		Oxygen uptake (m.moles/kgm.)	
	Means	Medians	Means	Medians
	Aerobic			
104/104/10 120/120/10	0·3±0·7 (63)	−0·1 (63)	10·7±0·5 (25)	9·8 (25)
120/104/10	22·1±1·6 (35)	22·1 (35)	16·2±1·6 (22)	15·6 (22)
			Lactic acid formed	
			Means	Medians
	Anaerobic			
120/120/10	−1·1±2·6 (12)	−1·3 (12)	30·1±2·1 (12)	30·1 (12)
120/104/10	6·4 (4)		33·8 (4)	
120/104/30	22·7±2·4 (12)	23·1 (12)	43·7±2·1 (12)	41·6 (12)
			Mean	Median
Value of the ratio : $\frac{\text{m.equiv. sodium excreted}}{\text{extra oxygen uptake}}$			3·96	3·97
Value of the ratio : $\frac{\text{m.equiv. sodium excreted}}{\text{extra lactic acid}}$ (taking differences between the 120/120/10 and the 120/104/30 results)			1·75	2·12

Anaerobic Secretion of Sodium Ions from Skeletal Muscle

It was shown[3,4] that the excretion of sodium in the re-immersion period of the 120/104/10 procedure could be inhibited in the average by 60 per cent. It was then obvious that, on the average, 40 per cent of the aerobic excretion of sodium could occur anaerobically. Similar results were obtained with anoxia. These conclusions were based on 74 experiments as published[4], and were much added to recently.

Such distribution shows a wide scatter, and in an appreciable fraction of the experiments there was very little inhibition, whereas in another it was almost complete.

At an early stage of such work[3], when about 13 experiments had been carried out, in which a high proportion showed very marked inhibition by cyanide, it was thought that the cyanide effect was fully inhibitory, but the accumulation of a large number of further experiments showed that the true average inhibition under our conditions was 60 per cent[3]. Recently, Frazier and Keynes[9] have stated that they were unable to find any cyanide inhibition under their conditions (which were essentially similar to ours, but differing in some points of detail).

It would seem that the concept of the critical energy barrier, and certain recent experiments based thereon, throw light on this difference. It is shown in Table 1 that decreasing the energy barrier by using 30 mM potassium ions externally instead of 10 mM completely removed all inhibition by cyanide. Thus the difference in the effect of cyanide found by the two laboratories may be referable to different metabolic states in the frog muscle used.

Explanation by the Redox Pump Theory

In this theory (refs. 2, 8, 10, 11) it is supposed that the reductant of a redox system specifically adsorbs sodium ions, and when it loses electrons to a second system these are released into solution. The energy change may be written:

$$\frac{\mathrm{d}G}{\mathrm{d}n} = F(E_2 - E_1) + [RT\ln[\mathrm{Na}^+]_i \qquad (2)$$

$F(E_2 - E_1)$ within the cell or fibre is the driving force for the excretion. The manner in which it can be considered to be utilized is as follows. If, instead of existing only in the free fibre water, the system with the adsorbed sodium ion existed in the membrane, transferring its electrons at the outermost edge to another system, with simultaneous release of sodium ions into the external fluid, the energy equation could then be written:

$$\begin{aligned}\mathrm{d}G/n &= F(E_2 - E_1) + RT\ln[\mathrm{Na}^+]_i\\ &= F(E_2 - E^1{}_1) + RT\ln[\mathrm{Na}^+]_o - E_mF \qquad (3)\end{aligned}$$

where $E^1{}_1$ represents a raised potential. From equation (3):

$$F(E_2 - E_1) - F(E_2 - E^1{}_1) = RT\ln\frac{[\mathrm{Na}]_o}{[\mathrm{Na}]_i} - E_mF \qquad (4)$$

The electrons transferred to the second redox system can either go up the respiratory chain to oxygen or, in the anaerobic state, be finally received by pyruvic or enolpyruvic acid after linking with hydrogen ions to form lactic acid. Now there is a maximum level of $RT\ln[\mathrm{Na}]_o/[\mathrm{Na}]_i - E_mF$ which is reached when $F(E_2 - E^1{}_1)$ becomes zero following increases of $[\mathrm{Na}]_o$ or E_m. If at the outset the value of $RT\ln[\mathrm{Na}]_o/[\mathrm{Na}]_i - EF$ is greater than $F(E_2 - E_1)$, no electrons can pass through the system and the critical energy-level is exceeded. The magnitude of this critical energy-level can vary with the conditions, and this is provided for in the theory.

Thus, the driving force $F(E_2 - E_1)$ can be expanded:

$$F(E_2 - E_1) = F(E_{20} - E_{10}) - \frac{RT}{F}\ln\left\{\frac{[\mathrm{Red.}]_2}{[\mathrm{Ox.}]_2} \times \frac{[\mathrm{Ox.}]_1}{[\mathrm{Red.}]_1}\right\} \qquad (5)$$

where E_{20} and E_{10} are the characteristic potentials of the systems. The expression under the log sign could be expected to vary in different metabolic states of the muscle. We may in this way interpret the fact that in the normal frog *in vivo*, or in very freshly excised muscle, the critical energy barrier must be much higher than 2,000 calories and probably at the level of 4,000 calories. The nearer the muscle to the normal condition, the greater there would seem to be the driving force. This may also explain recoveries (that is, in secretion of sodium and uptake of potassium) under certain experimental conditions when the external potassium is as low as 3·5 mM (Harris, private communication).

Thus the facts here mentioned of the critical energy barrier, of the extra oxygen with sodium excretion, and the extra lactic acid with anaerobic excretion, with approximate average ratios near 4·0 and 2·0 respectively as referred to above, are very well explained by the redox pump theory.

In the case of the anaerobic secretion, it may be noted that while there is a very significant relation between the extra lactic acid found and the sodium excreted, there is rather much variability in the ratio mentioned above. One may say that the underlying trend of the ratio is near 2·0. The variability may be explained by somewhat different states of the enzyme systems involved, even using companion muscles. That the raised concentration of external potassium is not responsible for the extra lactic acid, apart from its effect on the energy barrier and the consequent excretion of sodium, would appear from the absence of this effect when comparatively little muscle sodium was present for excretion, as when 10 mM potassium chloride was incorporated in the soaking fluid. Also, it may be added, there appeared no contractures at any stage, under the conditions.

Space does not permit of further considerations of important points of detail in this presentation, but it is hoped to deal with these matters in coming communications with Drs. Kernan and Zadunaisky and with Miss Mullaney.

[1] Desmedt, J. E., *J. Physiol.*, 121, 191 (1953).

[2] Conway, E. J., *Physiol. Revs.*, 37, 1 (1957).

[3] Conway, E. J., and Carey, M., *J. Physiol.*, 129, 2, 232 (1955).

[4] Carey, M., Conway, E. J., and Kernan, R., *J. Physiol.*, 148, 1, 51 (1959).

[5] Graham, J., and Gerard, R. W., *J. Cell. Comp. Physiol.*, 28, 99 (1946).

[6] Keynes, R. D., and Maisel, G. W., *Proc. Roy. Soc.*, B, 142, 383 (1954).

[7] Keynes, R. D., and Swan, R. C., *J. Physiol.*, 147, 3, 591 (1959).

[8] Conway, E. J., in "The Method of Isotopic Tracers applied to the Study of Active Ion Transport", 1er. Colloque de Biologie de Saclay (Pergamon Press, London, 1958).

[9] Frazier, H. S., and Keynes, R. D., *J. Physiol.*, 148, 2, 362 (1959).

[10] Conway, E. J., *Int. Rev. Cytology*, 2, 419 (1953).

[11] Conway, E. J., *Int. Rev. Cytology*, 4, 377 (1955).

LETTERS TO THE EDITORS

ASTROPHYSICS

Local Increase of Intensity of Cosmic Radiation

DURING the International Geophysical Year, no important proton event of solar origin was detected on the Earth by the different stations; but on the other hand, high-altitude balloon flights show that arrivals of low-energy protons to the polar regions were rather frequent events. These arrivals of protons are generally preceded by a solar flare associated with a radio outburst of type IV, and are accompanied by ionospheric absorption, total or partial, in the polar regions.

As these events are of considerable importance in the investigation of Earth–Sun relations, we thought it interesting to communicate some local increases of the cosmic-radiation intensity (impact region), detected by stations on the Earth, which seemed difficult to explain at the time they occurred. The correlations between these increases and the information given by other stations or observatories will perhaps make it possible to find the exact cause of these events.

Thus, on December 4, 1957, we recorded at the Paris Cosmic Ray Survey Station (geomagnetic co-ordinates: 51·2° N., 84·7°, altitude: 90 metres), by means of an unshielded telescope detecting the total component, an increase in intensity of cosmic radiation.

Particulars of the equipment are as follows: Thickness of the materials constituting the roof of the Paris Cosmic Survey Station reduced to gm./cm.^{2}: 2·5 gm./cm.^{2}. Characteristics of the unshielded telescope detecting the total compound: 3 trays of 7 counters assembled in threefold coincidence. Aperture angle: 130° × 130°. Thickness of the materials which constitute the telescope reduced to gm./cm.^{2}: 9 gm./cm.^{2}. Average counting-rate: 227 counts/min. at a pressure of 760 mm. of mercury. Characteristics of the shielded telescope detecting the hard component: 3 trays of 5 counters assembled in threefold coincidence. Aperture angle: 55° × 110°. Shielding: 10 cm. of lead, 1 cm. of steel. μ-meson detection threshold: 165 MeV. Average counting rate: 87 counts/min. at a pressure of 760 mm. of mercury.

The recording of received impulses is done by a printing clock, which marks the times for 10,000 impulses. On average we thus obtain a record covering 44 min. (or 227 counts per min.) for a barometric pressure of 760 mm. mercury.

An increase, of 18 ± 2 per cent total amplitude, the maximum of which occurred at 22 hr. 45 ± 20 min. U.T., began at 21 hr. ± 20 min. U.T. and finished at 0 hr. 15 ± 20 min. U.T. on December 5, 1957 (Fig. 1). It was not detected on the hard component. The effect was therefore preponderant on the soft component.

We inquired whether this event had been recorded by other stations. Only the station at Thule (geomagnetic co-ordinates: 88·0° N., 1·1°) showed an increase of 5 per cent between 18 hr. and 20 hr. U.T. on the nucleonic component[1] (Fig. 1). As the records of this station were only recorded *bi*-hourly, it is possible that the increase would be more prominent on a shorter recording period.

The maximum time between the onset of these two increases of cosmic-ray intensity should be 3 hr. ± 20 min.

This event took place during a period of relatively quiet solar activity. For the whole day of December 4, 1957, only one important radio outburst was detected at Ottawa[2] on 2,800 Mc./sec., at 16 hr. 57·5 min. U.T., coinciding with a flare of importance 1 observed at Huncayo (16 hr. 56 min.–17 hr. 04 min.; max. 16 hr. 58 min. U.T.;—20·5–18° W.)[3].

The delay between this solar event and the increase recorded at the station at Thule should be 2 ± 1 hr.: a delay analogous in rough approximation to those corresponding to the arrival of protons of solar origin[4].

It must be noted that the heliographic longitude of the flare (18° W.) corresponds to the part of the Sun where protons emitted during a flare have a great probability of being observed in the vicinity of the Earth[5]. On the other hand, the increase at Thule took place during a period of small magnetic activity ($Kp = 1^-$ during 18–21 hr. U.T.), whereas the Paris event took place during a period when the magnetic activity began to increase ($Kp = 2^+$ during 21–24 hr. U.T. and 4° during 0–3 hr. U.T.)[6] (see Fig. 1). This may explain the delay noticed between the increases observed on the Thule and Paris records.

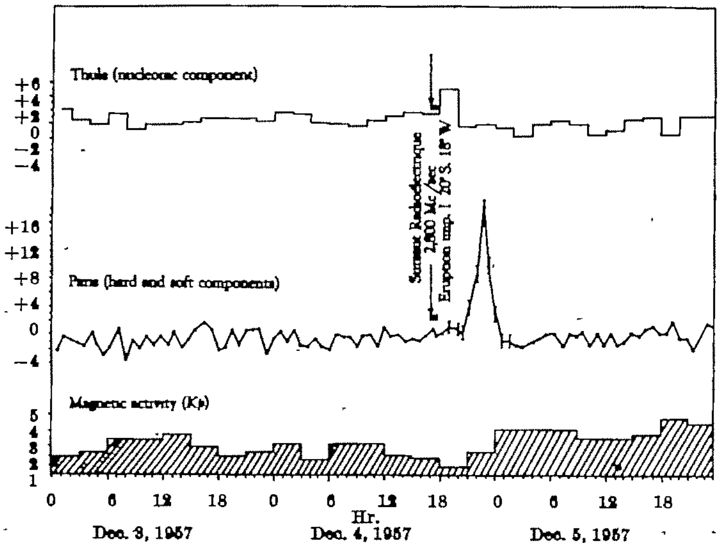


Fig. 1

Indeed, cosmic-ray particles with an energy less than that for geomagnetic cut-off in the latitude of Paris, which are generally forbidden, could in consequence of the increased magnetic activity penetrate by impact at this latitude. An analogous event was recorded at the Paris station on January 21, 1957 (ref. 7).

All these different events and the way in which they occurred suggest an arrival of protons of solar origin; but their small magnitude makes it necessary to have further experimental observations for a definite conclusion.

J.-P. LEGRAND
A. HELARY

Commissariat à l'Energie Atomique,
Limeil-Brevannes, S.-et.-O.

---

[1] Cosmic Ray Intensity during the International Geophysical Year No. 1 (Tokyo, March 1959).

[2] Solar Geophysical Data, *B*, Jan. 1958. Type: 2 Simple 2; Start 16 hr. 57 min. U.T.; duration, 15 min., max. 16 hr. 58 min.; peak flux, 97 × 10^{-22} W./m.^{2}/c./s. 4 Post increase; duration, 30 min.; peak flux, 8 × 10^{-22} W./m.^{2}/c./s.

[3] Solar Geophysical Data, Part *B*, Jan. 1958.

[4] Gallet, R., U.S. National Bureau of Standards, cycle of conferences on the Exosphere (1959).

[5] Avignon, Y., and Pick-Guttmann, M., *C.R. Acad. Sci., Paris*, **249**, 2276 (1959).

[6] Bartels, J., "Planetary Three-hour-Range Indices *Kp*".

[7] Legrand, J.-P., Chanson, P., and Bonpas, M., *C.R. Acad. Sci., Paris*, **244**, 1862 (1957).

RADIOPHYSICS

A Highly Directive Rotating Array for 16 Mc./s.

THE typical rotating back-scatter sounder[1,2] uses a horizontal 3 or 4 element Yagi for both transmission and reception. The main-lobe width for such aerials is commonly about 60° between half power points, and when the aerial is used in conjunction with a 'transmit–receive' switch the effective lobe width reduces to about 40°. This means that echoes will tend to become 'smeared out' in azimuth to a greater or lesser degree depending on the received signal strength.

One of the investigations being undertaken at Brisbane is concerned with the detection and analysis of echoes from field aligned ionization in the *F* region of the ionosphere[3], and for this purpose it is desirable to achieve some finer degree of discrimination of the azimuthal extent of echoing regions than is possible with the simple Yagi system. Considerable thought has been given to the design of a large low-cost rotatable array of aerials, and some degree of compromise proved to be necessary.

The system chosen consists of 4 three-element Yagis separated by 1·1 wave-lengths, mounted on a truss 228 ft. long pivoted at its centre, and supported by four bogies with normal truck wheels and balloon tyres running on concrete tracks (Fig. 1).

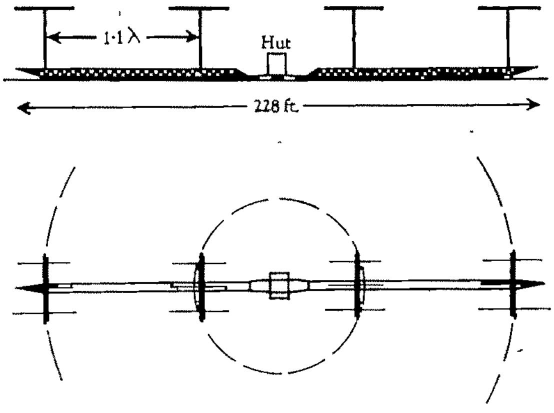


Fig. 1. Elevation and plan views of rotating array

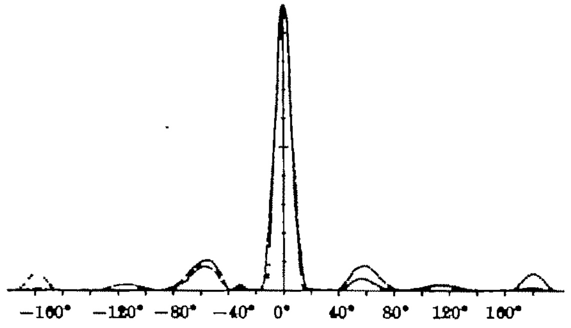


Fig. 2. Radiated power versus array orientation (in the horizontal plane). – – –, Computed power; . . . ., measured power

Each Yagi is constructed entirely of aluminium and mounted at the top of a guyed aluminium mast 30 ft. above ground-level. (This height gives maximum signal at an elevation angle of about 25°, a value suitable for the experiments in hand.) All the Yagis are fed in the same phase, and the relative currents are chosen to reduce the intensity of side lobes near the main beam. The computed aerial gain is 150.

A comparison of the computed and measured azimuthal radiation pattern of the aerial array is given in Fig. 2. The two major lobes at ± 55° are reduced from an amplitude equal to that of the central beam only by virtue of the reduced radiation from each individual Yagi in this direction. The high front-to-back ratio of the system is likewise entirely produced by the Yagis. The small degree of asymmetry shown in the measured pattern is not of any

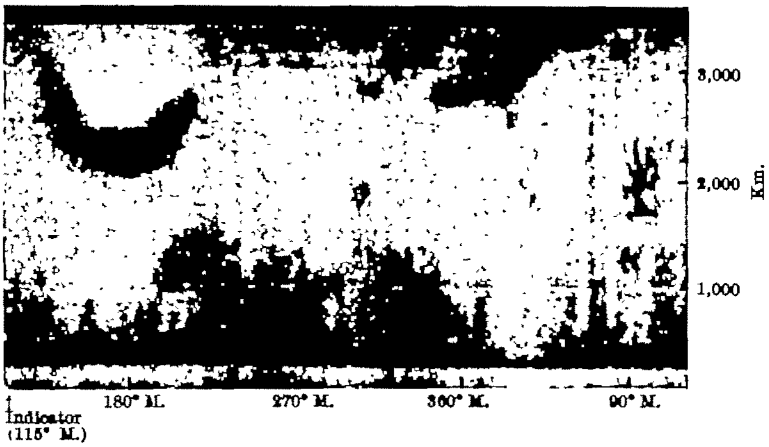


Fig. 3. Range-azimuth record using 16 Mc./s. array at Brisbane 0020, May 7. 1960. The U-shaped trace centred on 180° M. is typical of the aspect-sensitive reflexions obtained

major importance when the array is used both for transmission and reception. Under such conditions the effective beam-width is 8° (to half-power points), and the lobe at − 55° is 19 decibels down with respect to the main beam, thus giving a considerable increase in azimuthal resolution over the use of a single Yagi. The back lobe is 24 decibels down with respect to the forward beam.

The system is rotated by two 1 horse-power electric motors hydraulically coupled and geared down to drive one of the wheels on each outer bogie. Normal speed of rotation is one revolution in 3 min.

Fig. 3 shows an example of a range-azimuth display obtained using the array, which illustrates the particular advantage of the narrow beam for the purpose of identifying aspect-sensitive reflexions.

This work has been sponsored by the Electronics Research Directorate of the Air Force Cambridge Research Centre, Air Research and Development Command, under contract No. *AF* 64(500)-9.

J. A. THOMAS
R. W. E. McNICOL

Physics Department,
University of Queensland,
Brisbane.

[1] Villard, O. G., and Peterson, A. M., *Trans. Inst. Rad. Eng.*, *PGAP-3*, 186 (Aug. 1952).

[2] Shearman, E. D. R., *Proc. Inst. Elec. Eng.*, 103, B, 203 (March 1956).

[3] Peterson, A. M., "Annals of I.G.Y.", 3, Part 4 (Pergamon Press, 1957).

Radar Determination of the Scattering Properties of the Moon

INFORMATION about the scattering properties of the Moon's surface has been deduced by Evans[1] from the rapid fading of lunar radio echoes. His results were obtained by picturing the surface as an assembly of randomly spaced scatterers. Such a concept, however, does not take into consideration the distribution in depth of the scattering elements. An approach which does so is that adopted by Feinstein[2], who used Huygens's principle to study the general problem of reflexion from a plane surface having random irregularities that are a function both of the space co-ordinates and of time. With minor modifications to take into account the curvature of the reflecting surface, Feinstein's results may be applied to lunar radio echoes.

Consider first the lunar surface to be corrugated in one dimension only, so that its height h above a mean level can be represented by the random variable $h(x,t)$, where x is distance measured along the surface from its intersection with the line connecting the centres of the Earth and the Moon. If the resultant surface velocity due to the lunar librations is v, and if the co-ordinate plane is determined by this vector and the line of centres, the function h will have the form $h(x - vt)$.

Now assume that h is normally distributed and that the joint distribution of the h's at any two points is bivariate normal. The space correlation function of the signal envelope observed by spaced receivers on the Earth's surface when the Moon is directly overhead can then be shown to be:

$$C(s) = \exp\{-a[1 - \rho(sR/2D)]\} \qquad (1)$$

where s is separation between receivers, a is $4k^2\overline{h^2}$, k is $2\pi/\lambda$, where λ is the radar wave-length, $\overline{h^2}$ is variance of the distribution of h, ρ is normalized space correlation function of the lunar surface, R is radius of the Moon, D is Earth–Moon distance.

By fitting experimental data to (1), it is possible to determine both the lunar space correlation function ρ and the constant a, since $C(s)$ approaches $\exp(-a)$ asymptotically. It is important to note, however, the occurrence of an approximately 500-fold change in the scale of this function that results from the reflexion of the incident wave-front at the curved lunar surface. Space diversity tests carried out by the U.S. Army Signal Research and Development Laboratory over its circuit from Belmar, N.J., to the University of Illinois, at Urbana, Ill., have verified this expansion in scale.

The autocorrelation function of the received signal envelope at one location on the Earth's surface is given by:

$$P(\tau) = \exp\{-a[1 - \psi(\tau)]\} \qquad (2)$$

where $\psi(\tau)$ is the autocorrelation function that would be observed at any point on the mean lunar surface that is fixed relative to the co-ordinate system postulated. Because of the relation between x and t, it is immaterial whether we determine $P(\tau)$ or $C(s)$ experimentally, since both contain the same information. Only $C(s)$, however, is expanded by the factor $2D/R$.

The one-dimensional results for the correlation functions are directly applicable to the two-dimensional case, if the variance of h is independent of direction. For the determination of the distribution of angular power, however, the lunar surface must be treated as two-dimensional, and, in addition, the form of the function ρ must be specified. Feinstein[2] has derived the angular distribution for the case where:

$$\rho = \exp(-d^2/l^2) \qquad (3)$$

where d is distance measured in any direction along the lunar surface and l (or more commonly $l/\sqrt{2}$) is called the structure size. Because surface irregularities much smaller than λ will not appear in the reflected wave-front, the smallest value of l determinable from radar observations will be of the order of magnitude of λ. If Feinstein's results are again modified to fit the lunar problem, the angular power distribution is found to be:

$$p(r) = (\exp - a)\left[\cos(kr^2/R) + \sum_{n=1}^{\infty} \frac{a^n}{n.n!} \exp(-r^2k^2l^2/nR^2)\right] \qquad (4)$$

In order to determine $p(r)$ completely, we must first assume that $\rho(d)$ has the form given in (3) and obtain numerical values of a and l by fitting observational data to (1) or (2). These values of a and l are then substituted into (4).

FRED B. DANIELS

U.S. Army Signal Research and
Development Laboratory,
Fort Monmouth,
New Jersey.

[1] Evans, J. V., *Proc. Phys. Soc.*, B, 70, 1105 (1957).

[2] Feinstein, J., *Inst. Rad. Eng. Trans.*, AP, 2, 23 (1954).

GEOPHYSICS

Anomalous Leads from a Selected Geological Environment in West-Central New Mexico

A DETAILED study of lead isotopes has been undertaken in order to evaluate variations in the isotopic composition of lead with respect to the geological environment of the sample area. Support for the project is being provided by the New Mexico Bureau of Mines and Mineral Resources division of the New Mexico Institute of Mining and Technology and by the Geophysics Laboratory of the University of Toronto.

A field area was desired in which the number of geological variables would be at a minimum. An area of approximately 5,000 square miles in west-central New Mexico was found to satisfy this requirement. Barite-fluorite-galena deposits are scattered throughout the field area[1,2]. These deposits have identical mineralogy, very similar geological settings with respect to host rock type, and a common depth-temperature type of mineral deposition. Within the field area, the Hansonburg mining district was selected for detailed studies of single galena crystals and for determination of local isotopic detail across parallel north–south mineralized fractures. The other samples have been taken from localities scattered across the field area in order to investigate the possibility of widespread isotopic variations. The location of sample number 1054 is unique in that it is located near deep-seated acid intrusives, but here too the mineralization is very similar to that of the other sample locations[3].

Galena (PbS) was the mineral collected from each site chosen for this preliminary study. Fresh, unweathered specimens were utilized, and wherever possible the entire sample was taken from a single galena crystal. When the samples contained only fine-grained, disseminated galena, the sample was crushed and pulverized to minus 20 mesh, screened, and a heavy mineral concentrate prepared by panning. Fresh galena was then hand picked from the heavy mineral concentrate under a microscope.

Following the sample preparation at the New Mexico Bureau of Mines, the samples were sent to Toronto for analysis. The hand-picked samples of galena were dissolved in hydrochloric acid, and the lead ions precipitated as lead iodide. A Grignard reaction of lead iodide and methylmagnesium bromide at room temperature was used to produce lead tetramethyl. The lead tetramethyl was mass analysed in the Nier-type 180-deg. mass spectrometer operated by the Geophysics Laboratory of the University of Toronto. The precision of the various analyses is shown in Table 1.

Table 1. PRECISION OF ANALYSES

Lead isotope	Sample variation range	Average sample variation
204	$S = \pm 0\ 001$ to $\pm 0\ 011$	$S = \pm 0\ 005$
206	$S = \pm 0\ 02$ to $\pm 0\ 08$	$S = \pm 0\ 04$
207	$S = \pm 0\ 02$ to $\pm 0\ 06$	$S = \pm 0{,}03$
208	$S = \pm 0\ 03$ to $\pm 0\ 09$	$S = \pm 0\ 05$

$S = \pm \left[\frac{\Sigma (s - \bar{s})^2}{n - 1}\right]^{1/2}$. This is the precision of an individual mass scan and is not the error of the average values reported in Table 2.

A large crystal of galena from the wall of an open fracture zone in the Hansonburg district was selected for detailed study. The galena crystal, illustrated in Fig. 2, had the form of a cube cut in half along a diagonal plane. The diagonal surface of the crystal was attached to a large breccia fragment of silicified limestone. The crystal was sampled by cutting it into small cubes with a diamond saw. A corner (sample 111) and two samples along a diagonal (samples 222 and 333) were analysed. The positions of these samples are indicated in Fig. 2. The corner sample was found to be distinctly different from the internal samples. The compositions of the crystal samples are listed in Table 2 under sample number 1049.

Samples of galena were collected along east–west lines across the north–south mineralized fractures in the Hansonburg mining district. Small, consistent

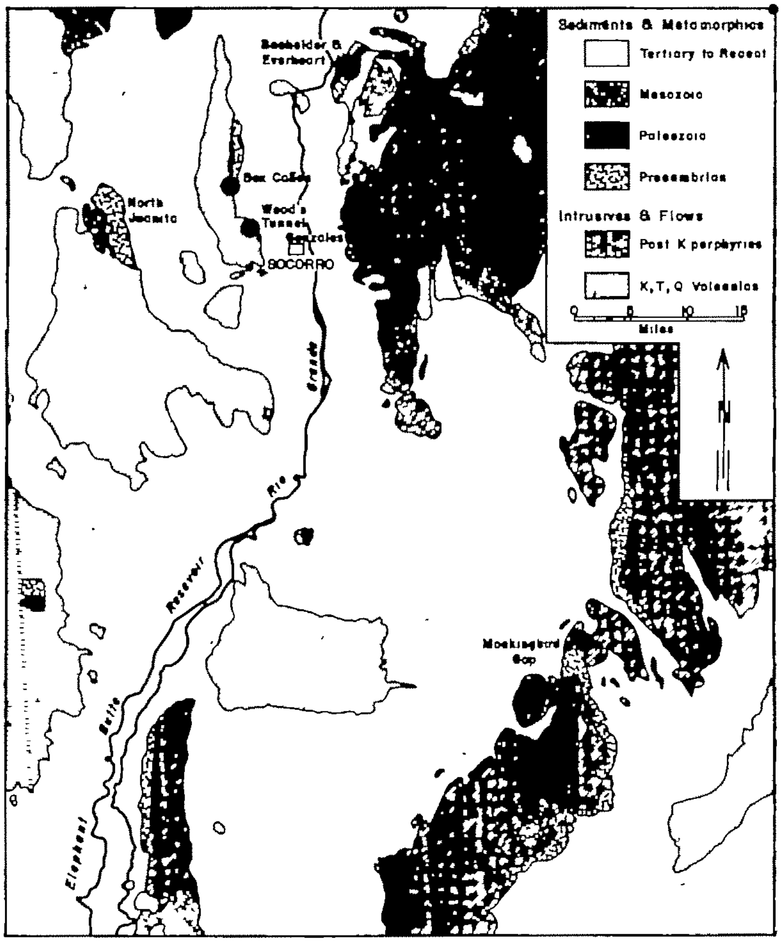


Fig. 1. Map of field area showing location of samples

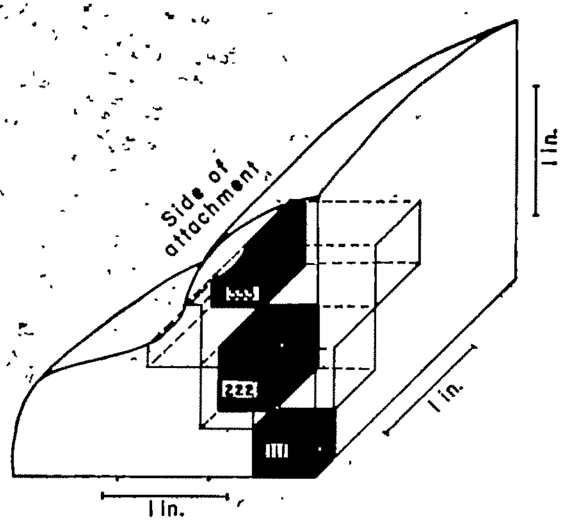


Fig. 2. Single crystal with sample positions shown

variations in isotopic composition were found from west to east. Radiogenic lead was found to increase to the east. Samples 1,040, 1,046 and 1,047, taken from west to east, illustrate this. The sample spacing is 200 ft. between samples 1,040 and 1,046, and 100 ft. between samples 1,046 and 1,047. No north–south trends were noted in the Hansonburg mining district.

Regionally, the geological map of New Mexico[4] suggests a northwest-trending basement structure underlying samples 1,054, 1,059 and 1,065. These three samples have had distinctly less radiogenic lead added to them during their history of emplacement than the other samples taken in the field area. Such isotopic variations suggest that basement structure may be reflected by the isotopic composition of the lead present in the overlying mineral deposits.

When all of the samples are plotted as lead-207/lead-204 versus lead-206/lead-204, they fall in a straight line. The slope of this line, as determined by the least squares method, is 0·0938. Applying the method of Farquhar and Russell[5], the maximum age for the source of the radiogenic lead additions is calculated as 1,530 million years. This figure agrees fairly well with the age of 1,300–1,450 million years given by Tilton and Davis[6] for the basement rocks of the south-western United States.

Table 2. Presentation of Data

Mine name or sample location	Sample number	Percentage			
		Pb-204	Pb-206	Pb-207	Pb-208
Hansonburg district Sunshine-Blanchard	1,040	1·252	27·86	20·06	50·82
	1,046	1·247	27·97	20·09	50·68
	1,047	1·242	28·10	19·96	50·70
	1,049 (111)	1·284	27·15	20·47	51·08
	(222)	1·245	27·83	20·06	50·87
	(333)	1·256	27·74	20·14	50·87
Royal Flush	1,041	1·250	27·72	20·12	50·90
	1,042	1·260	27·28	20·21	51·15
Snake Pit	1,043	1·252	27·80	20·04	50·90
Max-Tex	1,044	1·252	27·76	20·09	50·90
Hurlow	1,045	1·261	27·69	20·18	50·87
Hinkey	1,048	1·265	27·60	20·26	50·88
North Juanita	1,054	1·351	25·12	21·20	52·34
Mockingbird Gap	1,059	1·335	25·29	20·96	52·41
Wood's Tunnel	1,065	1·354	25·24	21·22	52·19
La Bonita	1,055	1·173	29·74	19·10	49·99
Gonzales	1,056	1·242	27·83	19·96	50·96
Box Cañon	1,057	1·290	26·66	20·47	51·58
Bacheldor-Everheart	1,058	1·263	26·77	20·10	51·87
Salinas Peak	1,060	1·208	28·47	19·46	50·86
	1,061	1·212	28·28	19·48	50·92
	1,062	1·203	28·49	19·43	50·88
	1,063	1·203	28·64	19·37	50·80
	1,064	1·205	28·51	19·45	50·83

The preliminary work reported herein indicates that continued research is warranted within the limited field area selected. The lines of isotopic research being continued by us are: (1) Delineation of basement structure. (2) Single-crystal detail to obtain relative ages for isotopic variations within local areas. (3) Delineation of local isotopic trends, such as the east–west trend found in the Hansonburg mining district.

WILLIAM F. SLAWSON

Geophysics Laboratory,
Department of Physics,
University of Toronto.

CARL F. AUSTIN

New Mexico Bureau of
Mines and Mineral Resources,
a division of the New Mexico
Institute of Mining and
Technology.

---

[1] Kottlowski, F. E., New Mexico Bureau of Mines and Mineral Resources Circ. 23 (1953).

[2] Lasky, S. G., New Mexico Bureau of Mines and Mineral Resources Bull. 8 (1932).

[3] Loughlin, G. F., and Koschmann, A. H., U.S. Geol. Survey Prof. Paper 200 (1942).

[4] Darton, N. H., "Geologic Map of New Mexico", 1 : 500,000 (U.S. Geol. Surv., 1928).

[5] Farquhar, R. M., and Russell, R. D., *Trans. Amer. Geophys. Union*, 38, 552 (1957).

[6] Tilton, G. R., and Davis, G. L., "Researches in Geochemistry", edit. by Abelson, P. H. (John Wiley and Sons, New York, 1959).

PHYSICS

A Method for the Routine Measurement of Particle Shape Factors in the Sieve Range

SIZE distribution cannot alone describe a particle population, and for some purposes it becomes necessary to measure the particle shape within closely sized ranges. Some instances of the use of shape factors are in estimating approximate surface areas, calculating the number of particles in a size range and investigating the variation of particle shape with size. Since these applications are not confined to one field or industry, interest in shape factor is widespread.

If k and f are the volume and the surface shape factors respectively, then by definition:

$$V = kd^3$$

and

$$S = fd^2$$

where V is particle volume, S is surface area and d is some measure of the particle diameter. It is usual to use the statistical diameter[1–3], but for the present purpose the geometrical mean between the limiting and retaining screen apertures on the British Standard $\sqrt[4]{2}$ scale[4] is convenient. Heywood[5] has given relationships between statistical and sieve aperture diameters for various particle shapes. Clearly, these definitions must be interpreted statistically; V and S represent the mean of a large number of measurements. Consequently, although particle shape factors as defined here are simple in conception, their experimental determination is laborious since it may be necessary to sample, count and weigh several thousand closely sized particles. However, particularly careful work of this nature has been reported for coal particles[4] but generally there is not much published work on this topic.

Routine shape factor measurements for particles smaller than about 36 British Standard mesh (500μ) will be undertaken reluctantly with such slow and tedious counting methods. The alternative automatic scanning procedures, though speeding the process, require expensive equipment. With this in mind a simple method for counting and weighing large numbers of closely sized particles was developed.

The original procedure[7,8] used a sieve, which was the limiting screen for the closely sized particles under investigation, carrying on its underside a weighed strip of 'Cellotape' of known area. Consequently, the number of covered apertures could be calculated. This will be referred to in the following as the 'working surface'.

The particles of known density were dusted over the working surface and generally one particle per aperture was retained by the adhesive film on the 'Cellotape'. However, a few exceptions were noted. If a wide range of shapes occurred within a size fraction it was found that the number of particles per aperture varied from none to two or three. While these frequently averaged one per aperture, as a refinement a few sample rows were counted by scanning with a travelling microscope. Since the particles were arranged in a rectangular matrix this proved a simple operation. With the larger particle sizes a simple precaution was necessary; because the 'Cellotape' must cover an integral number of apertures it was therefore preferable to measure the effective area of the working surface after dusting with particles. Carefully removing the 'Cellotape' with its adhering particles and re-weighing enabled the average weight and volume of a single particle to be calculated. Thus, k may then be determined directly, and f may be calculated from specific surface area data.

While the application of a mesh in this manner for particle counting was found to be a most useful innovation (it has since been discovered that the idea of counting by using a specially moulded plate holding one particle per recess is sometimes employed when bottling pharmaceutical products such as aspirin), the two main steps: (*a*) measuring the area of the 'Cellotape' for each determination; (*b*) peeling the 'Cellotape' away from the sieve for re-weighing, were inconvenient and the original method has been improved.

Disadvantage (*b*) is avoided by using rimmed British Standard mesh disks of about 7-cm. diameter. These weigh about 20 gm. and consequently the entire disk and 'Cellotape' with the adhering particles *in situ* can be weighed on an analytical balance.

Disadvantage (*a*) is not as easy to overcome as (*b*) but fortunately it is not as serious. However, if a mesh were available containing a known standard number of apertures then the entire surface could be covered with 'Cellotape' and area determination would be unnecessary. Utilizing this idea it was found that mesh rectangles were easily cut to give a working surface containing a standard number of apertures. However, these meshes possessed little mechanical strength, becoming both easily distorted and frayed at the edges. Sealing the edges to a depth of several aperture diameters with a plastic material, while still retaining a rectangular working surface, completely obviated these disadvantages.

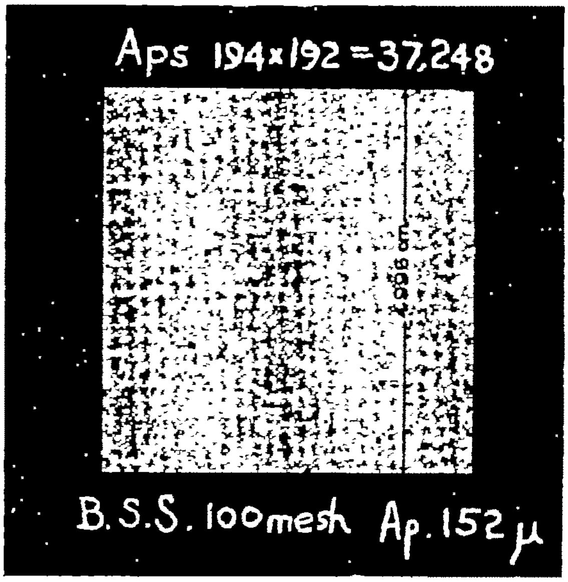


Fig. 1. Standard count mesh · 100 British Standard (152-μ aperture) containing 37,248 apertures

The technique of making these meshes is to use 'Cellotape' to avoid sealing the working surface when the plastic is applied to the edge and is given in the Appendix. Fig. 1 illustrates a standard aperture count mesh made from a 7·5-cm. square of 100 British Standard mesh (152-μ aperture, 102-μ wire diameter). Its edges were sealed to a depth of about 40 apertures (~ 1 cm.) and the working surface contains 37,248 apertures. Fig. 2 shows a magnified section near a corner of this mesh after dusting with coal particles sized between 100 and 120 British Standard mesh (152–124μ). This incidentally illustrates how sieves tend to select some coal particles along a diagonal and indicates that the ratio between the statistical diameter and the mean sieve aperture should be $\sim \sqrt{2}$. Values reported by Needham and Hill[9] support this.

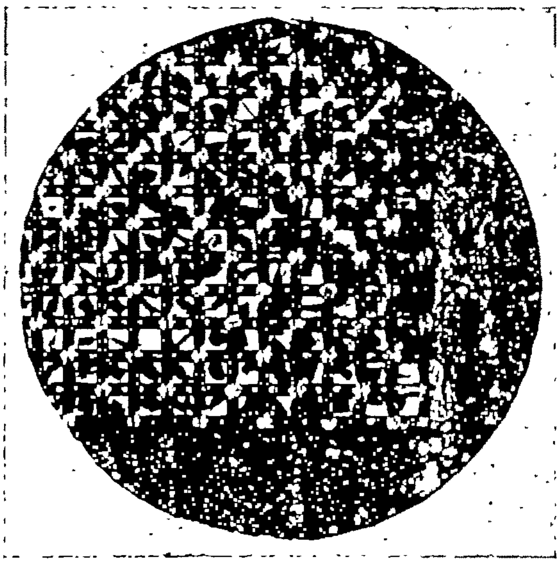


Fig. 2. Corner of mesh in Fig. 1 after dusting with 100–120 British Standard mesh coal particles (scale: aperture 152μ, wire diameter 102μ). Photograph taken by transmitted and reflected light. The highlights caused by reflexion of light from the wires have been reduced in intensity

This technique becomes difficult with meshes finer than about 100 British Standard. However, having sealed the edges, even though the working surface may not be rectangular, and consequently estimating the number of apertures becomes laborious; once the number is counted the operation need never be repeated. A photographic enlargement of the mesh is useful here.

For counting the finer particles, electrolytically deposited grids have been used. These have excellent mechanical strength and can be cut easily to produce a standard rectangular working surface. Sealing the edges is not necessary as it is with meshes and this is a decided advantage. However, preliminary results indicate that they are slightly inferior to woven mesh, for often two particles occupied one aperture. The grid is thinner than the correspondingly sized mesh, and its wires are rough and rectangular in section as against smooth and circular; observation indicates that these factors may have some influence on the adverse effects noted. Nevertheless, a technique for using these grids could probably be developed.

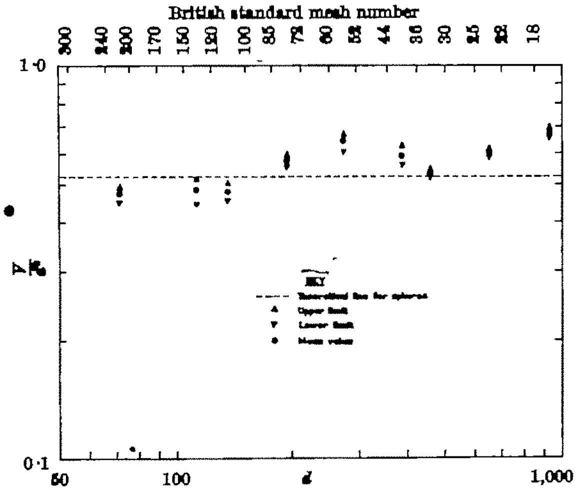


Fig. 3. Relationship between shape factor and mean particle size: coal sample

It is suggested that suitable fine meshes could be specially woven for this purpose. These would contain a standard number of apertures to British Standard or any other specification surrounded by a closely woven edging which would serve both to suitably terminate the working surface and to strengthen the mesh. A large number of these standard aperture count meshes could be woven simultaneously as one piece of cloth, the 'pattern' being (say) 5-cm. squares of working surface separated by 1-cm. wide stripes of close weave. These could be cut and suitably mounted. It should be noted that for 100 British Standard mesh material a 5-cm. square of working surface would contain about 40,000 apertures.

Preliminary results were reported earlier[7,8] where with a particular coal sample an average of $k = 0{\cdot}54$ was obtained. Interesting confirmation of this value based on Heywood's work has since been communicated (Bramley, J., private communication, reproduced in ref. 8).

Some recent measurements on coal samples are illustrated in Fig. 3, which demonstrates a variation in k with particle size. The method of plotting is clearly more revealing to changes in k than the usual logarithmic plot of V against d. Also, if a differently defined measure of particle size is introduced as a ratio with d then a plot by dimensionless groups follows; this could be useful in correlating shape factor data.

This work is part of a project concerned with the moisture retention properties of fine coal.

I wish to thank Prof. J. T. Whetton and my colleagues in this Department for interest, and especially Mr. D. Howitt, who carried out the experimental work.

COLIN C. HARRIS

Department of Mining,
University of Leeds. March 28.

[1] Herdan, G., "Small Particle Statistics" (Elsevier, Amsterdam, 1953).
[2] Dallavalle, J. M., "Micromeritics", second ed. (Pitmans, New York, 1948).
[3] Orr, C., and Dallavalle, J. M., "Fine Particle Measurement" (Macmillan, New York, 1959).
[4] British Standards Institution, "Test Sieves", 410 (1943).
[5] Heywood, H., "Symposium on Particle Size Analysis", 14 (Inst. Chem. Eng., 1947).
[6] Needham, L. W., and Hill, N., *Fuel*, 14, [illegible] (1935).
[7] Harris, C. C., and Smith, H. G., "Second Symposium on Coal Preparation", paper 9 (University of Leeds, 1957).
[8] Harris, C. C., Ph.D. thesis, University of Leeds (1959).

Appendix. A Method for making Standard Aperture Count Meshes

(1) Commence with a suitably sized mesh rectangle which has been cleaned in a grease solvent. A 7·5-cm. square was used here.

(2) Stick a strip of opaque 'Cellotape' on to the mesh so that the outer edge of the tape lies along and covers a wire situated about 1 cm. from the edge of the mesh. Repeat on the reverse side of the mesh for the same wire.

(3) Repeat the operation for the opposite edge of the mesh.

(4) Apply a layer of plastic material to both sides of one uncovered edge and quickly spread evenly on both sides with a spatula. Treat the opposite edge in the same way. An epoxy resin and a proprietary brand of plastic solder have both been used successfully.

(5) When the plastic is dry, but still soft, peel the 'Cellotape' away and a straight clean edge should result. To assist this it is sometimes advantageous to score the plastic gently with a sharp knife.

(6) When the plastic has hardened treat the remaining edges in the same way.

D. HOWITT

Gallium Arsenide as a Semi-insulator

SOME semiconductors have comparatively low resistivity, and this is due to their containing electrically active impurities with energy-levels near a band edge. Others have very high resistivity and this is due to their containing a predominance of impurities with levels far from the band edges, that is, far compared with the thermal energy kT. These latter materials are often referred to as insulators, but since they can carry electronic currents we prefer to introduce the term 'semi-insulator' to describe them. A material such as cadmium sulphide, which by suitable choice of impurity content can be made a semiconductor or a semi-insulator, is of particular interest and much work has been done on cadmium sulphide in the past few years. Gallium arsenide is another substance with the same property, but has the advantage that both n- and p-type material may be readily prepared.

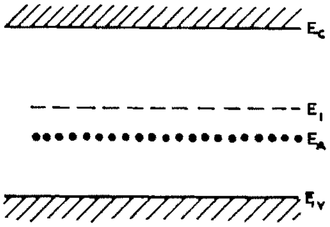


Fig. 1. Energy-levels of the model to be considered

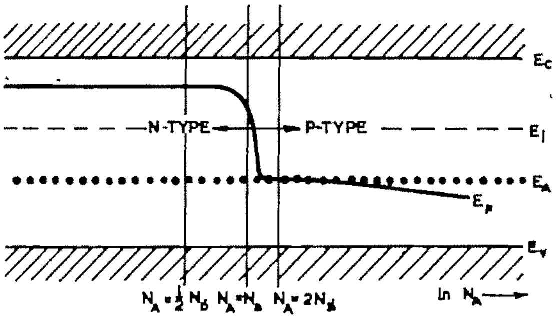


Fig. 2. Fermi-level as a function of acceptor concentration for fixed donor concentration (schematic)

As normally prepared in this laboratory undoped gallium arsenide is *n*-type with about 10^{16} electrons/cm.^{3}, which come from a residual impurity acting as a shallow donor. Under conditions in which oxygen is present during the preparation high-resistivity material is obtained. The most reasonable hypothesis is that oxygen gives rise to a deep acceptor-level which compensates the donors. It is therefore of interest to consider the behaviour of a system with a given concentration of donors N_D and a variable number of deep acceptors with concentration N_A. My experiments suggest that the acceptor-level at E_A lies below the intrinsic Fermi-level E_i, as shown in Fig. 1. The Fermi-level varies with N_A in the manner shown schematically in Fig. 2. It will be of advantage to introduce a quantity:

$$\chi \equiv \frac{N_A}{N_D}$$

which I shall call the 'degree of compensation'. Four regions of interest may be distinguished:

(1) $N_A \ll N_D$, $\chi \ll 1$. The concentration of electrons in the conduction band n is, to a good approximation, equal to N_D and the material is low resistivity *n*-type.

(2) $N_A \simeq N_D$, $\chi \simeq 1$. The Fermi-level drops from a position near the conduction band to one near the acceptor-levels, this change occurring over a very small change of N_A. For example, if N_A is 0·9 N_D then n is 0·1 N_D and the material is still of fairly low resistivity, the Fermi-level having dropped from its position in region 1 by only kT ln10 (about 0·06 eV. at room temperature), while if N_A is 1·1 N_D then the Fermi-level has dropped to a position only kT ln10 above the acceptor-level, and n will decrease by many orders of magnitude. In the present model which has E_A below E_i the material will change from high resistivity *n*-type to high resistivity *p*-type in this region. When N_A is greater than but not much greater than N_D the electron concentration is given by:

$$n \simeq \frac{1}{\chi - 1} \, . \, N_c \, . \, \exp \frac{E_A - E_c}{kT} \qquad (1)$$

that is, it is determined by the degree of compensation and the acceptor energy-level only. From the absolute magnitude of n and its variation with temperature both χ and $E_c - E_A$ may be determined.

(3) $N_A > N_D$, $\chi > 1$. As soon as N_A becomes appreciably greater than N_D the Fermi-level becomes locked near the acceptor-level and the material is high resistivity *p*-type. In this region the hole concentration is given by:

$$p \simeq (\chi - 1) \, . \, N_v \, . \, \exp \frac{E_v - E_A}{kT} \qquad (2)$$

It should be noted that the range of validity of equation 2 is the same as that of equation 1, for both hold when the position of the Fermi-level is determined by N_A and N_D alone, p and n both being negligible.

(4) $N_A \gg N_D$, $\chi \gg 1$. The position of the Fermi-level is now determined by the distribution of electrons between the valence band and the impurity-level. As N_A increases the hole concentration increases, but since E_A is far from E_v then p cannot be large and the material is still high resistivity *p*-type. In this region:

$$p \simeq (N_v N_A)^{\frac{1}{2}} \exp \frac{E_v - E_A}{2kT} \qquad (3)$$

By considering Fig. 2 it is easy to see what modifications to this behaviour are introduced if E_A lies above E_i. The general shape of the curve of E_F against N_A is unchanged but now the point of intersection of E_F with E_i is moved to the right, that is, the change from high resistivity *n*-type to high resistivity *p*-type occurs at a much higher acceptor concentration, and in practice this may not be attainable.

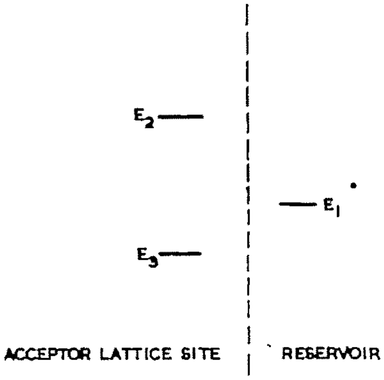


Fig. 3. The energy scheme for the formation of an acceptor during auto-compensation

Experimentally it is found that in semi-insulating gallium arsenide E_A does lie below E_i. The existence of *n*-type high resistivity material requires that $\chi \sim 1$ and we find from the experiments, using equation 1, that $\chi - 1$ is as little as 10^{-4}. Clearly it is unlikely to happen in a large number of specimens that N_A should approach N_D so closely just by chance, and some mechanism of automatic compensation must be operative. A rather general model for this is illustrated in Fig. 3. Again we regard N_D as a fixed given quantity. There is a reservoir of lattice defects (in which term I shall include impurities) which are in an electrically inactive state at energy E_1. These can go over to lattice sites at which they behave as acceptors, with energy E_2. If in this site they accept an electron the energy of the crystal decreases by an amount $E_c - E_A$, and this state has energy E_3. One then has a problem in statistical thermodynamics in which defects are distributed over levels E_1, E_2, E_3 and electrons over levels

E_2, E_1, E_3, the two systems being coupled by the fact that the level E_2 has an electron associated with it. To investigate this model in detail requires a more exact specification of the states; but it is immediately obvious that if the energy differences $E_2 - E_1$ and $E_1 - E_3$ are both large compared with kT and the entropy difference between the states is not too great then almost exact compensation will occur as long as the reservoir contains sufficient defects. In other words, it is energetically advantageous for defects to become acceptors so long as there is an electron for them to accept, but not otherwise.

An alternative possibility is that acceptors and donors form associated pairs[1], but this mechanism should lead to an increase in electron mobility, contrary to observation. Also the calculated degree of pairing is insufficient to account for the exactness of compensation found.

In the case of semi-insulating gallium arsenide it seems probable that oxygen is dissolved in the lattice in two different sites, being electrically active in one site (as an acceptor) and inactive in the other (as the reservoir). In the case of cadmium sulphide and similar compounds, the work of Kröger and Vink[2] shows clearly that the deep levels are associated with crystal defects arising from non-stoichiometry, and the reservoir of such defects is obviously the ambient atmosphere. In cadmium sulphide one can vary χ by annealing crystals at various temperatures and in various atmospheres, and similarly in gallium arsenide one should be able to vary χ by suitable heat treatment.

My model suggests that semi-insulators of the type I have described, that is, those in which a shallow donor is auto-compensated by a deep acceptor, should exhibit pronounced hole trapping effects but little electron trapping. This has a number of practical implications. For example, the high photoconductivity of these materials is readily explained. Also the existence of large space-change currents in certain crystals of cadmium sulphide[3] but not in others may be explained by variations in χ between the crystals. One might predict that semi-insulating gallium arsenide suitably heat-treated might also show such currents.

The ideas expressed here were developed while attempting to account for the experimental results of Dr. G. T. Wright on cadmium sulphide and of Dr. C. Hilsum and his colleagues on gallium arsenide. I wish to thank them both for extensive discussion of the problems involved.

Acknowledgment is made to the Admiralty for permission to publish this communication.

J. W. ALLEN

Services Electronics Research Laboratory,
Baldock, Herts.

---

[1] Prener, J. S., *J. Chem. Phys.*, **25**, 1294 (1956).

[2] Kroger, F. A., and Vink, H. J., *Physica*, **20**, 950 (1954).

[3] Wright, G. T., *Nature*, **182**, 1296 (1958).

Gallium Arsenide for γ-Ray Spectroscopy

CRYSTAL conduction counters offer an improvement in energy resolution over ionization chambers or scintillation counters for spectroscopy of nuclear particles. Semiconductor counters which employ a *p–n* junction are useful only for heavy charged particles of moderate energy. For energetic charged particles or γ-rays with ranges exceeding 1 mm. of silicon a crystal with efficient charge collection throughout its bulk is required. Most crystals of sufficiently high resistivity contain so many electron traps that collection of the ionization current is inefficient, and only diamond has previously been found to count single γ-ray events. The usefulness of diamond as a crystal counter is restricted.

We have found that the semiconductor gallium arsenide with resistivity at room temperature exceeding 10^8 ohm-cm. is an efficient particle counter. When a bar of this material is bombarded with γ-radiation from cobalt-60, pulses of charge are readily observed. The time for the pulse-rise is about 5 μsec., and pulses of 0·5 mV. across a megohm load are seen with an applied field of 200 V./cm. This effect occurs in both *n*-type and *p*-type gallium arsenide of high resistivity. The samples used in these experiments were of dimensions 1 cm. × 0 2 cm. × 0·1 cm., but there appears to be no reason why larger crystals should not be made. We are examining the spectrum of the pulse-height and resolution of energy, and our results will be reported elsewhere.

Acknowledgment is made to the Admiralty for permission to publish this communication.

W. R. HARDING
C. HILSUM
M. E. MONCASTER
D. C. NORTHROP
O. SIMPSON

Services Electronics Research Laboratory,
Baldock, Herts. May 25.

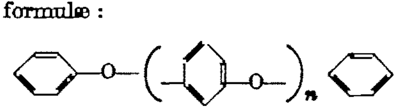
ENGINEERING

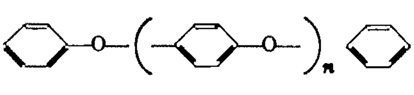
Pump Fluids for Higher Vacuums

IN the decade after Burch introduced petroleum oils[1] as working fluids for the Langmuir condensation pump, the silicones, octyl alcohol esters and petroleum pump fluids converged to a low-pressure optimum at about 10^{-7} mm. mercury, which the succeeding 20 years has lowered, perhaps, to 5×10^{-8} in an untrapped three-stage glass pump when measured at an ambient temperature of 25° C.

Recently, particle accelerators and the conquest of space have made demands for pressures ten or a hundred times lower, to be induced in relatively enormous containers, and it has been necessary to augment the pumps with traps filled with liquid nitrogen or helium, together with means for periodic baking out. The proliferation of apparatus occasioned by these and other alternatives is becoming far too cumbersome and expensive.

In April 1959, learning of their use as high-temperature lubricants, I began examination of a class of phenoxy benzenes and polyphenyl ethers[2] of the general formulæ:


(1)


(2)

which may restore simplicity to the vapour pump. Not only can some of the compounds give pressures in the 10^{-8}–10^{-10} range untrapped, but also their tendency to wander through vacuum labyrinths is reduced many hundredfold over previously used fluids. Thus a Bayard–Alpert ionization gauge[3] attached to a three-stage glass air-cooled pump (type 25*W*, Consolidated Vacuum Corp.) by a tube 2 cm. in diameter with two right-angle bends showed no clouding of the glass beyond the first bend in two weeks at an ambient temperature of 30° C. The filament, energized after 54 hr. inactivity, indicated an immediate pressure of 8×10^{-8}—the initial gas burst—and 1×10^{-9} 13 min. later, without resort to degassing or baking. The lowest indicated pressure with the filling:

m-bis(*m*-phenoxyphenoxy)-benzene (3)

was $4 \cdot 5 \times 10^{-10}$ mm. mercury, again untrapped. This is equivalent to an altitude above the Earth of 400–800 km.[4], according to latitude, and a mean free path of 10–100 km., depending on the composition of the residual gas.

Table 1

Name of pump fluid	Temperature in pump boiler (approximately)	Vapour pressure (25° C., mm. mercury) (extrapolated)	Lowest pressure (mm. mercury) yet recorded in untrapped pumps, 25° C., ambient	
			1-Stage*	3-Stage†
2-Ethyl hexyl sebacate	190° C.	2×10^{-8}	1×10^{-6}	8×10^{-8}
bis (*m*-Phenoxyphenyl) ether	195° C.	10^{-9}		
m-bis(*m*-Phenoxyphenoxy)-benzene	250° C.	10^{-11}	5×10^{-9}	5×10^{-10}
bis-m(*m*-Phenoxyphenoxy)-phenyl ether	280° C.	10^{-12}	5×10^{-8}	
Mixed meta- and para-5-ring ethers	250° C.	$<10^{-12}$	5×10^{-7}	$1 \cdot 1 \times 10^{-9}$

* This experiment, tested in vertical glass pump, with *Vg*. 1*a* gauge tube.

† This experiment, tested in 3-stage glass fractionating pump, with Bayard-Alpert *G.I.C.* 110 tube.

The results of some early comparative tests are shown in Table 1, while the gas bursts at ultimate vacuum are recorded at an ambient temperature of 30° C. in Fig. 1. The single-stage pump was fitted with a *Vg*. 1*a* ionization gauge tube through two right-angle turns; and the three-stage pump with a Bayard–Alpert gauge *G.I.C.* 110. In each case, the gauge had been de-energized for 16 hr. after reaching a low-pressure plateau, and it is the response immediately after re-energizing the filament that is shown in Fig. 1. Other compounds, tested only in the single-stage glass pump, for lack of material, showed considerable promise, for example:

bis(*m*-(phenoxyphenoxy)-phenyl) ether (4)

which on one occasion reached an unreadable value with the *Vg*. 1*a* ionization tube. A 5-ring meta-para-isomer gave a very high vacuum in the three-stage pump, 1×10^{-9} or better. Since the vapour pressures at room temperature of the 5-ring ethers are of the order 10^{-12} mm., it is probable that further purification, coupled with modification of pumps, should lead to the direct production of still lower pressures. The ultimate vacuums of the present experiments were not immediately obtainable, but required treatment of the samples and generous insulation of the pumps to conserve heat and prevent charring of the bench with the higher boiling fillings. The behaviour in metal pumps and other vacuum properties of these fluids will be presented through the vacuum journals.

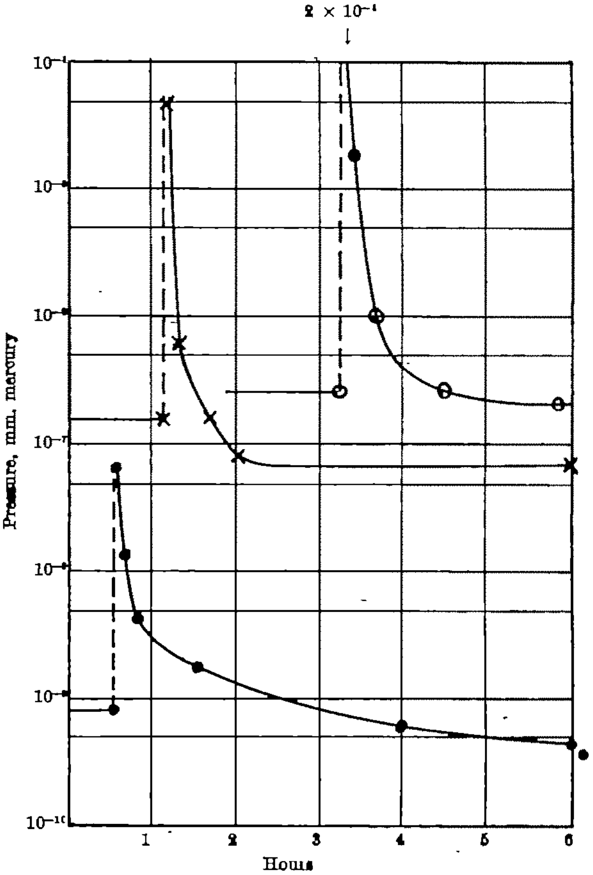


Fig. 1. ○, A petroleum base pump oil; ×, 2-ethyl hexyl phthalate; ●, *m-bis*(*m*-phenoxyphenoxy)-benzene

I am indebted to the Monsanto Chemical Co., St. Louis, Missouri, for gifts of the compounds, and to the Trans Penn Wax Corporation, Titusville, Pennsylvania, for contributory financial support. Correspondence concerning vacuum applications of the fluids may be addressed to me.

KENNETH HICKMAN

136 Pelham Road,
Rochester, 10,
New York.

[1] Burch, C. R., *Nature*, **123**, 729 (1928).
[2] "Meta- Poly Phenyl Ethers: Synthetic Lubricants of the Future", Hamman, W. C., and Blake, E. S., presented at the Boston meeting of the American Chemical Society (April 1959).
[3] Bayard, R. T., and Alpert, D., *Rev. Sci. Instr.*, **21**, 571 (1950).
[4] Newell, H. E. *Science*, **131**, 385 (1960).

METALLURGY

The Sulphide Phase in Some Iron Meteorites

METALLIC meteorites are composed in varying proportions of two iron–nickel metallic solid solutions, kamacite, which has a low nickel content, and taenite, which has a higher nickel content. The structure and distribution of these phases have been extensively examined on a macro- and on a micro-scale. Many iron meteorites also contain non-metallic inclusions of an iron–nickel phosphide (schreibersite) or an iron–nickel sulphide (troilite). Troilite has not been subject to very detailed microscopic examination for

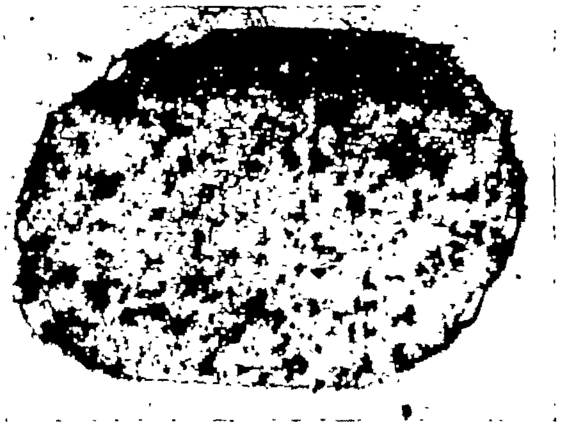


Fig. 1. Walker County unetched. (× c. 215)

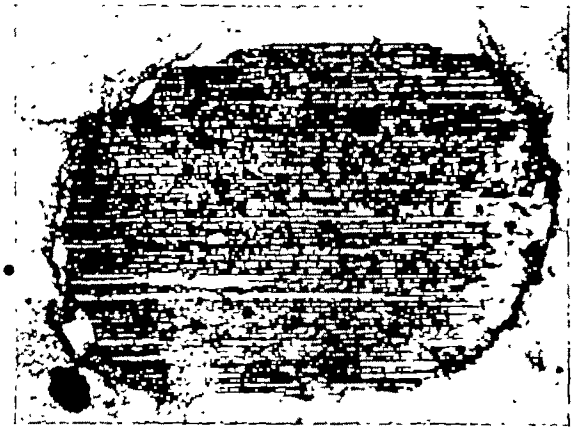


Fig. 2. Same area after sulphur printing. (× 215)

two reasons. First, it shows a great tendency to chip and disintegrate during preparation and, secondly, it is very reactive towards most etching agents; hence, when metallic meteorites are deeply etched for museum exhibition the troilite is usually protected from the etching agent by a suitable stopping-off compound.

Perry[1] has published a photograph of an anomalous lamellar structure which he found at a single location within a vein of terrestrial weathering material in the Walker County hexahedrite and which he identified as a kamacite–taenite aggregate. However, the general appearance and location seem to suggest that the structure might have arisen from a partly weathered non-metallic compound, hence a search for similar structures has been made in unweathered portions of Walker County and other hexahedrites. Several examples have been found in a small piece of Walker County loaned for study by the British Museum (*B.M.* 35413). Fig. 1 shows an area in the unetched condition. The groundmass is kamacite, in which is embedded a roughly circular brown patch of striated material. The black areas are holes due to the chipping out of material during preparation, and there are occasional patches of white schreibersite situated between the striated phase and the groundmass of kamacite. The striated phase proved to be sulphide bearing, as shown by its response to sulphur printing[2]. The same area examined immediately after sulphur printing shows the striations much more distinctly (Fig. 2) and reveals that the dark component of the striated pattern, which is undoubtedly troilite, is more heavily cracked than the light component. It is not possible at this stage to give a firm identification of the light striations.

Similar effects have also been obtained from small troilite areas in the hexahedrites Coahuila (*B.M.* 53295) and Tocopilla (*B.M.* 1931, 13). In each case the sulphide body was associated with a partial or complete rim of schreibersite.

H. J. Axon

Metallurgy Department,
University of Manchester.

---

[1] Perry, S. H., "The Metallography of Meteoritic Iron", pl. 6 (Smithsonian Institution, Washington, 1944).

[2] Williams, R. S., and Homerberg, V. O., "Principles of Metallography", 234 (McGraw-Hill, 1948).

A New Phase in a Silicon bearing 17 per cent Chromium, 8 per cent Nickel and 1 per cent Niobium Steel

During the study of a 17 per cent chromium–8 per cent nickel–4 per cent silicon–1 per cent niobium steel, the composition of which is shown in Table 1, a phase not previously reported was extracted and subjected to X-ray examination.

An X-ray diffraction pattern was obtained from the extracted residue in a 19-cm. powder camera using cobalt radiation filtered with iron foil. The interplanar spacings of the phase contained in the residue are shown in Table 2. The pattern can be indexed on a tetragonal structure having parameters $a = 4{\cdot}806$ Å., $c = 5{\cdot}955$ Å. and a c/a ratio of 1·238. The presence of gelatinous silicic acid in the residue prevented an accurate chemical analysis being performed, although it appeared that a high concentration of niobium together with some chromium,

Table 1

Element	C	Si	Ni	Cr	Nb
Per cent	0·206	3·90	8·11	16·90	1·04

Table 2. *d* Spacings

Tetragonal $a = 4{\cdot}806$ Å.; $c = 5{\cdot}955$ Å.; $c/a = 1{\cdot}238$

h,k,l	*d* calculated	*d* observed	Intensity
002	2·978	2·98	8
111	2·951	2·944	2
102	2·531	2·527	2
200	2·403	2·413	10
—	—	2·331	1
201	2·228	2·184	1
210	2·149	2·147	9
211	2·021	2·022	1
003	1·985	1·986	7
202	1·870	1·875	5
212	1·743	1·743	6
310	1·520	1·519	6
004	1·489	1·486	6
213	1·458	1·459	6
312	1·354	1·351	4
223	1·291	1·285	8
214	1·224	1·224	4
313	1·207	1·207	4
400	1·201		
005	1·191	1·191	1
401	1·178	1·180	2
420	1·074	1·074	5
314	1·063	1·063	6
215	1·042	1·043	4
403	1·028	1·021	7
422	1·011	1·011	1
333	0·984	0·982	6
500, 430	0·961	0·961	7
423	0·945	0·945	5
315	0·937	0·938	5
502	0·915	0·915	6

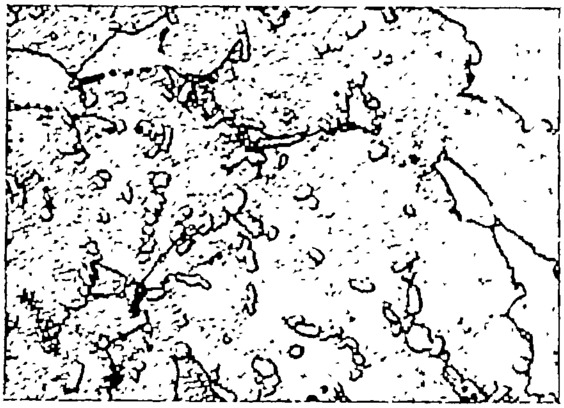


Fig. 1. Unidentified phase in 17/8/1 niobium + 4 per cent silicon alloy etched in Kalling's reagent. (×1,000)

silicon and carbon was present. The difficulty of extracting the phase under examination free from contamination by silicic acid prevented a density measurement being performed and so no space group could be assigned to the phase.

The appearance of the phase in the microstructure is shown in Fig. 1.

We wish to acknowledge that Dr. H. Hughes (United Steel Companies' Research Laboratory) pointed out the tetragonal nature of the X-ray pattern before it had been finally indexed.

M. J. O'Hara
D. Wilkinson
R. T. Allsop

G.K.N. Group Research Laboratory,
Birmingham New Road,
Lanesfield,
Wolverhampton.
May 30.

CHEMISTRY

Mass Spectrometric Investigation of the Vaporization of Sulphides and the Dissociation Energy of S_2

The disagreement between second- and third-law values of the dissociation energy of $S_2(D^\circ_0(S_2))$ obtained from equilibrium measurements was emphasized many years ago[1]. A relationship was also pointed out between the heat of combustion of SO, $D^\circ_0(O_2)$, $D^\circ_0(SO)$ and $D^\circ_0(S_2)$, which should permit one to choose one of the values allowed by observed predissociations for $D^\circ_0(S_2)$ and $D^\circ_0(SO)$. Recent measurements[2] do not seem to settle the question[3].

In the vapour phase above calcium sulphide we have observed by mass spectrometry the dissociation $S_2 \rightleftharpoons 2S$, and $CaS \rightleftharpoons Ca + S$, and have calculated $D^\circ_0(S_2) = 4{\cdot}4 \pm 0{\cdot}2$ eV., $D^\circ_0(SO) = 5{\cdot}4 + 0{\cdot}2$ eV., $D^\circ_0(CaS) = 3{\cdot}0 \pm 0{\cdot}2$ eV. and ΔH°_{298}(vap., CaS) = $6{\cdot}4 \pm 0{\cdot}2$ eV.

The mass spectrometric method has been described previously[4,5]. The sample was heated in a molybdenum Knudsen cell; provisions were made for distinguishing between residual gas molecules and those of the beam, which passes through a cooled collimation system; ion intensities were measured with an electron multiplier. Absolute values of partial vapour pressures were obtained from $P_i = I_iT/S_i$; I_i is the measured current corresponding to a species i, T the absolute temperature of the Knudsen cell and S_i the sensitivity for i (ref. 6): $S_i = (M_i/2\pi R)^{1/2}(s/G_i)\Sigma I_i T^{1/2}\,\Delta t$; M_i is its molecular mass, R the gas constant, s the area of the effusion orifice and t the time necessary to evaporate the weight G_i of species i. Brightness temperatures of a small threaded hole at the bottom of the Knudsen cell have been measured with an optical pyrometer; emissivity and window corrections were made[7].

Dissociation energies were calculated from: $D^\circ_0 = -RT\ln K + T\,\Delta((F^\circ_T - H^\circ_0)/T)$ (third law) and $D^\circ_T = -R d\ln K/d(1/T)$ (second law) using free-energy functions taken from Stull and Sinke[8], or for calcium sulphide, calculated by comparison of oxides and sulphides, assuming $\omega_e = 390$ cm.$^{-1}$, $r_e = 2{\cdot}3$ Å. and that only the $^1\Sigma$ ground-state is important.

Ionization cross-sections were taken from Otvos and Stevenson[9], and it was assumed that those of molecules are equal to the sum of those of the constituent atoms. The mass effect and the molecular effect of the multiplier[10] were considered to compensate each other. A possible error of 20° in the temperature measurement would lead to an uncertainty of 12 per cent in the second-law and of 1 per cent in the third-law values; instead of the assumptions made above, it is reasonable to suggest that the product of ionization cross-section and multiplier gain is the same for the atom and for the molecule[11]: in that case the third law D°_0 values of Table 1 are increased by about + 3·5 kcal. and ΔH°_{298}(vap., CaS) diminished by the same amount.

Table 1

T ° K.	log p (S)*	log p (S_2)	log p (Ca)	log p (CaS)	D°_0 (S_2) (kcal.)	D°_0 (CaS) (kcal.)	ΔH°_{298} (vap., CaS) (kcal.)
1,922	−5 67	−6 27	−5·47	—	97 4	—	—
1,975	−5·17	−5 96	−5 11	—	93 9	—	—
2,026	−5 05	−5 72	−4 86	—	95 3	—	—
2,048	−4·75	−5 53	−4 67	—	93·7	—	—
2,063	−4·74	−5·54	−4 64	−6·86	93 7	68·2	152 6
2,070	−4 80	−5 59	−4 74	−6 63	96 0	73 2	149 7
2,098	−4·57	−5 34	−4·45	−6·59	94 5	68 8	152 2
2,143	−4·47	−5·19	−4 35	−6 26	96 0	71·6	152 3
2,144	−4·31	−5 09	−4·22	−6 32	93 8	68 2	152 9
2,154	−4 42	−5·15	−4 31	—	95 9	—	—
2,156	−4·35	−5 09	−4·18	−6·31	93 9	67·9	153 6
2,190	−4·23	−4·99	−4·07	−6 15	95·4	69 1	154·3
2,223	−3·98	−4 73	−3·90	−5 87	94 4	68 7	154 5
2,297	−3 69	−4·53	−3·56	−5 59	93 8	68·1	156·4
				Average	94·8	69 3	153·2†
				Slope method	108	92	129
				Proposed value	101 ± 5	70 ± 5	147 ± 10

* Decimal logarithms of pressures in atmospheres.

† $[F^\circ_T - H^\circ_{298}]/T$ for this process is based on very scanty data on C_p (CaS) (Kelley, K. K., U.S. Bureau of Mines Bulletin 476, Washington (1949)).

The results in Table 1 and ΔH°_{298}(vap., Ca) (ref. 8) = 42·2 kcal., $\Delta H^\circ_{298}(\frac{1}{2}S_2)$ = 15·4 kcal., the standard heat of formation ΔH°_{298f}(CaS) = 110·0 ± 2 kcal. (ref. 12) permit one to calculate ΔH°_{298}(vap., CaS) = 147 kcal. The value obtained from this cycle is considered to be more reliable than that given in Table 1 (see note to Table 1).

$D^\circ_0(S_2)$ obtained here, combined with ΔH°_0(SO) (ref. 2b) for the reaction $\frac{1}{2}S_2 + \frac{1}{2}O_2 \rightleftharpoons SO$, definitely rules out a value D°_0(SO) smaller than 5·2 eV. There are good spectroscopic arguments for D°_0(SO) = 5·358 eV. (ref. 13) rather than 5 027 eV. (ref. 3). Our measurements are not accurate enough to permit one to settle the question whether the predissociation at 4·41 eV. gives the exact dissociation of S_2 (ref. 14) or an upper limit[15]; a value $D(S_2) = 4 \cdot 2$ eV. would agree with our results[16]. Within the accuracy quoted in Table 1, all available data on $D(S_2)$ and $D(SO)$ (ref. 3) except appearance potential measurements[17] and older equilibrium measurements (cf. refs. 1, 2, 3, 14) seem to be in agreement.

Experimental details and further data on strontium sulphide and barium sulphide will be published shortly.

Thanks are due to the Comité Belge de Spectrométrie de Masse (I.R.S.I.A.), which has made available part of the equipment. The investigation was sponsored in part by the Wright Air Development Center of the Air Research and Development Command, United States Air Force, through its European Office, under contract No. *AF* 61(052)-225.

R. Colin*
P. Goldfinger
M. Jeunehomme

Laboratoire de Chimie Physique I,
Université Libre de Bruxelles,
Brussels.

* Boursier de l'I.R.S.I.A.

[1] Goldfinger, P., Jeunehomme, W., and Rosen, B., *Nature*, 138, 205 (1936).

[2] (*a*) St. Pierre, G., and Chipman, J., *J. Amer. Chem. Soc.*, 76, 4787 (1954); *J. Metals*, 8, 1474 (1956). (*b*) Dewing, E. W., and Richardson, F. D., *Trans. Farad. Soc.*, 54, 679 (1958).

[3] (*a*) Brewer, L., *J. Chem. Phys.*, 31, 1143 (1959). (*b*) Marsden, D. G. H., *ibid.*, 1143 (1959).

[4] Goldfinger, P., and Jeunehomme, M., "Advances in Mass Spectrometry", 534 (Pergamon Press, London, 1959).

[5] Drowart, J., and Goldfinger, P., *J. Chim. Phys.*, 55, 721 (1958).

[6] Goldfinger, P., Ackerman, M., and Jeunehomme, M., Final Technical Report, EOARDC, Contract No. *AF* 61(052)-19 (1959). Colin, R., Goldfinger, P., Jeunehomme, M., and Verhaegen, G., Amer. Chem. Soc. National Meeting, Atlantic City, Sept. 13–18, (1959) (to be published).

[7] Ackerman, M., Stafford, F., and Drowart, J. (unpublished work).

[8] Stull, D. R., and Sinke, G. C., "Thermodynamic Properties of the Elements", American Chemical Society, November 1956.

[9] Otvos, J. W., and Stevenson, D. P., *J. Amer. Chem. Soc.*, 78, 546 (1956).

[10] Inghram, M. G., and Hayden, R. J., Nuclear Science Series, Report No. 14, National Research Council, Washington, D.C. (1954). Inghram, M. G., Hayden, R. J., and Hess, D. C., in N.B.S. Circ. 522, 257 (Washington, 1953). Stanton, H. E., Chupka, W. A., and Inghram, M. G., *Rev. Sci. Instr.*, 27, 109 (1956).

[11] Schissel, P., *J. Chem. Phys.*, 26, 1276 (1957).

[12] Kubaschewski, O., and Evans, E. Ll., "Metallurgical Thermochemistry" (Pergamon Press, London, 1956).

[13] Norrish, R. G. W., and Oldershaw, G. A. O., *Proc. Roy. Soc.*, A, 249, 498 (1959).

[14] Gaydon, A. G., "Dissociation Energies", second ed. (Chapman and Hall, Ltd., London, 1953).

[15] Herzberg, G., and Mundie, L. G., *J. Chem. Phys.*, 8, 263 (1940).

[16] See Walsh, A. D., in "Threshold of Space", in Proc. Conf. on Chemical Aeronomy in Cambridge, Mass., 1956, edit. by Zelikoff, M. (Pergamon Press, New York, 1957).

[17] Blanchard, L. P., and Le Goff, P., *Canad. J. Chem.*, 35, 89 (1957) Dibeler, V. H., Franklin, J. L., and Reese, R. M., *J. Chem. Phys.*, 29, 880 (1958).

Ionization and Attachment Coefficients in *n*-Alkyl Chloride Gases

We have measured ionization coefficients in the five *n*-alkyl chloride gases, methyl, ethyl, propyl, butyl, and amyl chloride, using an experimental apparatus similar to that described by Geballe and Harrison[1]. Despite the fact that these gases contain a halogen atom, they exhibit no detectable electron attachment to form negative ions. The present work constitutes part of an experimental programme for measuring ionization and attachment coefficients in a large variety of electronegative gases. We hope that such data will serve as a guide for the correlation of these coefficients, important to an understanding of the electrical breakdown of gases, with molecular structure.

The gases used in this work are commercially available products which, when necessary, were purified by vapour phase chromatography. We estimate the final purity of each gas to be greater than 99 per cent.

The essential part of the experimental apparatus consists of a pair of plane, parallel electrodes of 10 cm. diam., the spacing between which is variable from 0 to 3 cm. The cathode is irradiated with ultra-violet light through perforations in a 1-in. diam. area in the centre of the anode, to produce a constant primary electron photocurrent, i_0. The current to the anode, i, is measured as a function of the electrode spacing, δ, at constant field strength, E, and gas pressure, P. Pressures used varied from 1 to 40 mm. mercury.

In each of the alkyl chloride gases the current was found to vary as $i = i_0 \exp \alpha\delta$. From the absence of curvature in plots of log i versus δ over a range $0 \cdot 1 < \delta < 3$ cm., we can estimate that if negative ion formation occurs at all, the coefficient of attachment, η, must be smaller than 10–15 per cent of the observed ionization coefficient, α, at each E/P in every gas. Furthermore, in methyl chloride, for example, at $E/P = 40$, $\alpha/P = 0 \cdot 0307$ and $\eta/P \lesssim 0 \cdot 005$. Since an electron capture process, for example, $e + CH_3Cl = CH_3 + Cl^-$, is usually characterized by an η/P which varies slowly with E/P[1], an upper limit to η/P for capture processes in methyl chloride can probably be set at approximately 0·005 for all the E/P range studied.

The absence of measurable attachment is consistent with the mass spectrographic studies of methyl chloride by Dibeler and Reese[2]. They found that negative ions are not produced by capture processes, but only by a double-ion process, $CH_3Cl + e = CH_3^+ + Cl^- + e$, which has a small probability (about 1 per cent for 75-V. electrons) relative to that for the production of CH_3Cl^+ ions.

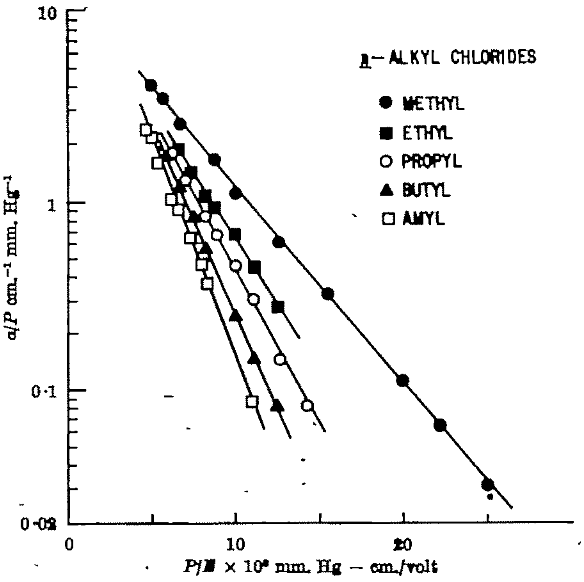


Fig. 1. Observed ionization coefficients as functions of P/E

The variation of α with E and P in the alkyl chlorides is expressed accurately by the functional form $\alpha/P = A\exp(-BP/E)$, as is illustrated in Fig. 1. It is especially to be noted that the functional form $\alpha/E = A\exp(-BP/E)$ will not fit the data. Values of the constants A and B, as derived from the curves in Fig. 1, are listed in Table 1.

Table 1

Gas	A cm.$^{-1}$ mm.$^{-1}$	B v cm.$^{-1}$ mm.$^{-1}$	ϵ_i eV.	$B/\epsilon_i^{3/2}$ cm.$^{-1}$ mm.$^{-1}$ v$^{-1/2}$
CH_3Cl	13·4	244	11·28*	6·4
C_2H_5Cl	16·1	325	10·97*	8·9
n-C_3H_7Cl	20·7	388	10·8†	10·9
n-C_4H_9Cl	28·4	471	10·7‡	13·4
n-$C_5H_{11}Cl$	40·4	549	10·6‡	15·8

* Watanabe, K., *J. Chem. Phys.*, **26**, 542 (1957).
† Stevenson, D. P., and Hippel, J. A., *J. Amer. Chem. Soc.*, **64**, 2766 (1942).
‡ Estimated.

At present there exists no exact theory for the correlation of these quantities with molecular structure. The approximate theory of Crowe, Bragg and Devins[3] predicts that the constant B will vary with molecular parameters in a homologous series as $B = C\epsilon_i^{3/2}\theta$, where ϵ_i is the molecular ionization energy and θ the total cross-section for electron scattering. Devins and Crowe[4] and Heylen and Lewis[5] derived values of B for a number of saturated hydrocarbon gases from sparking potential measurements. They found that $B/\epsilon_i^{3/2}$ is directly proportional to the number of carbon–hydrogen bonds in the n-alkane gases, indicating that electrons in the carbon–hydrogen bonding orbitals (that is, the electrons in the outermost molecular orbitals) are most effective in electron scattering.

The values of $B/\epsilon_i^{3/2}$ of Devins and Crowe for the alkanes are plotted in Fig. 2 along with our values for the alkyl chlorides. From the theory, the slope of the alkyl chloride curve is proportional to the C–H bond cross-section, while the intercept is proportional to the cross-section of chlorine bonded to a carbon atom. Analysis of the data yields a least-squares line of slope 1·16 ± 0·03 and intercept 2·97 ± 0·07. The slope for the alkyl chloride data is approximately twice that for the alkanes. The largest part of this difference is possibly due to an incorrect choice for the functional form for α by Devins and Crowe. The sparking potential data cover a rather limited range of E/P, so that their data can be fitted equally well using either $\alpha/P = A\exp(-BP/E)$ or $\alpha/E = A\exp(-BP/E)$. The B values they quote were obtained using the latter form. If the former expression were used instead, all of the B values for the alkanes would be larger by a multiplicative constant of approximately 1·5. Even so, the two slopes in Fig. 2 would still be different by 25 per cent, indicating either a larger C–H bond cross-section in the alkyl chlorides or different proportionality constants for the two homologous series in the equation $B = C\epsilon_i^{3/2}\theta$.

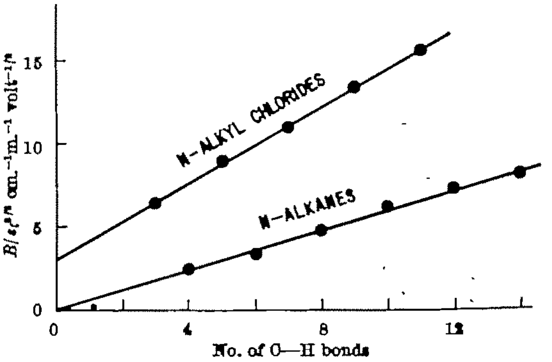


Fig. 2. Dependence of $B/\epsilon_i^{3/2}$ on the number of carbon–hydrogen bonds per molecule. Upper curve, this work; lower curve, ref. 4

The constant A in the alkyl chlorides appears to vary as $a + b(n_{C-H})^2$. The significance of this observation is not clear.

We are indebted to E. M. Hadsell for performing analyses and purifications by vapour phase chromatography.

J. C. DEVINS
O. H. LEBLANC, JUN.

General Electric Research Laboratory,
Schenectady,
New York.

[1] Geballe, R., and Harrison, H. A., *Phys. Rev.*, 91, 1 (1953).

[2] Dibeler, V. H., and Reese, R. M., *J. Res. Nat. Bur. Standards*, **54**, 127 (1955).

[3] Crowe, R. W., Bragg, J. K., and Devins, J. C., *J. App. Phys.*, **26**, 1121 (1955).

[4] Devins, J. C., and Crowe, R. W., *J. Chem. Phys.*, **25**, 1053 (1956).

[5] Heylen, A. E. D., and Lewis, T. J., *Brit. J. App. Phys.*, 1, 411 (1956).

Homogeneous Synthesis of Isotactic Polystyrene using n-Butyllithium Initiator

ORGANOLITHIUM compounds are known to cause the stereospecific polymerization of dienes[1] and methacrylates[2]. Via n-butyllithium, styrene polymerizes easily to atactic polymer at ordinary temperatures[3,4]. We have now found that styrene may be polymerized at low temperatures, employing butyllithium as a soluble initiator, to crystallizable isotactic polystyrene.

Polystyrene prepared in a hydrocarbon medium at temperatures in the range of − 30° C. and below exhibits infra-red, X-ray diffraction and nuclear spin resonance spectra identical to those shown by isotactic crystalline polystyrene prepared via triethyl-aluminium–titanium trichloride catalysis. In the presence of ethers, however, only atactic polymer forms, even at − 78° C. Isotactic polymerization is much slower at − 40° (~ 5 per cent conversion in 48 hr.) in a 7 : 1 volume ratio styrene–toluene mixture than at − 78° in tetrahydrofuran (> 90 per cent conv. in 1 hr.). Butyllithium concentrations of 5–10 m.mol./l. were used.

A block copolymer of atactic and isotactic types of polystyrene may be prepared by adding an ether to a styrene polymerization proceeding at − 40° in toluene. The same result may be achieved by raising the temperature to 0° after polymerizing for a period of time at about − 40°. Blocks of a second monomer species (such as isoprene, alkyl methacrylates and acrylonitrile) on isotactic polystyrene can be prepared even though styrene conversion is far from complete[5].

R. J. KERN

Monsanto Chemical Co.,
Dayton 7, Ohio.
June 20.

[1] Stearns, R. S., and Forman, L. E., *J. Polymer Sci.*, **41**, 381 (1959).

[2] Fox, T. G., Garrett, B. S., Goode, W. E., Gratch, S., Kincaid, J. F., Spell, A., and Stroupe, J. D., *J. Amer. Chem. Soc.*, 80, 1768 (1958).

[3] Welch, F. J., *J. Amer. Chem. Soc.*, 81, 1345 (1959).

[4] O'Driscoll, K. F., and Tobolsky, A. V., *J. Polymer Sci.*, **35**, 259 (1959).

[5] Graham, R. K., Dunkelberger, D. L., and Goode, W. E., *J. Amer. Chem. Soc.*, **82**, 400 (1960).

BIOCHEMISTRY

Presence of Neutral Carbohydrates in Human Aortic Tissue

In 1938, Hisamura[1] demonstrated that demineralized bone tissue contained two carbohydrate-protein fractions, a uronic acid-containing and a uronic acid-free fraction.

Consden[2] and Glegg *et al.*[3] later showed that connective tissue from different organs contains both acid mucopolysaccharides and considerable amounts of neutral heteropolysaccharides. The designation neutral heteropolysaccharides covers neutral mucopolysaccharides, containing hexosamine, and neutral monosaccharides, as well as glycoproteins which have bound hexosamine and/or various neutral monosaccharides in a firmly covalent bond to the protein. The term neutral refers only to the absence of hexuronic acids as constituents of the molecule.

Bertelsen and Jensen[4] showed in an earlier publication that the content of acid mucopolysaccharides in aortic tissue increases with age. They also found with increasing age a deposit of ground substance which—after oxidation with periodic acid—was strongly stained with Schiff's reagent.

This communication reports preliminary results obtained from experiments made in an attempt to isolate neutral mucopolysaccharides from macroscopically normal aortic tissue.

An extraction was made with 0·5 *N* sodium hydroxide for 4 days in an ice-box. The aortic tissue had already been rid of adventitia, disintegrated and defatted. After neutralization of the filtrate a precipitate was deposited in two volumes of absolute alcohol (fraction I). According to Meyer and Chaffee[5] this fraction contains the acid mucopolysaccharides. By increasing the alcoholic percentage to 84 a further precipitate (fraction II), which according to Glegg *et al.*[3] contains uronic acid-free carbohydrates, was deposited.

Table 1 shows that the ratio fraction I/II increases considerably with age. Both fractions increase, but the percentage increase of fraction I is much larger than that of fraction II.

Table 1. FRACTIONS EXPRESSED IN PERCENTAGES OF DRY, DEFATTED WEIGHT

Age	Fraction I	Fraction II
7 months	3·3	3·1
2 years	5·3	4·2
45 years	11·4	4·9
58 years	14·1	5·4
60 years	14·6	6·2

The qualitative determination of uronic acid was made by carboxylic reaction. The monosaccharides were determined by their colour reactions to cysteine, carbazol and sulphuric acid, as described by Dische[6] (Table 2). The content of hexosamine in the fractions was determined quantitatively by Blix's[7] modification of Elson and Morgan's method after hydrolysis.

Table 2

Age	Uronic acid	Hexosamine	Ketohexose	Aldohexose	PAS
Fraction I					
7 months	+	+	÷	+	(+)
2 years	+	+	÷	÷	(+)
45 years	+	+	÷	−	(+)
58 years	+	+	÷	÷	(+)
60 years	+	+	÷	+	(+)
Fraction II					
7 months	+	+	+	+	+
2 years	÷	+	+	+	+
45 years	÷	+	+	+	+
58 years	+	+	+	+	+
60 years	÷	+	+	+	+

The quantitative content of hexosamine determined in fractions I and II respectively, and converted into 100-gm. dried, defatted tissue, is given in Table 3. An unmistakable increase of the hexosamine contents with age will be observed in both fractions. The increase in percentage is by far the greatest in the fraction containing the acid mucopolysaccharides.

Table 3. HEXOSAMINE CONTENT (MGM. PER 100-GM. DRIED, DEFATTED TISSUE)

Age	Acid mucopolysaccharides	Neutral mucopolysaccharides
7 months	262	128
2 years	358	137
45 years	550	156
60 years	625	176

The periodic acid–Schiff reaction was carried out according to the method indicated by McManus and Hoch-Ligeti[8]. Fraction II showed a very strong reaction, whereas fraction I only showed a faint reaction. There was a distinct difference between the ways in which the fractions were soluble in water. Fraction I proved slowly soluble, forming fairly viscous solutions; whereas fraction II was quickly soluble, with a viscosity similar to that of water.

The preliminary result shows that with increasing age a considerable deposit of mucoid substance occurs in aorta; acid mucopolysaccharides, forming the mucoproteins, and neutral mucopolysaccharides, forming glycoproteins similar in nature to serum proteins.

The increase of acid mucopolysaccharides is greater than the increase of glycoproteins, which is in complete agreement with the histological picture.

Histochemical experiments made on aortic tissue, concurrently with the biochemical experiments, were found to be in agreement with the abovementioned results. A big increase in the content of acid mucopolysaccharides, starting even in childhood, was found. The deposit of periodic acid–Schiff-positive substance was not distinct in the adult aorta until after the second decade, and then it increased gradually with the years.

SV. BERTELSEN

Department of Pharmacology,
20 Juliane Maries Vej,
University of Copenhagen.

March 21.

---

[1] Hisamura, H., *J. Biochem.*, 28, 473 (1938).

[2] Consden, R., in "Nature and Structure of Collagen", edit. by Randall, J. T., 196 (Butterworths Scientific Publications, London, 1953).

[3] Glegg, R. E., Eidinger, D., and Leblond, C. P., *Science*, 120, 839 (1954).

[4] Bertelsen, Sv., and Jensen, C. E., *Acta Path. Microbiol. Scand.*, 48, 305 (1960).

[5] Meyer, K., and Chaffee, E., *J. Biol. Chem.*, 138, 491 (1941).

[6] Dische, Z., "Methods of Biochem. Analysis", 2, 313 (1955).

[7] Blix, G., *Acta Chem. Scand.*, 2, 467 (1948).

[8] McManus, J. F., and Hoch-Ligeti, C., *Lab. Invest.*, 1, 19 (1952).

Organic Matrix of Tooth Enamel

LITTLE is known about the chemical nature of the organic matrix of enamel, although it presumably plays an essential part in the initiation and organization of the growth of hydroxyapatite crystals. The mature enamel finally resulting from these processes is the hardest and most highly mineralized of vertebrate tissues. Other mineralized tissues, bone[1] and dentine[2], contain 15–26 per cent of persistent organic matrix, at least 90 per cent of which is collagen. Mature human enamel contains only some 0·6 per cent of organic matter and 0·36 per cent of proteins, approximately half of which are soluble in acid decalcifying fluids[3]. Investigations of the composition of enamel proteins have been largely confined to insoluble residues from the demineralization of the mature tissue[3–5]. A recent finding, in this laboratory, that partly mineralized enamel from developing teeth in the human fœtus contains approximately 20 per cent of material of protein character was followed by a preliminary investigation of its amino-acid composition.

The upper central incisors were carefully removed from a 33-week old fœtus and the calcified caps, which consist of both enamel and dentine, were freed from soft tissues. The tooth caps were gently wiped with cotton wool, slightly moistened with saline solution, to remove traces of blood. The enamel was readily removed from the underlying dentine by gently chipping with a dental excavator, the procedure being carried out under an ophthalmic operation microscope. The enamel was thereby reduced to a white crystalline powder, which had a somewhat waxy texture and showed evidence of prism structure with the optical microscope. The enamel was dissolved in 6 *N* hydrochloric acid and the solution heated at 100° C. for 48 hr. to hydrolyse any proteins. After removal of the hydrochloric acid, the amino-acids were determined by a semi-micro, resin chromatographic method[6], loads equivalent to 0·8 mgm. of protein being transferred to 0·4-cm. diameter 'Dowex 50' columns.

The results, expressed as numbers of amino-acid residues per thousand total residues, are summarized in Table 1. No peaks were observed corresponding to hydroxyproline and hydroxylysine, which are characteristic constituents of collagen. It was concluded that no collagen was present and that the enamel had been adequately separated from dentine. The composition differed markedly from collagen[7], epidermal 'keratin'[8], elastin[9], blood proteins[10] and the insoluble proteins of mature enamel[3–5]. The overall composition was very characteristic and no similar results for another protein have so far been found in the literature. Characteristic features are: (1) proline accounts for one-quarter of the total residues; (2) the high ratio of glutamic to aspartic acid; (3) histidine is the predominant basic amino-acid; (4) tyrosine greatly exceeds phenylalanine; and (5) the high methionine content.

Table 1. AMINO-ACID COMPOSITION OF DEVELOPING ENAMEL AND INSOLUBLE PROTEIN FROM MATURE ENAMEL

(Values are given as numbers of amino-acid residues per thousand total residues)

	Developing enamel from human fœtus	Acid-insoluble residue from mature human enamel
	Present work	Hess *et al.* (ref. 4)
Alanine	20·3	111
Glycine	65·0	304
Valine	39·6	33·8
Leucine	91·2	41·9
*iso*Leucine	32·7	16·3
Proline	251	47·0
Phenylalanine	23·4	45·8
Tyrosine	53·4	6·9
Serine	62·5	75·5
Threonine	38·1	44·8
Half-cystine	<4	6·1
Methionine	42·2	8·3
Arginine	23·3	47·0
Histidine	64·5	9·0
Lysine	17·7	31·2
Aspartic acid	30·3	45·8
Glutamic acid	142	78·0
Hydroxyproline	0	47·3
Hydroxylysine	0	—
Amide	146	—

The most complete data for the insoluble protein from mature enamel due to Hess *et al.*[4] (Table 1) are in reasonable agreement with the results of Battistone and Burnett[5] but show differences from those of Stack[3]. All three analyses, however, revealed significant amounts of hydroxyproline which, together with the glycine and alanine values, suggest that collagen is present. The cystine, serine and basic amino-acid values are compatible with the presence of an epithelial keratin, similar to that found in epidermis[8], in addition to collagen. The increased quantity of cystine found in the cuticle of enamel[11] may indicate that the protein of epidermal type is associated with the epithelial layer.

The existence of a high proportion of amino-compounds in hydrolysates of partially mineralized enamel suggests the original presence of proteins rather than free amino-acids or small peptides. The amino-acid composition of developing enamel differs remarkably from that of the insoluble protein fraction from mature enamel (Table 1). It is considered that this difference results from the developing enamel containing one or more proteins associated with the true enamel matrix, in which hydroxyapatite crystals are formed. The large differences in composition suggest that the matrix protein accounts for a substantial proportion of the total protein of developing enamel. It is not surprising that the matrix protein should be unlike the keratins in composition since it is secreted by highly active ameloblasts, whereas the epithelial keratins result from cell degeneration. The decrease in protein content from 20 per cent in fœtal enamel to 0·36 per cent in the mature tissue, together with the change in composition, suggest that the matrix protein is removed either during maturation of enamel, after eruption of the teeth or during subsequent aqueous extraction of the ground enamel. Removal of organic matrix in the later stages of enamel development would seem to be consistent with, and may be essential for, the attainment of a high degree of mineralization. This view is supported experimentally by the widespread finding that in sections of teeth decalcified with strong acids, structure attributable to the enamel matrix is visible in the earlier stages of tooth development, whereas mature enamel is completely dissolved. A transition from one stage to the other has been observed in continuously growing teeth[12].

J. E. EASTOE *

Department of Dental Science,
Royal College of Surgeons of England,
London, W.C.2. April 5.

* Senior Leverhulme Fellow in Biochemistry.

[1] Eastoe, J. E., "The Biochemistry and Physiology of Bone", edit. by Bourne, G. H. (Academic Press, New York, 1956).
[2] Long, C., "The Biochemist's Handbook" (Spon, London, in the press).
[3] Stack, M. V., *J. Amer. Dent. Assoc.*, 48, 297 (1954).
[4] Hess, W. C., Lee, C. Y., and Neidig, B. A., *J. Dent. Res.*, 32, 585 (1953).
[5] Battistone, G. C., and Burnett, G. W., *J. Dent. Res.*, 35, 260 (1956).
[6] Eastoe, J. E., *Biochem. J.*, 74, 8 *P* (1960).
[7] Eastoe, J. E., *Biochem. J.*, 61, 589 (1955).
[8] Bowes, J. H., and Elliott, R. G., *J. Soc. Leather Tr. Chem.*, 41, 87 (1957).
[9] Partridge, S. M., and Davis, H. F., *Biochem. J.*, 61, 21 (1955).
[10] Tristram, G. R., "Adv. Protein Chem.", 5, 83 (1949).
[11] Losee, F. L., and Hess, W. C., *J. Dent. Res.*, 28, 512 (1949).
[12] Fish, E. W., and Harris, L. J., *Phil. Trans.*, B, 223, 489 (1934).

Starch-like Polysaccharide of *Streptococcus pyogenes*

MANY strains of Lancefield group *A* streptococci synthesize a starch-like polysaccharide when grown on a medium containing maltose or maltose-polymers[1], and some of these strains also produce an extracellular amylase[2]. It has been shown that amylase-negative starch-accumulating strains are associated with acute glomerulonephritis and acute rheumatic fever[3]. There is as yet no direct proof that the starch itself is more than a metabolic marker of bacterial variants, but because of the possibility of its production *in vivo* its isolation and characterization were of considerable interest, for it has been shown that bacterial polysaccharides of high molecular weight may have long persistence in the tissues[4].

The group *A* strain, *IRP* 118, type 19, was grown in 15 litres brain–heart–infusion broth, with repeated additions of maltose and automatic adjustment to pH 7·4 during 48 hr. Thrice-washed cell suspensions (about 40 gm. dry weight) were extracted for 1 hr. at 0° with 400 ml. perchloric acid. The final perchloric acid concentration used differed in different experiments, but although the yield of polysaccharide was greater with 5 N acid than with 2 N acid, the properties of the products were very similar. After clarifying by centrifugation, the extract was carefully neutralized at 0° with sodium hydroxide to pH 6·0. On saturation of the neutralized extract with n-butanol and allowing to stand for two days at 0°, a small amount of a white precipitate appeared at the interface, but this did not stain with iodine and was therefore discarded.

The polysaccharide was then precipitated as a complex with iodine, iodine (0·1 N) in potassium iodide (0·3 N) being added to the aqueous layer until no more blue precipitate appeared and the supernatant solution was just yellow with excess iodine. (Further addition of iodine produced a brown turbidity.) The purple precipitate was washed with dilute iodine solution and then suspended in warm distilled water and just decolorized with dilute sodium thiosulphate. The polysaccharide was then precipitated from this solution by successive additions of acetone at 0°, the bulk of the iodine-staining material being precipitated between 35 per cent and 45 per cent v/v acetone. The product was washed with n-butanol and then with acetone and ether. The amorphous white powder thus obtained was poorly soluble in water, and solutions were best obtained by dissolving in 0·3 N sodium hydroxide and only neutralizing immediately before use.

It was shown by paper chromatography that the sole sugar produced by acid hydrolysis[5] of the product was glucose. Reducing-sugar estimation[6] after acid hydrolysis, however, showed that the product was only 95 per cent polysaccharide, the remainder being apparently inorganic salts. When calculations were based on the polysaccharide content it was found that hydrolysis with salivary α-amylase resulted in a 100 per cent yield of maltose (as estimated by the method of Somogyi[6]) and 100 per cent hydrolysis based on iodine stain. With a commercial sample of purified β-amylase, 98 per cent maltose was liberated and the optical density of the iodine stain[7] fell to 3 per cent of its original value. Since the residual iodine stain was always of the same quality as that of the original material, it seems likely that this discrepancy was due to partial retrogradation. The 'blue value'[8] of the product varied from preparation to preparation as did the yield. For example, one preparation of 60 mgm. polysaccharide from 38 gm. dry weight cells had a 'blue value' of 0·65, and one of 200 mgm. from 49 gm. cells had a 'blue value' of 0·8. Controlled retrogradation of the latter product gave fractions with 'blue values' of 0·87 and 0·75 respectively and a trace of a red-staining fraction.

None of these fractions, however, showed any significant limit to β-amylolysis. It therefore seems that the polysaccharide extractable from this culture by perchloric acid is of the purely straight-chain amylose type with a range of chain-lengths from about 40 to 60 glucose units. (Based on 'blue values' for linear dextrins (Whelan, W. J., private communication).) This is confirmed by the fact that the product is completely hydrolysed when incubated in the presence of excess glucose with a preparation of amylomaltase obtained from the same strain of group *A* streptococcus according to the method of Monod and Torriani[9] for the amylomaltase of *E. coli mutabile* (*ML*).

Although the polysaccharide isolated does not have a very high molecular weight it exhibits a great tendency to retrograde and this retrograded form is very insoluble and might be expected to persist for long periods if it was in fact ever formed in tissues.

H. BAUM

Department of Biochemistry and Chemistry,
Royal Free Hospital School of Medicine,
8 Hunter Street,
London, W.C.1.

N. CROWLEY

Department of Bacteriology,
Royal Free Hospital,
Gray's Inn Road,
London, W.C.1.

[1] Crowley, N., and Jevons, M. P., *J. Gen. Microbiol.*, 13, 226 (1955).

[2] Crowley, N., *J. Gen. Microbiol.*, 10, 411 (1954).

[3] Crowley, N., *J. Hyg.* (Camb.), 57, 235 (1959).

[4] Coons, A. H., "Rheumatic Fever: A Symposium", 217 (University of Minnesota Press, 1952).

[5] Pirt, S. J., and Whelan, W. J., *J. Sci. Food Agric.*, 2, 224 (1951).

[6] Somogyi, M., *J. Biol. Chem.*, 160, 61 (1954).

[7] Bailey, J. M., and Whelan, W. J., *Biochem. J.*, 67, 540 (1957).

[8] Bourne, E. J., Haworth, W. N., Macey, A., and Peat, S., *J. Chem. Soc.*, 924 (1948).

[9] Monod, J., and Torriani, A. M., *Ann. Inst. Pasteur*, 78, 65 (1950).

Ubiquinone (50) and Ubichromenol in *Aspergillus fumigatus*, Fresenius

FOLLOWING the recent discovery[1–3] of a series of ubiquinones in various biological tissues, a useful system for studying their biosynthesis was sought. A strain of *Aspergillus fumigatus*, Fresenius (we wish to thank Prof. J. H. Birkinshaw for the gift of a specimen culture), studied by Anslow and Raistrick[4], was observed to secrete 3-hydroxy, 4-methoxy, 2,5-toluquinone (fumigatin) into the medium. This compound is closely related to the ring nucleus of ubiquinone and it seemed possible that the above organism might also produce sufficient ubiquinone for the study of its biosynthesis.

Cultures of the fungus were grown at 30° in Roux bottles, each containing 200 ml. Raulin–Thom medium at pH 3·8. After various intervals from 3 days to 8 weeks, the thalli from groups of 2 bottles were removed and examined for ubiquinone. In the preliminary experiments, the tissue was saponified directly in methanolic potassium hydroxide in the

Table 1. THE STIMULATORY EFFECT OF LEUCINE ON THE SYNTHESIS OF UBIQUINONE (50) AND UBICHROMENOL IN *Aspergillus fumigatus* FRES-

Group	Medium				Thallus				
	Leucine concentration (per cent)	Final pH	Ether extract*		Dry weight (gm.)	Lipids (mgm.)	Ubiquinone		Ubichromenol (mgm.)
			Total (mgm.)	Fumigatin			(mgm.)	(μmol./gm. dry weight)	
A 1	0	3·0	245	+++	2·35	219	1·17	0·6	0·02
2	0·10	3·5	127	++	1·97	225	1·74	1·0	<0·02
3	0·25	6·0	89	0	1·83	225	2·07	1·3	0·17
4	0·50	7·3	54	0	1·35	171	2·00	1·7	0·33
B 1	0	2·0	—	+++	1·98	224	1·18	0·7	—
2	1·00	4·0	—	0	0·62	104	1·22	2·3	0·20

There were three Roux bottles in each experimental group but the yields after 7 days growth are expressed per bottle containing 200 ml. Raulin–Thom medium with initial $pH = 3·8$.

* The ether extract consists mainly of substituted quinones of which a variable fraction is fumigatin. There were approximately 80 mgm. fumigatin in each bottle of control medium.

presence of pyrogallol, and the unsaponifiable matter extracted with ether. In the later work, the lipids were extracted directly from the thalli using acetone, alcohol and ether in turn. The unsaponifiable material or the lipid extract was then chromatographed on a column of partially deactivated, acid-washed alumina (Brockmann Grade III) by a standard procedure[7] for ubiquinone.

A pale yellow zone with the same chromatographic behaviour and absorption band as ubiquinone ($\lambda_{max.}$ 272 mμ in *cyclo*hexane) was eluted from the column. A second chromatography on a column of silicic acid/'Celite' (2 : 1 w/w) enabled ubiquinone to be obtained from pooled samples in crystalline form. It had the following properties which are characteristic of ubiquinone (50)[3]: m.p. 48·5° C. (uncorr.), $E(1\%, 1 \text{ cm.})$ 272 mμ = 168, infra-red spectrum identical with that of ubiquinone (50). Chemical analysis gave percentages carbon, hydrogen and oxygen of 81·62, 10·90 and 7·47 respectively compared with theoretical values of 82·04, 10·42 and 7·54. The methoxyl contents of two different samples were 7·38 and 7·21 per cent respectively, which also agree with the theoretical 7·19 per cent for ubiquinone (50) within experimental error. The dry weight of the thallus and ubiquinone content (0·6 μmol./gm. dry wt.) were maximal after 7–10 days growth and declined thereafter.

This level of ubiquinone is comparable with that in animal tissues and some yeasts[5]. Ubiquinones from the latter, however, generally possess shorter isoprenoid side-chains with 30–45 carbons.

From the aqueous medium, fumigatin[6] and another quinone, believed to be spinulosin (3,6-dihydroxy-4-methoxy 2,5-toluquinone), have been isolated. The formation of these, however, can be reduced or suppressed by adding *l*-leucine to the culture medium. At the same time, the organism is stimulated to make a larger amount of ubiquinone and also its cyclic isomer, ubichromenol[7,8] (Table 1). Ubichromenol was first isolated from animal tissues, but it can also be produced artificially by the adsorption of ubiquinone on very strong alumina[4]. The material found in *Aspergillus fumigatus* is not an artefact, because it was obtained from the tissue by direct extraction with organic solvents and resolved from ubiquinone by a chromatographic procedure known to be incapable of converting ubiquinone into ubichromenol.

The amounts of ubichromenol available from the fungus were insufficient to permit full chemical analysis, but its ultra-violet absorption spectrum in ethanol and the isosbestic points for the bathochromic shift with alkali are identical with those of the pure material isolated from human kidney tissue. Furthermore, both show the same R_F value on reversed-phase chromatography. It is therefore reasonable to assume that the ubichromenol isolated is isomeric with ubiquinone (50).

The table of results shows clearly that the reduction in output of free quinone from the thallus in the leucine-supplemented medium more than accounts for the absolute increase in ubiquinone (50) and ubichromenol. So the leucine is altering the pattern of metabolism of the mould in a more fundamental way than merely providing a readily available pool of isoprenoid units for the synthesis of the side-chain molecules which become coupled to the nucleus.

Fumigatin and ubichromenol may be related to intermediates in the biosynthesis of ubiquinone.[9] Full details of this work and experiments with ^{14}C-labelled substrates will be published elsewhere.

One of us (N. M. P.) is in receipt of a Department of Scientific and Industrial Research studentship.

N. M. PACKTER
J. GLOVER

Biochemistry Department,
University of Liverpool.

[1] Morton, R. A., Wilson, G. M., Lowe, J. S., and Leat, W. M. F., *Chem. and Indust.*, 1649 (1957).

[2] Lester, R. L., Crane, F. L., and Hatefi, Y., *J. Amer. Chem. Soc.*, **80**, 4751 (1958).

[3] Morton, R. A., Gloor, U., Schindler, O., Wilson, G. M., Chopard-dit-Jean, L. H., Hemming, F. W., Isler, O., Leat, W. M. F., Pennock, J. F., Ruegg, R., Schwieter, U., and Wiss, O., *Helv. Chim. Acta*, **41**, 2343 (1958).

[4] Gloor, U., Isler, O., Morton, R. A., Ruegg, R., and Wiss, O., *Helv. Chim. Acta*, **41**, 2357 (1958).

[5] Lester, R. L., and Crane, F. L., *J. Biol. Chem.*, **234**, 2169 (1959).

[6] Anslow, W. K., and Raistrick, H., *Biochem. J.*, **32**, 687 (1938).

[7] Laidman, D. L., Morton, R. A., Paterson, J. Y. F., and Pennock, J. F., *Biochem. J.*, **74**, 541 (1960).

[8] Laidman, D. L., Morton, R. A., Paterson, J. Y. F., and Pennock, J. F., *Chem. and Indust.*, 1019 (1959).

[9] Links, J., *Biochim. Biophys. Acta*, **38**, 193 (1960).

Bradykinin-releasing Factor from *Bothrops jararaca* venom

IT was first shown by Rocha e Silva, Beraldo and Rosenfeld[1] that the venom of the snake *Bothrops jararaca* contains a bradykinin-releasing substance. Holtz and Raudonat[2] verified that the bradykinin-releasing substance is precipitated with ammonium sulphate at the level of 60 per cent, is independent of the proteolytic activity on hæmoglobin and accompanies the coagulating activity. Hamberg and Rocha e Silva[3] observed that the bradykinin-releasing factor is heat-resistant and that the decrease of its activity in presence of prolonged heating is parallel to that of the coagulating activity and to the fall of esterase activity on L-benzoylarginine methyl ester.

Table 1

Fraction	Coagulating specific activity†	L-Benzoyl-argine amidase specific activity†	µgm. bradykinin* released per 100 µgm. protein
1	143	1,196	40
2	609	65	70

* Standard preparation of bradykinin (3 units/mgm.).
† As described by Henriques, Fichman and Henriques (ref. 6).

Recently, Contzen, Holtz and Raudonat[4] found that the bradykinin-releasing substance is dialysable and ultra-filtrable, being independent of the coagulating factor but being accompanied by the hydrolysing activity on L-benzoyl-arginine methyl ester.

In the experiments reported here we have attempted to discover if the bradykinin-releasing activity is connected to the coagulating or to the L-benzoyl-arginine amidase activity of the venom and also to purify the bradykinin-releasing substance. In a first experiment a purified enzyme obtained from the venom of *Bothrops jararaca*, the *Bothrops* protease *A* (ref. 5), which is highly active on L-benzoyl-arginine amide, and a partially purified preparation of the coagulating factor, obtained by precipitation with ammonium sulphate[6], were studied. Table 1 shows that the bradykinin-releasing factor is independent of *Bothrops* protease *A*, its activity being higher in the fraction that has the strongest coagulating activity. In fact fraction 1, which is about 18 times as active as fraction 2 in its hydrolysing activity on L-benzoyl-arginine amide, liberated less bradykinin than fraction 2. On the other hand fraction 2, which is about four times as active as fraction 1 in its coagulating activity, is about twice as active as fraction 1 in its bradykinin-liberating activity. In another experiment a more active preparation of coagulating factor obtained by ammonium sulphate precipitation followed by electrophoresis on a starch column[6] was found to be less active as a releaser of bradykinin than the crude venom used for the same preparation. It can be seen (Table 2) that the coagulating specific activities found were 357 and 1,000 respectively for the crude venom and the purified preparation, while the crude venom liberated 100 µgm. of bradykinin and the preparation 50 µgm. of bradykinin per 100 µgm. of protein. It was therefore concluded that the bradykinin-releasing activity is independent of the *Bothrops* protease *A* and coagulating activities of the venom. This does not exclude, however, the possibility that the bradykinin-releasing substance has some amidase or esterase activity, but if so it must be certainly weaker than that of *Bothrops* protease *A*.

Table 2

Fraction	Coagulating specific activity	µgm. bradykinin released per 100 µgm. protein
Crude venom	357	100
Coagulating	1,000	50

Table 3

Fraction	Percentage of saturation with ammonium sulphate	Amidase specific activity	µgm. bradykinin released per 100 µgm. protein
1	Crude venom	27	30
2	0·45	5	—
3	0·55	9	—
4	0·60	24	—
5	0·70	72	90
6	0·80	208	240
7	1·0	35	15

Table 3 shows the experiment in which attempts were made to purify the bradykinin-releasing factor. The preparation was made by heating the venom and fractionally precipitating the supernatant with ammonium sulphate as previously described for *Bothrops* protease *A* (ref. 5). All the fractions were dialysed against saline for 48 hr. and then tested for its bradykinin-releasing activity. The fraction precipitated at the level of 0·70–0·80 saturation with ammonium sulphate contained the peak of the activity, being eight times as active as the crude venom used for the preparation, that is, 100 µgm. of protein of crude venom liberated 30 µgm. of bradykinin while the same amount of protein from the fraction liberated 240 µgm. of bradykinin. The peak of activity of the bradykinin-liberating substance coincides with the peak of activity of *Bothrops* protease *A*, but as was shown above, the two activities are independent. Also in our conditions the bradykinin-releasing factor was not dialysable as observed by Contzen, Holtz and Raudonat[4].

OLGA B. HENRIQUES
MINA FICHMAN

Laboratory of Biochemistry,
Instituto Butantan,
C.P. 65, São Paulo.

W. T. BERALDO*

Department of Physiology,
Faculdade de Medicina da U.S.P.,
São Paulo. Feb. 5.

* Present address: Faculdade de Medicina da U.M.G., Belo Horizonte, Minas Gerais.

[1] Rocha e Silva, M., Beraldo, W. T., and Rosenfeld, G., *Amer. J. Physiol.*, 156, 261 (1949).
[2] Holtz, P., and Raudonat, H. W., *Arch. Exp. Pathol. Pharmakol.*, [illegible], 113 (1956).
[3] Hamberg, U., and Rocha e Silva, M., *Experientia*, 13, 489 (1957).
[4] Contzen, C. H., Holtz, P., and Raudonat, H. W., *Naturwiss.*, 46, 402 (1959).
[5] Henriques, O. B., Lavras, A. A. C., Fichman, M., Mandelbaum, F. R., and Henriques, S. B., *Biochem. J.*, 68, 597 (1958).
[6] Henriques, O. B., Fichman, M., and Henriques, S. B., *Biochem. J.* (in the press).

Anti-Pneumococcus Type XIV Activity of Precipitins from *Ricinus communis* Seeds

A CHEMICAL structure closely similar to type XIV pneumococcus polysaccharide is probably the basic substrate used in the formation of the human A, B, H and Le^a blood group specific substances[1]. Studies of the precipitation of the various blood group specific substances and related materials by *Ricinus communis* seed extract suggest that the activity of the *Ricinus* precipitin is directed towards the basic chemical framework of the human blood group substances[2–4]. It is thus possible that the *Ricinus* precipitin is actually specific for type XIV pneumococcus polysaccharide. The following experiments were carried out to investigate this possibility.

Purified pneumococcal polysaccharides of type II, VIII, IX, XII, XIV and XVII were made up as 1/1,000 (w/v) aqueous solutions and tested by the conventional precipitation technique against *Ricinus communis* seed extract prepared by the method of Boyd and Reguera[5], clarified by filtration through Whatman No. 42 filter paper and sterilized by Seitz filtration. Only type XIV polysaccharide was precipitated (Table 1).

Table 1. PRECIPITATION OF PNEUMOCOCCAL POLYSACCHARIDES BY *Ricinus communis* EXTRACT

Polysaccharide	Dilution			Controls
	1/1,000	1/10,000	1/100,000	
Type II	0	0	0	0
VIII	0	0	0	
IX	0	0	0	
XII	0	0	0	
XIV	3	1	tr	
XVII	0	0	0	

3, 1, denote degrees of precipitation ; tr, trace ; 0, no precipitate ; controls, extract + saline, polysaccharide + saline.

The type XIV polysaccharide was allowed to diffuse in an Ouchterlony agar-gel plate[6] against *Ricinus* extract and horse anti-XIV serum. The precipitins present in the extract and in the serum gave a "reaction of identity"[4] ; this means that the *Ricinus* precipitin and the specific precipitin for type XIV pneumococcus precipitate the same substance.

Thus there is evidence that the activity of *Ricinus communis* precipitin is directed towards the structural configuration of the type XIV pneumococcus polysaccharide. Because it was not possible to test a complete series of more than seventy known types of pneumococcal polysaccharides, it cannot as yet be claimed that the *Ricinus communis* precipitin, in this system, is exclusively specific for type XIV ; it is anticipated, however, that this will prove to be so, and that *Ricinus communis* seed extract will specifically agglutinate suspensions of type XIV pneumococci. I intend to complete this study by testing all known serological types of pneumococcus and purified preparations of their specific polysaccharides. The difficulty in obtaining all these materials is such that the project will take much time ; it is therefore considered useful briefly to direct attention, at the present stage, to the relationship of the *Ricinus communis* precipitin to specific antibody to type XIV pneumococcus.

I am indebted to the State of New York Department of Health (Division of Laboratories and Research), Albany, New York, for the pneumococcal polysaccharides and horse anti-XIV serum.

G. W. G. BIRD

Armed Forces Medical College,
Poona.

[1] Watkins, W. M., and Morgan, W. T. J., *Vox Sang.*, 4, N.S., 97 (1959).
[2] Bird, G. W. G., Ph.D. thesis, University of London (1958).
[3] Bird, G. W. G., *Brit. Med. Bull.*, 15, 165 (1959).
[4] Bird, G. W. G., *Vox Sang.*, 4, N.S., 313 (1959).
[5] Boyd, W. C., and Reguera, R. M., *J. Immunol.*, 62, 333 (1949).
[6] Ouchterlony, O., *Acta Path. Microbiol. Scand.*, 32, 231 (1953).

Enzymatic Synthesis of Formylglutamic Acid by a Plant Protein

SILVERMAN *et al.*[1], working with refined enzyme systems from hog liver, found indications that folinic acid functions directly only in the formylation of glutamate, with N-formylglutamic acid and tetrahydrofolic acid as the products. This communication reports the occurrence of a similar transformation in cell-free systems prepared from plant tissues.

Enzymatically active protein was obtained from mustard leaves. 2·5 kgm. of plant tissue were homogenized in an ice-cold solution of acetone and phosphate buffer *p*H 7·2 (v/v) in a Waring blendor. The solids were collected by filtration. Acetone was removed under vacuum and the residue extracted with 500 ml. of 0·02 *M* phosphate buffer *p*H 7·2. The precipitate which formed during the reduction of the volume to 250 ml. by pervaporation was removed by centrifugation and discarded. 7 gm. of ammonium sulphate were added per 100 ml. of the cell-free suspension (10 per cent of saturation at 0° C.). The precipitate was discarded. The supernatant received 14 gm. ammonium sulphate per 100 ml. (20 per cent of saturation). This precipitate was also discarded. The precipitate resulting from the treatment with 21 gm. ammonium sulphate per 100 ml. solution (30 per cent of saturation) was retained as the crude enzyme preparation. This crude product was suspended in water and dialysed for 24 hr. against 20 vol. 0·02 *M* phosphate buffer at *p*H 7·2.

Each biosynthesis medium contained 3·4 mgm. of the refined protein fraction ; 0·2 μmole each of synthetic folinic acid, adenosine triphosphate, magnesium chloride, triphosphopyridine nucleotide, and a potential formyl group acceptor in buffer to a total volume of 3 ml. In addition to glutamic acid, glycine was used for comparison purposes. After incubation at 30° C. for 4 hr., 1 ml. was withdrawn and added to 1 ml. of 4 per cent perchloric acid. The resulting precipitate was removed and the supernatant was allowed to stand at room temperature for 30 min. to allow conversion of unused folinic acid to anhydrofolinic. The latter was determined spectrophotometrically at 360 mμ. The amount of folinic acid utilized was calculated by taking the difference in absorption between biosynthesis and a control containing denatured protein. This difference was referred to a standard curve prepared with synthetic folinic acid, since the optical density of anhydrofolinic at 360 mμ was found to be a linear function of folinic acid concentration. The results are presented in Table 1.

Table 1. TRANSFORMYLASE ACTIVITY OF A PLANT PROTEIN FRACTION IN PRESENCE OF SYNTHETIC FOLINIC ACID
(3·4 mgm. protein and 0·2 μmole folinic acid in 3 ml. biosynthesis medium*)

Tests	Acceptors	
	Glycine 20 μ*M*	Glutamate 4·0 μ*M*
Folinic acid transformed (μgm.)	1·5	7·8
Chromotropic acid :		
Biosynthesis	−	+
Control	−	−
Ninhydrin :		
Before hydrolysis—		
Biosynthesis	+	−
Control	+	+
After hydrolysis—		
Biosynthesis	+	+
Control	+	+

* For composition see text.

Separation of the biosynthesis product from the mixture containing glutamate by existing methods resulted in the isolation of a compound which was bound by chromotropic acid, under testing conditions similar to those described by Frisell *et al.*[2], and which reacted negatively with ninhydrin. After mild acid hydrolysis, the product was ninhydrin positive and formed a benzoyl derivative which melted at 135–137° C. (lit. for glutamic acid, 138° C.). Comparison indicated that the biosynthesized product was identical with a synthetic sample of formylglutamic acid. Glycine treated similarly did not become ninhydrin-negative and the product was not bound by chromotropic acid. However, the amount of unreacted folinic acid in each case diminished, indicating deformylation activity. These reactions were reversible in the absence of potential formyl group acceptors and in the presence of formaldehyde and tetrahydrofolic acid. Results obtained by separate experiments show that glycine is converted into serine by this protein fraction in the presence of synthetic folinic acid. This is in substantial agreement with Wilkinson and Davies[3], who reported that tetrahydrofolic acid appears to be a requirement for serine-glycine interconversion in plant tissues. Thus, at least two types of formylation activity are demonstrated by these results; one in which the amino-group of glutamic acid is acceptor and the other in which the 2-C of glycine is acceptor.

Further purification of the protein fraction should make it possible to obtain more information about the specificities of the transformylases occurring in plant tissues, and thus permit a more detailed study of the possible role of formylglutamic in C-1 metabolism.

This work was supported in part by a National Institutes of Health Grant No. C-1552.

ERNEST H. BYERS, JUN.
T. J. BOND

Department of Chemistry,
Baylor University,
Waco, Texas.

[1] Silverman, Milton, Keresztesy, J. C., Koval, G. J., and Gardiner, R. C., *J. Biol. Chem.*, 226, 83 (1957).

[2] Frisell, W. R., Lloyd, A. M., and MacKenzie, G. C., *J. Biol. Chem.*, 207, 709 (1954).

Wilkinson, A. P., and Davies, D. D., *Nature*, 181, 1070 (1958).

Crystallization of a Photosynthetic Reductase from a Green Plant

WE would like to describe a method for crystallizing the protein now known as photosynthetic triphosphopyridine nucleotide reductase[1], formerly known as the methaemoglobin reducing factor for chloroplasts[2].

The reductase was prepared from frozen parsley (*Petroselenium sativum*) leaflets in May, following the procedure of San Pietro up to the preparation of an extract from the acetone precipitate. 4 kgm. parsley were used. After removing suspended matter the clear fluid, pH 8 in 0·005 *M tris* buffer, was chromatographed on a column of Whatman anion exchanger powder *DE* 50, 3·3 cm. diam. × 6·5 cm. This gave a narrow brown band at the top of the column, while yellow colour passed through. The column was washed with *tris* buffer (0·05 *M*, pH 8), followed by 0·2 *M* sodium acetate buffer, pH 5·5, until the washings were colourless and free from protein. The brown protein was then completely eluted with *M* acetate buffer, pH 5·5, giving 100 ml. of coloured solution. This was dialysed against 0·005 *M tris* buffer, pH 8, at 0° C. with stirring for 2 hr. and the 180 ml. solution passed through a second *DE* 50 column, 1 cm. × 3 cm. The column was washed with 0·05 *M tris* buffer, pH 8, followed in turn by 0·2 *M*, 0·5 *M* and 0·8 *M* acetate buffers, all at pH 5·5. The brown protein then occupied nearly all the column. Elution was carried out as before with *M* acetate buffer pH 5·5, giving 13 ml. of dark red-brown solution. This was then dialysed against half-saturated ammonium sulphate solution buffered with 100 ml. 0·33 *M* phosphate buffer at pH 6·7 (2 litres total volume) overnight at 0° C. The more concentrated solution, now 5·5 ml., was clarified in a centrifuge. The clear fluid was then treated with 0·15 ml. 5 per cent v/v acetic acid, when a faint turbidity appeared. After standing at 0° C. for 10 min. a precipitate was formed, consisting of minute spherical hedgehog crystal aggregates which later could be spun down in the centrifuge to a volume of about 0·5 ml. The crystal pellet was dark pinkish-brown and the liquid nearly colourless. Examination of the freshly formed crystal mass showed the crystals to be coloured, with virtually no accompanying insoluble material. This preparation was not suitable for photography as the crystals radiated in three dimensions. Crystals were therefore allowed to form on a slide under a cover glass, giving flat rosettes otherwise identical in appearance with those formed in the bulk of the solution. The crystals appeared to be plate-like as in Fig. 1*a* and more or less elongated as in Fig. 1*b*. The crystallization was repeated by dissolving the first pellet in 0·8 ml. disodium phosphate (0·05 *M*). 1 ml. saturated ammonium sulphate solution was then added and the solution spun. A small, pale precipitate was rejected. 5 per cent acetic acid was added as before to the clear fluid. Now the rosettes were mainly replaced by free crystal forms; minute elongated plates (10μ), thin plates and fine needles up to 150μ long were observed.

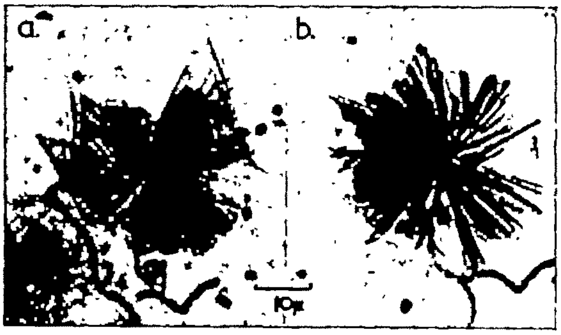


Fig. 1

This protein may be said to occupy a key position in the observed reducing properties of illuminated chloroplasts[3].

This investigation forms part of a programme of work supported by the Agricultural Research Council. We are very grateful to Prof. J. D. Boyd and to Mr. J. A. F. Fozzard for the microphotographs.

R. HILL
FAY BENDALL

Department of Biochemistry,
University of Cambridge.

[1] San Pietro, A., and Lang, H. M., *J. Biol. Chem.*, 231, 211 (1958).

[2] Davenport, H. E., Hill, R., and Whatley, F. R., *Proc. Roy. Soc.*, B, 139, 346 (1952). Davenport, H. E., *Biochem. J.*, 73, 45 *P* (1959). Davenport, H. E., and Hill, R., *ibid.*, 74, 493 (1960).

[3] Hill, R., Symp. Soc. Exp. Biol., 5, 222 (1951).

PHYSIOLOGY

Differential Reactivity of Saliva from 'Tasters' and 'Non-Tasters' of 6-*n*-Propylthiouracil

IN a previous publication[1] a difference in reactivity between the saliva of 'tasters' and 'non-tasters' towards 6-*n*-propylthiouracil was reported. This communication attempts further to describe the above phenomenon and to relate the data thus obtained to the mechanism of taste in general and to taste-blindness in particular.

A 20-min. sample of mixed morning saliva stimulated by rubber band was centrifuged at +4° C. for

Table 1

No.	Compound	'Δ optical density 8-min' effect at λ_{max}	Δ optical density at molecular concentration of compound	Taste blind differentiator	Taste quality at $1 \cdot 5 \times 10^{-3}$ M concentration	Antithyroid activity
1	6-*n*-Propylthiouracil	+	$3 \cdot 75 \times 10^{-4}$	+	bitter	+
2	2-Mercapto-imidazole	+	$3 \cdot 75 \times 10^{-4}$	+	bitter	+
3	1-Methyl-2-mercapto-imidazole	+	$3 \cdot 75 \times 10^{-4}$	+	bitter	+
4	2-Mercapto-5-carbomethoxy imidazole	—	$3 \cdot 75 \times 10^{-4}$	—	bitter	—
5	2-Mercapto-4 (or 5)-imidazole carboxylic acid	+	$3 \cdot 75 \times 10^{-4}$	—	sour	—
6	1-Methyl-2-mercapto-5-imidazole carboxylic acid	+	$3 \cdot 75 \times 10^{-4}$	—	bitter	—
7	Creatinine	—	$1 \cdot 5 \times 10^{-1}$	—	bitter*	+
8	Imidazole	—	$6 \cdot 0 \times 10^{-4}$	—	bitter	?
9	Quinine	—	$1 \cdot 5 \times 10^{-4}$	—	bitter	—

* Bitter taste quality only from 16–32-fold or higher concentration.

30 min. at 3,000 r.p.m. The supernatant was re-centrifuged and 1-ml. portions of it were diluted 1 : 5 with *tris* buffer to *p*H 7·36 at 23° C. and supplemented with 6-*n*-propylthiouracil; final concentration of *tris* and 6-*n*-propylthiouracil are 0·05 M and $3 \cdot 75 \times 10^{-4}$ M. Later, the rate of reaction in a sample was followed in a Perkin-Elmer 'Spectracord 4000-*A*' spectrophotometer at 17°, 27° and 37° C. in the ultra-violet range. The decrease in optical density was read at the λ (maximum) between 276 and 284 mμ in 8 min. This decrease, which is not photosensitive, indicates a significantly faster rate of reaction for extreme 'non-tasters' than for 'tasters' (Fig. 1).

The 'Δ optical density 8-minute' effect can be simulated in the absence of saliva by the action of hydrogen peroxide on 6-*n*-propylthiouracil. The decrease in optical density thus produced, however, increases with increasing temperature, which effect is the converse of that obtained with saliva.

The *p*H dependence of the reactivity ('Δ optical density 8-minute' effect) of saliva with 6-*n*-propylthiouracil is depicted in Fig. 2.

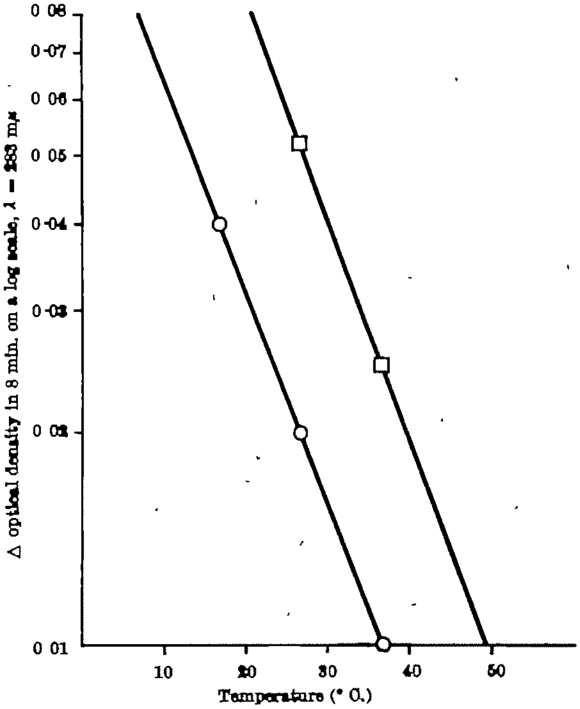


Fig. 1. Temperature dependence of the differential reactivity ('Δ optical density 8-min.' effect) of the saliva of a typical 'taster' and typical 'extreme non-taster' toward 6-*n*-propylthiouracil from a population of 32 subjects. ○ and □ represent results obtained from salivas of donors with taste-thresholds of $4 \cdot 7 \times 10^{-6}$ M and $6 \cdot 0 \times 10^{-3}$ M 6-*n*-propylthiouracil respectively

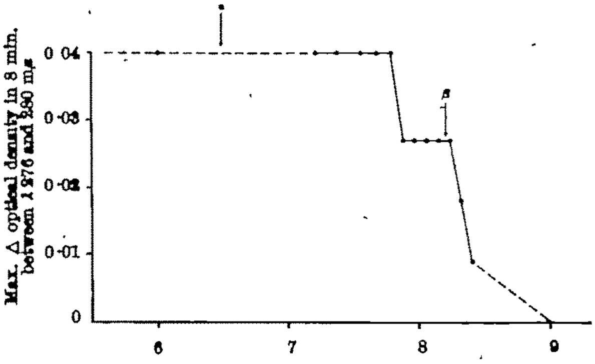


Fig. 2. *p*H dependence of the reactivity of a typical 'taster's' saliva with 6-*n*-propylthiouracil at 17° C. *Tris* buffer from *p*H 7·2–9; cacodylate buffer below *p*H 7·2

The sites α and β on the slopes of the curve approximate the *pK*(OH) values of the mono- and diiodo-derivatives of L-tyrosine. These thyroxine precursors, in fact, do lower at least 4–8- or even 32-fold the taste threshold of a subject towards 6-*n*-propylthiouracil if administered simultaneously. Specifically, 3×10^{-3} M 3-monoiodotyrosine and $7 \cdot 5 \times 10^{-4}$ M tyrosine or 3,5-diiodotyrosine have been used as solvents as well as placebos in the Harris and Kalmus[8] procedure. The actual originally defined 6-*n*-propylthiouracil threshold of the subject was a determining factor of the ability of monoiodotyrosine and/or diiodotyrosine to increase taste acuity towards 6-*n*-propylthiouracil. (The original 6-*n*-propylthiouracil threshold can also be altered by simply raising the temperature of the solution of the substance to 40° C.) Taste acuity of tasters with a $3 \cdot 75 \times 10^{-4}$ M 6-*n*-propylthiouracil threshold was increased with any of the three thyroxine precursors.

A similar increase in taste acuity towards quinine was produced under identical conditions. Only diiodotyrosine was capable of lowering thresholds of $1 \cdot 5 \times 10^{-3}$ M concentration of 6-*n*-propylthiouracil. None of the precursors was effective at threshold $6 \cdot 0 \times 10^{-3}$ M of 6-*n*-propylthiouracil, that of 'extreme non-tasters'.

Among the bitter-tasting anti-thyroid compounds which contain the thiocarbamide grouping, taste-blind differentiators other than 6-*n*-propylthiouracil also exhibit the 'Δ optical density 8-minute' effect. This effect alone, however, does not convey the quality of a taste-blind differentiator to a compound of the thiocarbamide type. Compounds No. 5 and 6 in Table 1 exemplify our contention. Another more tentative conclusion can be drawn from Fig. 1 in the light of additional (unpublished) results: anti-thyroid compounds of the thiocarbamide type with no taste-blind differentiating quality, such as creatinine (synthesized via creatine (*Org. Synthesis*, 4, 15; 1925); such a creatinine is free of picric acid, which is present in commercially available preparations. No. 7 in Table 1), an isosterically substituted thiocarbamide, are likely to produce their anti-thyroid activity[2] through another mechanism than that characteristic for compounds No. 1, 2 and 3.

Biochemical, genetic, pathophysiological and psychological aspects of the part played by thyroxine and its precursors in the mechanism of taste and 'taste-blindness' are under study and will be published elsewhere.

This work was carried out with the technical assistance of Edwin L. Mead. The active interest and helpful suggestions of Drs. B. Pasamanick and F. A. Kruger, Columbus, and M. D. Armstrong, Yellow Springs, are thankfully acknowledged. Our special thanks are due to Dr. S. Dinitz, Columbus, the first subject whose saliva elicited the 'Δ optical density 8-minute' effect, and to Drs. E. C. Kornfeld, R. G. Jones and W. R. Kirtley, from the Eli Lilly and Co., Indianapolis, who courteously supplied us with the imidazole derivatives.

The work was supported by the State of Ohio Department of Mental Hygiene and the U.S. Public Health Service, National Institutes of Health, Division of Mental Health, Grant No. *M*–2731.

FRANCES GRIFFIN
ROLAND FISCHER

Research Division,
Columbus Psychiatric Institute
and Hospital, and
Department of Physiological Chemistry,
Ohio State University College of Medicine,
Columbus 10, Ohio. March 17.

---

[1] Fischer, R., and Griffin, F., *Experientia*, 15, 447 (1959).

[2] Pataki, L., Pfeiffer, A. K., and Borsi, J., *Acta Physiol. Acad. Sci. Hung.*, 2, 199 (1951).

[3] Harris, H., and Kalmus, H., *Ann. Eugen.* (London), 15, 24 (1949).

Flight by Man-Power

BEING interested in the possibility of flight by man-power, we have read Dr. D. R. Wilkie's communication[1] on the "Work Output of Animals: Flight by Birds and by Man-power".

We agree[2] that for mechanical similarity the power requirement is a function of $(\text{weight})^{1\cdot167}$. Moreover, for flying insects and birds[3] we obtained from Pütter's data a different exponent for this statistical relationship, namely $(\text{weight})^{0\cdot667}$. It is interesting to note that according to the theory of biological similarity[2], the limits for these exponents of body-weight are 1·167 for mechanical similarity, and 0·667 for the electrodynamical similarity, whereas for biological similarities, power is a statistical function of $(\text{weight})^{0\cdot73}$.

Thus, in accordance with the principle of mechanical similarity the power requirement for a flying machine is proportional to $(\text{weight})^{1\cdot167}$; the same relationship was obtained by Nonweiler (quoted in Dr. Wilkie's paper) based on purely aerodynamic considerations. This equivalent conclusion provides evidence that the power necessary to initiate flight exclusively by muscular effort, without additional external forces (potential energy, wind velocity, etc.), is a function of $(\text{weight})^{1\cdot167}$. The slope of this theoretical relationship (line *E* of Fig. 1 in Dr. Wilkie's paper) intersects line *C* of the same graph, which represents the steady-state maximal effort that man is able to perform in oxygen balance for at least 5–30 min.

The theory of biological similarities[2] states that all power functions of living beings are related to $(\text{weight})^{0\cdot73}$, and since it was found[3] that flying insects and birds have mean power requirements which are a statistical function of $(\text{weight})^{0\cdot667}$, we presume that this represents the optimal conditions of natural flight which man should try to achieve during artificial flight.

Furthermore, from the experimental data of Bjerknes and of Müllenhoff, we have calculated[3], by extrapolation from the regression equation based on data for a weight range from the fly to the stork, that a man-powered flying machine (70 kgm. man and 30 kgm. flight-accessories) should have approximately the following characteristics for slow flapping flight: (*a*) flight surface, 6 m.^{2}; (*b*) pressure, 16·8 kgm./m.^{2}; (*c*) speed, 18·2 m./sec.; (*d*) power, 6 kgm.-m./sec.; (*e*) force of the wing-beat, 19·3 kgm.-weight; (*f*) speed of the wing tip, 5·8 m./sec.; (*g*) length of the wing, 3·15 m.; (*h*) wing-beats per second, 0·592/sec.

Another aspect of the same problem is related to the different density of birds and men. In order to have similar flight conditions, it might be wise to construct a man-powered flying machine of approximately the same density of those of insects and birds, so that the aerodynamics of the whole machinery should be similar to the natural models. The transfer of muscular power to the wings and the sensory information of the actual flight conditions must be based on the flight-physiology of insects and birds, since the reflex regulation of flight is of paramount importance.

We agree with Dr. Wilkie in the sense that man-powered flight is possible and should be tested experimentally, because new hypotheses and materials (both metals and plastics) are available which can be used to solve some of the engineering problems involved.

E. GUERRA
B. GÜNTHER

Departamento de Ciencias,
Universidad de Chile,
Casilla 130-V,
Valparaíso, Chile.

---

[1] *Nature*, 183, 1515 (1959).

[2] Guerra, E., and Günther, B., *Acta Physiologica Latinoamericana*, 5, 169 (1955).

[3] Günther, B., and Guerra, E., *Acta Physiologica Latinoamericana*, 7, 95 (1957).

Effect of Nitrate Ion on the Distribution of Sucrose in the Rat's Ventricle

CURRENT work in this laboratory shows that the exposure of driven rat ventricle strips to Locke's solutions, in which all the chloride has been substituted by nitrate, results in an increase of the total sodium in the tissue. In order to determine how this increase was partitioned between the extracellular and the intracellular compartments we attempted to measure the extracellular space by the distribution of sucrose. The results presented below show that this cannot be done in the case of nitrate, and reveal an interesting feature of the action of this anion, which may be that of increasing the permeability of cardiac tissue to a molecular species not ordinarily considered as being able to traverse the cell membrane.

Table 1. WATER CONTENT AND SUCROSE SPACE IN DRIVEN VENTRICLE STRIPS

Perfusion time	Total water content (percentage of wet weight)		Sucrose space (percentage of wet weight)		Sucrose space (percentage of total water)	
	Cl	NO_3	Cl	NO_3	Cl	NO_3
5 min.	(10) 75·56	(7) 77·41	22·23	34·18	29·43	44·14
15 ,,	(10) 75·71	(5) 77·54	27·44	40·03	36·23	51·62
30 ,,	(12) 75·63	(8) 77·18	28·69	48·51	37·91	63·08
1 hr.	(12) 75·31	(6) 77·90	30·88	49·96	41·08	64·11
3 ,,	(4) 75·88	(5) 77·84	34·90	71·12	46·01	91·42
5 ,,	(4) 75·90	(5) 78·25	53·60	76·53	70·61	97·80
7 ,,	(5) 75·42	—	62·14	—	82·38	—
9 ,,	(3) 75·50	—	63·04	—	83·50	—

The preparation of the tissue[1], the composition of the anionically substituted Locke's solution[2], and the experimental procedure[3,4] have all been described previously. In the present experiments the electrically driven ventricle strips were maintained at 37° C. in either chloride- or nitrate-reference solutions for periods up to 9 hr. in the former case and 5 hr. in the latter. Both types of solution contained sucrose in a concentration of 600 mgm./100 ml. The ventricle strips were removed from the muscle baths at the time intervals indicated in Table 1, dried and analysed for sucrose by the method of Ross and Mokotoff[5]. Since nitrate was found to interfere with the colorimetric determination of sucrose it was necessary to eliminate this anion by passing the solution through an anion exchange resin, 'Duolite *A*-101*D*'. Both wet and dry weights were recorded to determine water content.

The results presented in Table 1 show a small but significant increase in the wet weights of the nitrate-treated muscles, amounting to about 2 per cent above those of the chloride controls. Fig. 1 shows the time-course of sucrose distribution in the two classes of muscle. It is evident from Fig. 1 that the time-course of sucrose distribution can be separated, as has been done by Creese[6], into several kinetic components: an early linear phase, 1, an early exponential phase, 2, and a late exponential phase, 3. It is risky, of course, to reify kinetics into anatomical compartments, but it is significant that the early exponential phase becomes asymptotic to a line parallel to the *X*-axis which cuts the *Y*-axis at roughly the value of the extracellular phase[7,8] in the case of chloride. On that basis, the delayed exponential phase may represent either the rate of adsorption of sucrose by some structural barrier or, more probably, its slow penetration into the cell, which can be shown by extrapolation to begin very early in the process of sucrose uptake by the muscle. Treating all the phases, on a first approximation, by means of first-order kinetics, the following values were obtained for the three velocity constants:

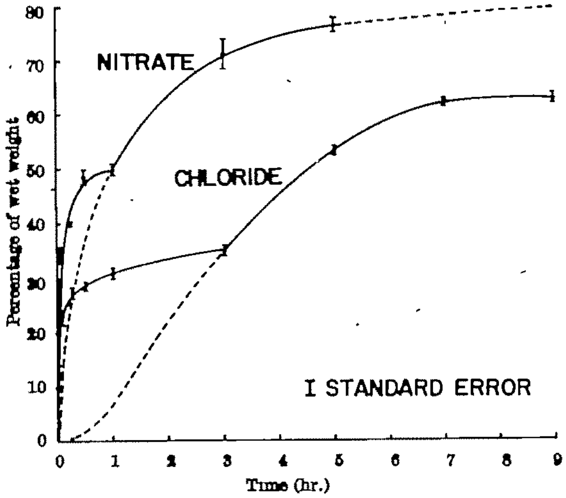


Fig. 1. Effects of NO_3^- and Cl^- on the time-course of sucrose distribution in the driven ventricle

	k_1/min.	k_2/min.	k_3/min.
Cl	0·245	0·0268	0·0046
NO_3	0·662	0·0643	0·0118
NO_3/Cl	2·70	2·25	2·56

Not only is the velocity of the several processes greater in nitrate than in chloride but, in addition, the apparent volume of distribution of sucrose is also increased by this anion, becoming commensurate with that of total tissue water in about 5 hr.

This work was carried out under contract 225(22) between the Office of Naval Research and Stanford University.

S. T. TAKETA
C. G. ALEXANDER
G. A. FEIGEN

Department of Physiology,
Stanford University School of Medicine,
Stanford, California.

---

[1] Feigen, G. A., Masuoka, D. T., Thienes, C. H., Saunders, P. R., and Sutherland, G. B., *Stanford Med. Bull.*, 10, 27 (1952).

[2] Feigen, G. A., Devor, D., and Thomson, C., *Nature*, 173, 638 (1954).

[3] Feigen, G. A., Sutherland, G. B., and Macpherson, C. H., *Stanford Med. Bull.*, 10, 89 (1952).

[4] Feigen, G. A., Devor, D., and Taketa, S. T., *Science*, 128, 1436 (1958).

[5] Ross, G., and Mokotoff, R., *J. Biol. Chem.*, 190, 659 (1951).

[6] Creese, R., *Proc. Roy. Soc.*, B, 142, 497 (1954).

[7] Barclay, J. A., Hamley, H. J., and Houghton, H., *J. Physiol.*, 149, 15 P (1959).

[8] Hercus, V. M., McDowall, R. J. S., and Mendel, D., *J. Physiol.*, 129, 177 (1955).

An Unidentified Pharmacologically Active Substance extracted from Cerebral Hemispheres

WHILE estimating the 5-hydroxytryptamine content of rat brain, it was observed that the acetone extract stimulated the isolated rat uterus even in the presence of atropine and 2-bromo-lysergic acid diethylamide (*BOL*–148, 10^{-7} gm./ml.). Different parts of the rat brain were then separately extracted and examined, and by far the largest proportion of the active material was found in the cerebral hemispheres. Similar results were obtained when extracts of different areas of other mammalian brains were tested. A study was therefore made of the properties of this smooth-muscle-stimulating substance present in extracts of cerebral hemispheres of mammals.

Smooth-muscle-stimulating substance stimulates the isolated atropinized rat uterus after a latent period of about 45 sec. and continues to increase its tone over the next 5 min. The threshold dose for this effect is, in terms of fresh cerebral hemisphere, about 50 mgm. for the rat and rabbit and about 100 mgm. for the dog. In slightly higher doses, smooth-muscle-stimulating substance also stimulates the isolated atropinized rat fundus, rat colon and rat duodenum. It produces a contraction of the isolated guinea pig ileum in the presence of atropine, mepyramine and *BOL*–148, but the most sensitive preparation used so far is the rabbit duodenum, which is stimulated by an extract of only 20 mgm. of the rat, rabbit or dog cerebral hemisphere. On the blood pressure of the cat or rabbit, smooth-muscle-stimulating substance exerts a depressor response both before and after atropine and mepyramine, yet it is pressor on the blood pressure of the rat. On cardiac and skeletal muscle, it is relatively inactive.

The active material is extracted from cerebral hemispheres with different concentrations of acetone (1–20 vol.) and with trichloracetic acid (2 vol. of 10 per cent) but not with saline containing 0·1 *N* hydrochloric acid. Extracts prepared in this way retain activity for more than 1 month if maintained at 0° C. at neutral or acid *p*H values ; but the activity slowly disappears when the extract is kept at *p*H 11. Smooth-muscle-stimulating substance is not inactivated by incubation with trypsin or chymotrypsin. On paper chromatograms, the active material has an R_F value of 0·60 in a sodium chloride solvent (8 per cent w/v), but it does not move from the origin in solvents of butanol–acetic acid, *iso*propanol–ammonia, or aqueous methanol (60 per cent v/v). With potassium iodate, ninhydrin reagent, Pauly's reagent, Folin–Ciocalteau's phenol reagent, or Ehrlich's reagent, the active material gives no colour reactions characteristic of catechols, amines, amino-acids, compounds containing hydroxyl groups, or indoles.

Thus, smooth-muscle-stimulating substance differs from histamine (which is inactive on the rat uterus), 5-hydroxytryptamine (actions blocked by *BOL*–148), acetylcholine (blocked by atropine), bradykinin (insoluble in acetone)[1], substance *P* (inactivated by chymotrypsin)[2], irin (inactive on rat uterus)[3], γ-aminobutyric acid (inactive on rabbit duodenum)[4], γ-aminobutyryl choline (blocked by atropine)[5], nasal mucosa factor (unstable in acid)[6], and cerebellar factor (which is insoluble in acetone)[7]. It is unlikely to be a polypeptide.

P. F. L. ANDREWS
SHIRLEY A. P. PRICE
G. B. WEST

Department of Pharmacology,
School of Pharmacy,
University of London,
29–39 Brunswick Square,
London, W.C.1. March 23.

[1] Rocha e Silva, M., Proc. Twenty-first Intern. Congr. Physiol. Sci. Symposia, 60 (1959).

[2] Amin, A. H., Crawford, T. B. B., and Gaddum, J. H., *J. Physiol.*, 126, 596 (1954).

[3] Ambache, N., *J. Physiol.*, 135, 114 (1957).

[4] Florey, E., and McLennan, H., *J. Physiol.*, 145, 66 (1959).

[5] Kuriaki, K., Yakushiji, T., Noro, T., Shimizu, T., and Saji, S. H., *Nature*, 181, 1336 (1958).

[6] Toh, C. C., and Mohiuddin, A., *Brit. J. Pharmacol.*, 13, 113 (1958).

[7] Crossland, J., *J. Pharm. Pharmacol.*, 12, 1 (1960).

Production of Muscular Weakness in Rats by a Creatine Analogue

IN an effort to clarify the role of abnormal creatine metabolism in producing muscular dystrophy a search for an antimetabolite to creatine has been made. If a specific defect in either the synthesis or utilization of creatine could be produced by an antimetabolite, it would then be possible to assess the change in muscle structure and metabolism which results from impaired creatine metabolism.

One analogue of creatine which has been tested is D,L α-guanidinopropionic acid (alacreatine)[1]. A group of 10 weanling Sprague–Dawley rats of both sexes was fed a purified diet containing 18 per cent casein, 74·4 per cent sucrose, 3 per cent hydrogenated vegetable fat, 2 per cent cod liver oil, and the usual salts and vitamins and supplemented with 2 per cent alacreatine. While receiving this diet during a 6-week period the rats gradually became quite weak in comparison with control animals receiving only the purified diet. The type of weakness seen in the rats receiving alacreatine resembled that seen in rabbits suffering from nutritional muscular dystrophy resulting from vitamin E deficiency. When placed on their side they had difficulty in righting themselves, particularly after exercise.

The finding of severe muscular weakness in animals fed an analogue of creatine strongly suggests that the analogue is a metabolic antagonist to creatine and that the weakness of muscular dystrophy is the result of the abnormal creatine metabolism of that disease. Study of the enzymes of creatine synthesis (transamidinase and guanidoacetate methylpherase) and utilization (creatine kinase) in animals given alacreatine should readily demonstrate a specific defect in creatine metabolism if one is present. This work and experiments to determine the influence of creatine feeding on the syndrome are now in progress.

This investigation was supported by research grant No. *A*-3615, National Institutes of Health.

COY D. FITCH
JAMES S. DINNING

Department of Biochemistry,
University of Arkansas,
School of Medicine,
Little Rock,
Arkansas.

[1] Bengelsdorf, I. S., *J. Amer. Chem. Soc.*, 75, 3138 (1953).

Damage to Liver induced by DL-Methionine-Ethylester

PERRI *et al.* have observed that tryptophan-methylester inhibits the growth of several bacteria[1]. Horváth *et al.* found that the adaptive enzyme product of *Penicillium chrysogenum* inhibits glycine-, *iso*leucine- and phenylalanine-methylester and supposed that the amino-acid-ester takes part in protein synthesis after the acyl-activation and with its bound carboxyl group stops peptide production[2]. According to this hypothesis the amino-group of the esterified amino-acid is more reactive than the natural one, therefore the activated amino-acid reacts mainly with the ester. Although in the above-mentioned work no completion experiments were performed, the results suggest that the amino-acid-esters behave like antimetabolites on lower organisms.

On the basis of the above we supposed that DL-methionine-ethylester is a methionine antagonist causing liver injury, which then could be inhibited by methionine administration.

Dimethionine-ethylester was synthesized by esterification of DL-methionine and of absolute ethanol in dry hydrochloric acid. The salt of the compound was isolated and recrystallized from absolute ethanol. The dimethionine-ethylester thus produced was chromatographically uniform.

Albino rats of both sexes weighing 80–90 gm. were used in the experiments. They were fed a normal diet during the experimental period and were divided in three groups. 7 rats (Group I) were given 0·34 m.mole methionine ; 16 rats (Group II) 0·24 m.mole dimethionine-ethylester and 7 rats (Group III) 0·34 m.mole methionine + 0·24 m.mole dimethionine-ethylester daily for 17 days, intraperitoneally. The dimethionine-ethylester was always administered after neutralization. Six rats from Group II died spontaneously between the fifth and the seventeenth day; in the other groups no death occurred. On the eighteenth day the rats were killed by decapitation, the liver was immediately removed, weighed and worked up histologically.

All the animals in group II had enlarged livers; in Groups I and III the livers were of normal size (Table 1).

Table 1

Group	No. of rats	Daily intraperitoneal administration in m.mole/rat	Days of administration	Liver-weights in gm./100 gm. body-weight
I	7	0·34 methionine	17	3 94 ±0·42 } t=1 06
II	16	0·24 methionine-ethylester	17	4 5 ±0 41 } P>0 2
III	7	0 34 methionine + 0 24 methionine-ethylester	17	3 62 ±0·45

Histological examination revealed that in Group II only one liver was normal; the others showed parenchymatous degeneration combined with perilobular fatty infiltration of various grades. Among the seven rats of Group III five had normal livers, and two showed mild fatty infiltration (Figs. 1, 2 and 3).

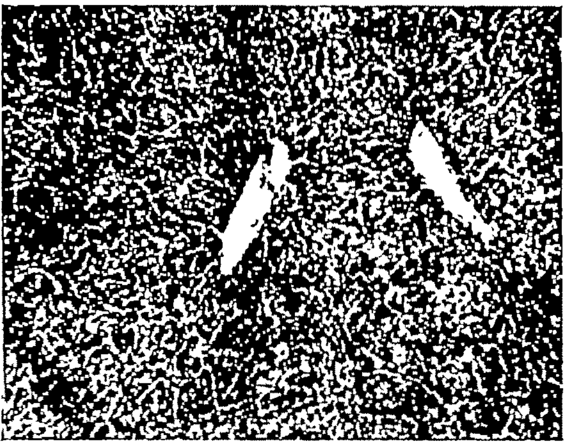


Fig. 1. Liver from group I. Normal structure. Hæmatoxylin-eosin stain. (× 200)

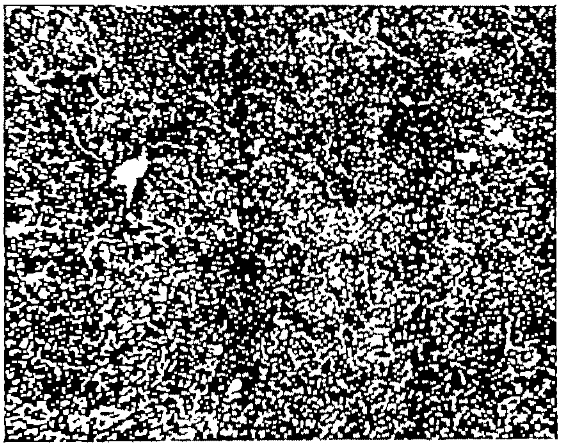


Fig. 2. Liver from group II. Parenchymatous degeneration with severe perilobular fatty infiltration. Hæmatoxylin-eosin stain. (× 200)

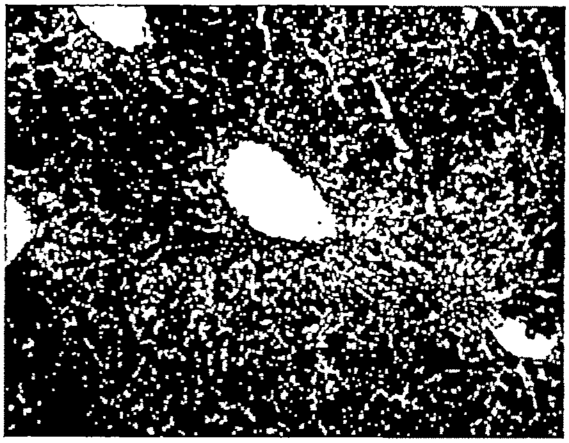


Fig. 3. Liver from group III. Mildly swollen liver baulks. Hæmatoxylin-eosin stain. (× 200)

It is therefore concluded that dimethionine-ethylester induces enlargement and pathological changes in the liver. The enlargement is presumably due to an increase in fat and water contents, while the injury itself depends on the individually different activity of the non-specific esterase. In this way various quantities of dimethionine-ethylester were destroyed, resulting in injury of varying gravity. This assumption, however, will have to be supported by further investigations.

I. Fehér
F. V. Selmeczi
K. Szalay
T. Kemény

Institute of Pathophysiology,
University Medical School,
Budapest.

---

[1] Perri, G. C., Kaplan, L., and Stock, C. C., *Nature*, 183, 116 (1959).

[2] Horváth, L., Bajusz, S., and Szentirmai, A., *Nature*, 183, 477 (1959).

Effect of Some Aromatic Hydroxy Compounds on the Phagocytic Activity of the Reticulo-Endothelial System

It has been reported previously that œstrogens stimulate the reticulo-endothelial macrophages in the spleen, liver and lymph nodes and lead to mobilization of the macrophages into the blood-stream and thus probably to an increase in the general defence of the body against infection and perhaps new growths; and that these results suggested the desirability of finding a substance which possesses a still more powerful stimulating effect on the reticulo-endothelial system without the ill effects of œstrogens[1]. Since then, the effects of various stilbenes, steroids, aliphatic hydrocarbons, antibiotics and sulphonamides on the phagocytic activity of the reticulo-endothelial system have been investigated and reported[2–4]. So far, the strongest stimulants of phagocytic activity are also strongly œstrogenic and it would appear that the configuration of the molecule which confers œstrogenic activity is also essential for reticulo-endothelial stimulation. Many other compounds are therefore being examined in the hope that the results may throw more light on the nature of the stimulative factor.

The present communication is a report on the effect of four aromatic hydroxy compounds on the phagocytic activity of the reticulo-endothelial system.

Thirty male white mice (*T.O.* Swiss strain) of 20–27 gm. body-weight were used in these experiments. Five animals were used to test each substance, each animal receiving one subcutaneous dose of 0·5 mgm. of the compound in 0·05 ml. arachis oil daily for 6 days. On the eighth day the phagocytic activity was measured by the rate of disappearance of a known amount of specially prepared carbon from the circulating blood[7], the procedure used being as follows. Each animal was given one intravenous injection of carbon of particle size 250 Å., the dose of the carbon being calculated on the basis of 16 mgm. per 100 gm. body-weight. Blood was then taken at short intervals during the first 60 min. following the injection, and the concentration of the carbon in each blood sample was measured by an absorptiometer. The logarithmic values of the absorptiometer readings lie along a straight line when plotted against time, and the slope of the line has been taken as the measure of total body phagocytic activity or the phagocytic index, which is denoted in the present communication by the symbol *K*.

Ten of the animals were used as controls and received 0·05 ml. arachis oil once daily for 6 days. The phagocytic activity was then measured on the eighth day by the carbon method referred to above. The arachis oil controls showed a phagocytic index or *K* value of 13 ± 2·4.

Table 1. EFFECT OF SOME AROMATIC HYDROXY COMPOUNDS ON THE PHAGOCYTIC ACTIVITY OF THE RETICULO-ENDOTHELIAL SYSTEM

Compound used	Phagocytic index (*K* value)
Racemic 3 : 4-di-*p*-hydroxyphenylhexan-1 : 6-diol	16 ± 1·6
meso 3 : 4-di-*p*-hydroxyphenylhexan-1 : 6-diol	17 ± 2·6
meso ββ′-di-*p*-hydroxyphenyladipic acid	18 ± 3·3
1 : 2-Di-α-naphthyl-1 : 2-dihydroxyacenaphthene	15 ± 1·8
Arachis oil controls	13 ± 2·4

The results are shown in Table 1. Compared with the control values, it can be seen that the four compounds investigated, which are similar in type, have little or no effect on the phagocytic activity of the reticulo-endothelial system.

We are indebted to Sir Charles Dodds for generously supplying these compounds. We also gratefully acknowledge assistance from the Central Research Fund of the University of London and from the Medical Research Council.

T. NICOL
C. DRUCE
C. C. WARE

Department of Anatomy,
King's College,
London, W.C.2.
March 1.

---

[1] Nicol, T., Helmy, I. D., and Abou-Elkry, A., *Brit. J. Surg.*, 40, 166 (1952).

[2] Nicol, T., Bilbey, D. L. J., and Ware, C. C., *Nature*, 181, 1538 (1958).

[3] Bilbey, D. L. J., and Nicol, T., *Nature*, 182, 674 (1958).

[4] Nicol, T., Ware, C. C., and Bilbey, D. L. J., *Nature*, 181, 1804 (1958).

[5] Sewell, I. A., and Nicol, T., *Nature*, 181, 1662 (1958).

[6] Nicol, T., and Sewell, I. A., *Nature*, 184, 1241 (1959).

[7] Biozzi, G., Benacerraf, B., and Halpern, B. N., *Brit. J. Exp. Path.*, 34, 441 (1953).

PATHOLOGY

Production of Tumours in *Rattus (Mastomys) natalensis* by Polyoma Virus

Rattus (*Mastomys*) *natalensis*, the multi-mammate mouse, is an African rodent intermediate in size between the rat and the mouse. These animals have been used in microbiological studies because they are highly susceptible to infection by plague bacilli[1], *Schistosoma mansoni*[2], and *Borrelia duttonii*[3]. They have recently been used in cancer research laboratories following Oettle's report of a high incidence of spontaneous adenocarcinoma of the stomach in a *Mastomys* colony in Johannesburg, South Africa[4]. Since the polyoma virus has been shown to produce tumours in mice, Syrian hamsters, rats and rabbits[5], we were interested in determining the response of *Mastomys* to this agent.

A small colony of *Mastomys* is now maintained by Dr. H. L. Stewart and Dr. K. C. Snell in the Laboratory of Pathology of the National Cancer Institute in Bethesda, Maryland. Four pregnant *Mastomys* were obtained from this colony.

The strain of polyoma virus used was isolated originally from a filtrate of an extract of a murine parotid gland tumour, and the details of the derivation of this strain have been reported by Dawe and his associates[6]. The virus has been serially passaged in cultures of milk-adapted murine lymphoma cells (strain *P388D1*)[7], and fifth, tenth and fourteenth tissue culture passage pools were used to inoculate the *Mastomys*. Tissue culture medium composed of 20 per cent autoclaved fatless milk and 80 per cent mixture 199 was used to inoculate control animals.

New-born *Mastomys*, less than 12 hr. old, were inoculated subcutaneously on the back with 0·05–0·10 ml. of virus pool or control tissue culture medium. The size of the litters, type of inocula and number of animals studied at autopsy are presented in Table 1. Six months after inoculation, 24 of the 30 animals that had received virus were dead; however, because of cannibalism, it was not possible to autopsy 7 of these. Tumours were found in 14 of the 17 animals that were autopsied. As shown in Table 2, 13 *Mastomys* had tumours in the kidneys, 4 had tumours in the liver, 2 had tumours in the heart and 2 had tumours in the subcutaneous tissues. None of the animals inoculated with control tissue culture medium has died 6 months after inoculation and no tumours have been observed or palpated in these animals.

The tumours of the kidneys varied on gross examination from small nodules 0·2–0·3 cm. in diameter to masses measuring 3–5 cm. in greatest dimension, and they were frequently multi-focal and bilateral. Histologically, they were composed of ovoid and elongated cells which were sometimes

Table 1. NEW-BORN *Mastomys* INOCULATED WITH POLYOMA VIRUS

Litter	No. of animals inoculated	Inoculum	Alive 6 months after inoculation	Dead: No autopsy	Dead: Autopsy
1	10	200,000 *TCD*50 of 14th *TC* passage	0	6	4
2	10	8,000 *TCD*50 of 10th *TC* passage	4	1	5
3	10	8,000,000 *TCD*50 of 5th *TC* passage	2	0	8
4	7	control fluid	7	0	0

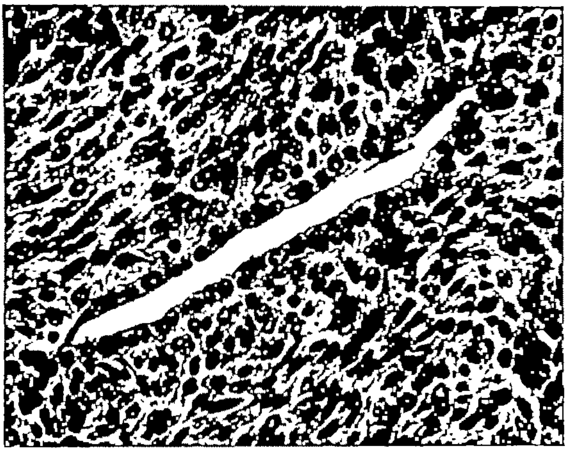


Fig. 1. Renal sarcoma in *Mastomys* inoculated with polyoma virus. A renal tubule is surrounded by tumour cells. Hæmatoxylin and eosin. (× c. 416)

arranged in interlacing bundles, and all were diagnosed as sarcomas. The nuclei of the tumour cells were pleomorphic and hyperchromatic, and frequently there was clumping of chromatin along the nuclear membranes with central clear areas in the nuclei. Similar nuclear changes have been observed in cells of the *P388D1* strain in tissue culture after infection with polyoma virus[7]. Occasionally, the tumours were very vascular and the neoplastic cells were arranged around blood vessels in a manner similar to that described in the intracranial sarcomas produced by polyoma virus in the Syrian hamster[8].

The tumours in the livers of 3 of the animals (Nos. 10, 12, 13, Table 2) were angiomatous in type and similar to those described in the livers of Syrian hamsters inoculated with polyoma virus[8]. The 3 animals with these angiomatous tumours were found dead, and at autopsy they had hæmoperitoneum associated with rupture of vessels of the hepatic tumours.

In the liver of one *Mastomys* (No. 15, Table 2), a white nodule 0·3 centimetre in diameter was noted grossly on the cut surface of the median lobe just beneath the capsule. Histologically, this was composed of irregularly shaped duct-like structures lined by columnar cells with pleomorphic hyperchromatic nuclei and amphophilic cytoplasm. The tumour was not encapsulated, and appeared to invade adjacent liver parenchyma. It was diagnosed as an adenocarcinoma, and we believe that it probably originated from bile duct epithelium, although the possibility of origin from altered hepatic cells has not been eliminated. Tumours of this type have not been described in mice, rats, hamsters or rabbits inoculated with polyoma virus. Proliferation of bile ducts, however, has been described in the livers of *Mastomys* infected with *Schistosoma mansoni*[9]. The relationship of this tumour to the inoculation of polyoma virus is therefore not clear at present.

The two heart tumours were small, each measuring approximately 0·1 cm. in greatest diameter. One was found beneath the endocardium of the right ventricle adjacent to the pulmonic valve, and the other in the wall of the right atrium. Histologically, they were composed of fusiform and oval cells, and resembled the sarcomas found in the hearts of Syrian hamsters inoculated with polyoma virus[8]. The subcutaneous tumours in the *Mastomys* were also diagnosed as sarcomas and were histologically similar to the subcutaneous tumours produced by polyoma virus in Syrian hamsters[8].

It has been possible to isolate polyoma virus in tissue culture from a suspension of one of the renal sarcomas of the *Mastomys*. At the time of autopsy, a portion of the tumour of the kidney from animal No. 11 (Table 2) was frozen at − 20°. It was later thawed and a 20 per cent suspension of tumour tissue was made in tissue culture medium (20 per cent autoclaved fatless milk and 80 per cent mixture No. 199). Cultures of milk-adapted *P388D1* cells were inoculated with 0·25 ml. of the 20 per cent tumour tissue suspension. In one of two inoculated tubes, a cytopathological effect similar to that seen in cultures inoculated with polyoma virus was observed after 21 days. The supernatant fluid from this culture was then inoculated into 9 new-born Syrian hamsters, and all died within 30 days. Five were autopsied and all had multiple tumours similar to those previously described in hamsters inoculated at birth with polyoma virus[8].

Although spontaneous tumours have been described in *Mastomys*, they have rarely been found in animals younger than one year of age, and they differ from the sarcomas of the kidneys and heart, and angiomatous tumours of the liver found in the animals inoculated with polyoma virus[4]. With the possible exception of the adenocarcinoma of the liver in one of our *Mastomys*, it therefore seems unlikely that the tumours we have observed are spontaneous, and we believe that they are related to the inoculation of the polyoma virus. The mechanism by which the virus

Table 2. Tumours in *Mastomys* inoculated with Polyoma Virus

Animal	Litter No.	Sex	Age at death	*K* = killed *F* = found dead	Tumours Kidneys	 Liver	 Heart	 Subcutis
1	1	F	61	*K*	+	−	−	−
2	1	F	101	*F*	+	−	−	−
3	1	M	104	*K*	+	−	+	−
4	1	F	160	*K*	+	−	−	+
5	2	M	150	*K*	−	−	−	−
6	2	F	150	*K*	−	−	−	+
7	2	M	159	*K*	−	−	−	−
8	2	F	165	*K*	−	−	−	−
9	2	M	172	*F*	+	−	−	−
10	3	F	36	*F*	+	+	−	−
11	3	M	45	*K*	+	−	+	−
12	3	M	46	*F*	+	+	−	−
13	3	M	52	*F*	+	+	−	−
14	3	F	134	*F*	+	−	eaten	−
15	3	M	151	*F*	+	+	−	−
16	3	F	156	*F*	+	−	−	−
17	3	F	159	*F*	+	−	−	−

produces tumours, however, remains completely obscure at present.

Since some difference of opinion exists whether to group the *Mastomys* taxonomically with the rat (genus *Rattus* Fischer) or with the mouse (genus *Mus* L.), the response of *Mastomys* to polyoma virus is of interest. The renal sarcomas produced by polyoma virus in *Mastomys* are grossly and histologically similar to tumours produced by polyoma virus in the kidneys of rats and mice[8]. The sarcomas in the heart, however, have not been described in either rats or mice, but are very frequently produced by polyoma virus in the Syrian hamster[9]. Thus far, no parotid gland tumours or thymic tumours similar to those produced by polyoma virus in mice have been found in the *Mastomys*. It should be noted, however, that the virus pools we have used show very little oncogenic activity in mice, although they readily produce tumours in Syrian hamsters.

Additional studies of *Mastomys* inoculated with varying doses and different strains of polyoma virus are now in progress in our laboratory and will be reported in detail later.

ALAN S. RABSON
WILLIAM J. BRANIGAN
FRANCES Y. LEGALLAIS

Laboratory of Pathology,
National Cancer Institute,
Bethesda,
Maryland.

[1] Davis, D. H. S., and Oettle, A. G., *Proc. Zool. Soc. Lond.*, 131, 293 (1958).

[2] Oettle, A. G., de Meillon, B., and Lazer, B., *Acta Unio Int. contre le Cancer*, 15, 200 (1959).

[3] Zumpt, F., *Nature*, 184, 793 (1959).

[4] Oettle, A. G., *Brit. J. Cancer*, 11, 415 (1957).

[5] Stewart, S. E., Eddy, B. E., and Stanton, M. F., *Acta Unio Int. contre le Cancer*, 15, 842 (1959).

[6] Dawe, C. J., Law, L. W., and Dunn, T. B., *J. Nat. Cancer Inst.*, 23, 717 (1959).

[7] Rabson, A. S., and Legallais, F. Y., *Proc. Soc. Exp. Biol. Med.*, 100, 229 (1959).

[8] Rabson, A. S., and Kirschstein, R. L., *Amer. Med. Assoc. Arch. Path.* (in the press).

[9] Eddy, B. E., Stewart, S. E., Young, R., and Mider, G. B., *J. Nat. Cancer Inst.*, 20, 747 (1958).

Hæmodynamic Aspects of Atherogenesis

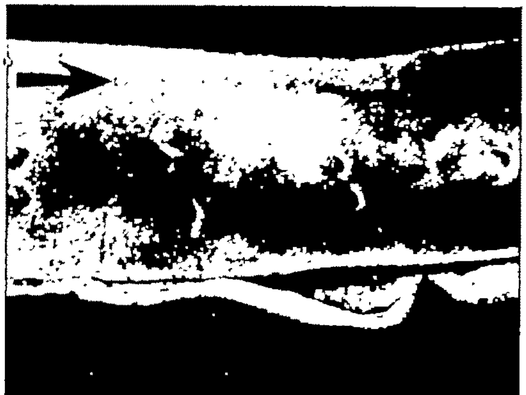
ATHEROSCLEROSIS is generally regarded as a disease process which is mainly due to disorder of metabolic factors such as lipoproteins, hormones, heparin, etc. These factors have been extensively studied, especially with respect to lipoproteins. However, careful examination of the artery at autopsy shows that plaques are scattered all along an arterial branch. An artery of considerable length uniformly and concentrically coated with lipid material without localized regions of sclerosis seems to be quite rare. On the contrary, plaques are in the majority of the cases deposited in a peculiar pattern. Such deposition of lipid materials and the topographical arrangement of plaques cannot be explained readily by general metabolic factors alone. Thus a method of quantitative grading of atherosclerosis has been developed[1] in order to distinguish the role of the general metabolic factors and local factors. This technique has been applied to a study of the interrelationship between cerebral and coronary atherosclerosis[2]. By quantitative grading of sclerosis and systematic analysis of the coronary artery for relative position and severity of plaques one is able to demonstrate the significance of local factors in atherogenesis.

Table 1. EFFECT OF BEND IN AN ARTERY ON ATHEROGENESIS

No. of sections	I/E	Position of sections
135	47·5 ± 14·2*	Pre-bend
125	59·8 ± 11·8	Bend
130	54·9 ± 13·7	Bend
139	48·4 ± 15·4	Post-bend
125	42·7 ± 16·4	Post-bend
105	32·9 ± 14·3	Post-bend

I, Area of intimal material; E, total area of arterial wall; I/E, atherosclerosis units.
* Standard deviation of distribution.

Table 1 shows the effect of the bend in the anterior descending branch of the left coronary artery. Before reaching the bend, sclerosis was measured as 47·5 I/E units; for the bend it was 59·8, 54·9 I/E units; and for the region following the bend, 48·4, 42·7, 32·9 I/E units. The higher value at the bend in the artery shows that this region is more susceptible to deposition.


(1)

(2)

Fig. 1. Early phase of experimental atherosclerosis of rabbit aorta. Note the plaques were beginning to form at each branching point. Flow of blood from left to right, as indicated by arrow. (× 3)

Fig. 2. Advanced phase of experimental atherosclerosis of rabbit aorta. Heavy plaques were formed at each branching point. Note the typical shape of the plaques in advanced sclerosis. Flow of blood from left to right, as indicated by arrow. (× 3)

The plaques along any artery are not randomly distributed as has been reported in the literature. They seem to be located at certain particular sites such as bifurcations. Fig. 1 shows a typical early phase of atherosclerosis which was formed at the branching point of an aorta from a rabbit given cholesterol in its feed. Fig. 2 shows another aorta with a comparatively advanced stage of atherosclerosis. Plaques are also particularly numerous at the branching point of an artery. In both photographs it is evident that plaques are formed at precisely the same location with respect to flow. Theoretical and a full treatment of this particular feature will be published elsewhere.

WEI YOUNG
Donner Laboratory of Medical Physics,
Department of Physics,
and
Lawrence Radiation Laboratory,
University of California,
Berkeley,
California.

[1] Young, W., *UCRL* 8705, 46 (1959).

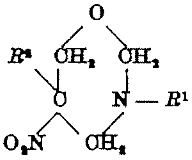
[2] Young, W., Gofman, J. W., Tandy, R., Malamud, N., and Waters, E. S. G., *Amer. J. Cardiology* (in the press).

Anti-neoplastic Activity of Tetrahydro-1,3-oxazine Derivatives

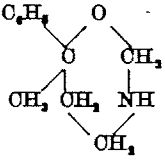
It has been demonstrated that benz-1,3-oxazine derivatives inhibit the growth of Crocker sarcoma in mice[1]. This was partly confirmed by F. Bergel, at the Chester Beatty Research Institute, London (private communication).

Further confirmation of the anti-neoplastic activity of benz-1,3-oxazine derivatives was obtained by the Miyamura test, *in vitro*[2]. Similar results were obtained by Leonardi[3] when he repeated our experiments *in vitro*.

All these results seemed to be sufficiently promising to justify searching for anti-neoplastic substances among the derivatives of 1,3-oxazine. Simpler compounds, derivatives of 5-nitrotetrahydro-1,3-oxazines (I) and 6-methyl-6-phenyltetrahydro-1,3-oxazine (II) proved to be fairly efficient *in vitro*[2].



I



II

$R^1 = CH_3$, $R^2 = CH_3$, *T* 398 (ref. 4) *T* 446 (ref. 7)
$R^1 = CH_3$, $R^2 = CH_2OH$, *T* 401 (ref. 4)
$R^1 = CH_3$, $R^2 = C_5H_{11}$, *T* 413 (ref. 5)
$R^1 = C_5H_{11}$, $R^2 = C_3H_7$, *T* 364 (ref. 6)

Their activity against the solid form of Ehrlich ascites carcinoma is shown in Table 1 and solid form of amytal ascites sarcoma in mice in Table 2.

It is believed that the active CH_2 group in position 2 is responsible for the anti-neoplastic activity of 1,3-oxazine derivatives.

Further experiments will be carried out with a number of the compounds (I) to elucidate the influence

Table 1. INHIBITION OF EHRLICH ASCITES CARCINOMA

Code No. of substance	Mouse strain	No. of mice in group	Daily dose of substance (mgm./mouse)	Average tumour weight (gm.)	σ* ± s	m† ± s	Tumour inhibition (per cent)‡
T 364	*A*	12	0	2·4	0·79	0·23	
		10	12	1·3	0·52	0·16	45·8
	R III	12	0	2·7	0·79	0·23	
		10	12	1·3	0·94	0·29	51·8
T 398	*A*	12	0	2·4	0·79	0·23	
		10	12	0·8	0·56	0·18	66·7
	R III	12	0	2·6	0·79	0·23	
		10	12	0·8	0·51	0·16	69·2
T 413	*A*	12	0	1·8	0·50	0·14	
		10	12	0·9	0·57	0·18	50·0
	R III	12	0	1·5	0·57	0·16	
		10	12	0·5	0·22	0·07	66·7
T 446	*R* III	12	0	1·1	0·47	0·13	
		10	12	0·6	0·32	0·10	45·4

(See footnotes to Table 2).

Table 2. INHIBITION OF AMYTAL ASCITES SARCOMA

Code No. of substance	Mouse strain	No. of mice in group	Daily dose of substance (mgm./mouse)	Average tumour weight (gm.)	σ* ± s	m† ± s	Tumour inhibition (per cent)‡
T 364	*A*	12	0	2·3	0·45	0·13	
		10	12	1·0	0·39	0·12	56·5
	R III	12	0	1·8	0·71	0·20	
		10	12	0·8	0·41	0·13	55·5
T 398	*R* III	12	0	1·7	0·77	0·22	
		10	12	0·7	0·26	0·08	58·8
T 401	*A*	12	0	1·5	0·50	0·14	
		10	12	0·8	0·35	0·11	46·7
T 413	*A*	12	0	1·5	0·50	0·14	
		10	12	0·6	0·17	0·05	60·0
	R III	12	0	1·8	0·94	0·27	
		10	12	0·7	0·22	0·07	61·0
T 446	*R* III	12	0	1·7	0·66	0·19	
		10	12	0·7	0·39	0·12	58·8

$$* \sigma = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}} \qquad \dagger m = \sqrt{\frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n(n - 1)}}$$

‡ Calculated according to the formula, $\frac{P - M}{P}$ 100 = percentage inhibition. *P*, average tumour weight in control group; *M*, average weight in treated group.

of various substituents on their anti-neoplastic activity.

T. Urbański
D. Gürne
S. Ślopek
H. Mordarska
M. Mordarski

Organic Chemical Laboratories,
and
Institute of Immunology and
Experimental Therapy,
Polish Academy of Sciences.
Wrocław.

---

[1] Urbański, T., Radzikowski, Cz., Ledóchowski, Z., and Czarnocki, W., *Nature*, 178, 1351 (1956).

[2] Slopek, S., Mordarska, H., Mordarski, M., Urbański, T., and Gürne, D., *Bull. Acad. Pol. Sci.*, Série chim., 6, 361 (1958).

[3] Leonardi, A., *Boll. Soc. Ital. Biol. Sperim.*, 35, 796 (1959).

[4] Senkus, M., U.S. Pat. 2,447,822 (1948).

[5] Urbański, T., Dąbrowska, H., Lesiowska, B., and Piotrowska, H., *Rocz. Chem.*, 31, 687 (1957).

[6] Gürne, D., and Urbański, T., *Bull. Acad. Pol. Sci.*, Cl. III, 4, 221 (1956); *Rocz. Chem.*, 31, 869 (1957).

[7] Schmidle, C. J., and Mansfield, R. C., *J. Amer. Chem. Soc.*, 78, 1702 (1956).

BIOLOGY

Fungitoxicity of Metal Ions

The relationship between the toxicity of metal cations and their physico-chemical properties has been considered in terms of electrode potential[1,2], insolubility of the metal sulphide[3], and electronegativity[4]. Danielli and Davies[4] suggested that the toxicity of metal ions is determined by their ability to form un-ionized complexes with ionogenic groupings at the cell surface, and they have taken the electronegativity values of the metals as a measure of the tightness of covalent binding to these groups. The application of this hypothesis to the toxicity of a number of metal salts to fungal conidia[5] has recently been questioned by Miller[6]. In his examination of my experimental results, Miller has arbitrarily disregarded the toxicities of metals less toxic than zinc by terming them "basically not toxic to fungus conidia" although they all possess measurable *ED*50 values. It was, of course, precisely to show that the same toxic mechanism may apply to a wide range of metal ions that these less toxic metals were examined.

Miller also criticizes the standard spore germination technique[7] as a measure of fungitoxicity. This technique determines the fungistatic ability (that is, inhibition of spore germination) of a fungicide as a function of the concentration of the external solution, and is closely related to the practical performance of fungicides. Moreover, the widespread use of this test for many years has established its value as a measure of the relative toxicity of protectant fungicides. Absolute toxicity values will only be obtained when the concentration of toxicant at cell receptor sites can be determined. For some years, McCallan and Miller[8] have advocated the ratio of the weight of fungicide accumulated by the fungal spores at the *ED*50 to the weight of spores as a measure of 'innate' toxicity. Although their ratio of μgm. toxicant/gm. spore weight is a most valuable measure of fungicidal activity and of the uptake of fungicides by spores[9], this weight ratio cannot be regarded as fundamentally related to absolute toxicity until much more information on the mode of action of fungicides and their possible detoxication by the cell is available.

The value of the electronegativity hypothesis may best be shown by an examination of the results of some recent experiments in which the fungitoxicity of twenty-two metal cations to conidia of *Botrytis fabae* Sardiña has been determined. The median effective doses (*ED*50) of unbuffered solutions of nitrates of potassium, sodium, barium (*ED*50 extrapolated), strontium, lithium, calcium, magnesium, manganese, zinc, beryllium, thallium, yttrium, lead, chromium, nickel, cobalt, palladium, copper, and silver, of mercurous and mercuric chloride, and of osmium tetroxide were estimated as before[5]. *B. fabae* conidia gave 98–100 per cent germination after 18 hr. incubation at 25° in distilled water, so that a spore stimulant was not required. In Fig. 1 logarithms of the *ED*50 values of the metal ions are plotted against the electronegativities of the metals as calculated by Pauling[10] and Hałaszinsky[11]. Hałaszinsky calculated electronegativities by Pauling's method for the whole Periodic Table, including values for some of the different valence states of the transition elements. Although electronegativities are not in their nature quantities which can be defined precisely, modern work has largely corroborated Pauling's original values[12].

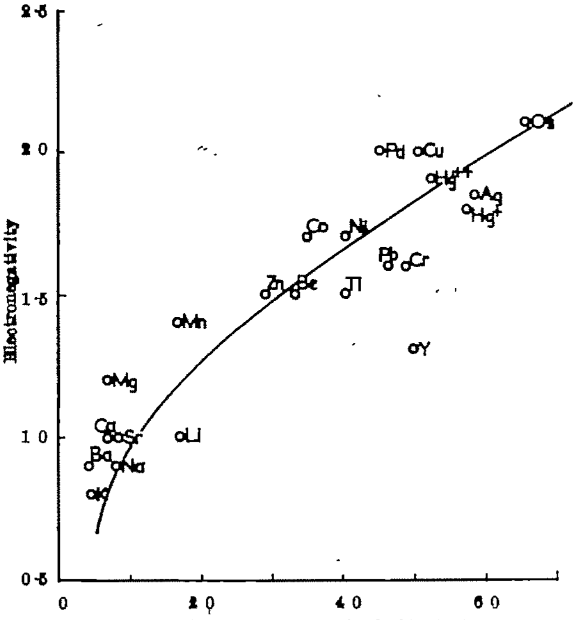


Fig. 1. Graph of toxicity of metal cations to *B. fabae* against electronegativity of the metal

Danielli and Davies[4] have shown that the values of Jones[13] for the toxicities of various cations to the planarian, *Polycelis nigra*, fit an exponential relationship of the form:

$$\log [M^{q+}] = \alpha - \gamma \exp(-0{\cdot}25x^2)$$

where $[M^{q+}]$ is the concentration of the metal cation of valency q in the bulk phase which gives the standard toxicity, x is the difference between the electronegativity of the metal and that of oxygen, and α and γ are constants. From the results in Fig. 1, $\log [M^{q+}]$ was plotted against $\exp(-0{\cdot}25x^2)$ and the regression line calculated, giving $\alpha = 1{\cdot}72$ (S.E., $0{\cdot}59$) and $\gamma = 13{\cdot}98$ (S.E., $1{\cdot}48$). These values of α and γ were used to plot the curve in Fig. 1 which, in spite of the anomalous position of yttrium, may be considered to give a good fit to the experimental results. In view of the very different organism tested and the different electronegativities used, the values of α and γ are in reasonable agreement with those given by Danielli and Davies, namely, 0·95 and 9·28.

These results certainly suggest that there is a common, non-specific, toxic action for most metal cations which can be related to their strength of covalent binding to the surface ionogenic groups (for example, imidazole, carboxyl, phosphate, or sulphydryl) present outside the cell protoplast. It must be pointed out that there is a great deal of evidence from work with bacteria, yeast and fungi to show that the initial uptake of cations is a surface phenomenon[13]. The extent of metal accumulation by fungal spores is too great to assume a classical unimolecular adsorption layer[14], but rather an adsorption in depth on the surface matrix (ref. 13a). Danielli and Davies point out that the formation of an un-ionized complex between metal ion and surface ionic groups may alter membrane permeability; and Miller's results, showing increased uptake by fungal spores after treatment with silver ions or a surface-active agent, can be attributed to reaction between the metal ions and lysed cellular components. This reaction, however, will be secondary to the formation of un-ionized complexes, which is considered to be primarily responsible for the fungistatic action of metal cations.

The experimental work discussed here will be reported in detail elsewhere.

E. SOMERS

Long Ashton Research Station,
University of Bristol.
March 14.

[1] Mathews, A. P., *Amer. J. Physiol.*, 10, 290 (1904).

[2] Jones, J. R. E., *J. Exp. Biol.*, 16, 425 (1939); 17, 408 (1940).

[3] Shaw, W. H. R., *Science*, 120, 361 (1954).

[4] Danielli, J. F., and Davies, J. T., "Adv. in Enzymology", 11, 35 (Interscience, New York, 1951).

[5] Somers, E., *Nature*, 184, 475 (1959).

[6] Miller, L. P., *Nature*, 185, 545 (1960).

[7] American Phytopathological Society, Committee on Standardization of Fungicidal Tests, *Phytopathology*, 37, 354 (1947).

[8] McCallan, S. E. A., and Miller, L. P., "Advances in Pest Control Research", 2, 107 (Interscience, New York, 1958).

[9] Somers, E., *Canad. J. Bot.*, 36, 997 (1958).

[10] Pauling, L., "The Nature of the Chemical Bond", 2nd edit. (Cornell Univ. Press, Ithaca, 1948).

[11] Haissinsky, M., *J. Phys. Radium*, (8), 7, 7 (1946).

[12] Howlett, K. E., *Sci. Progr.*, 47, 286 (1959).

[13] (*a*) Sussman, A. S., von Boventer-Heidenhain, B., and Lowry, R. J., *Plant Physiol.*, 32, 586 (1957). (*b*) Cochrane, V. W., "Physiology of Fungi", Chapter 14 (John Wiley, New York, 1958). (*c*) Rothstein, A., and Hayes, A. D., *Arch. Biochem. Biophys.*, 63, 87 (1956). (*d*) Davies, J. T., Haydon, D. A., and Rideal, Sir Eric, *Proc. Roy. Soc.*, B, 145, 375 (1956).

[14] Miller, L. P., McCallan, S. E. A., and Weed, R. M., *Contrib. Boyce Thompson Inst.*, 17, 173 (1953).

A Method for the Detection of Inhibition of Auxin Transport

EXPERIMENTS in which auxin has been supplied to either the morphologically apical or basal ends of coleoptile sections have been carried out by Åberg and Khalil[1] and by Housley *et al.*[2]. Both investigations demonstrated that more growth occurred when the apex-to-base auxin transport system could operate, that is, when the apical ends were in contact with the auxin. The present communication confirms this result and shows how the method can be used to investigate auxin transport and its inhibition.

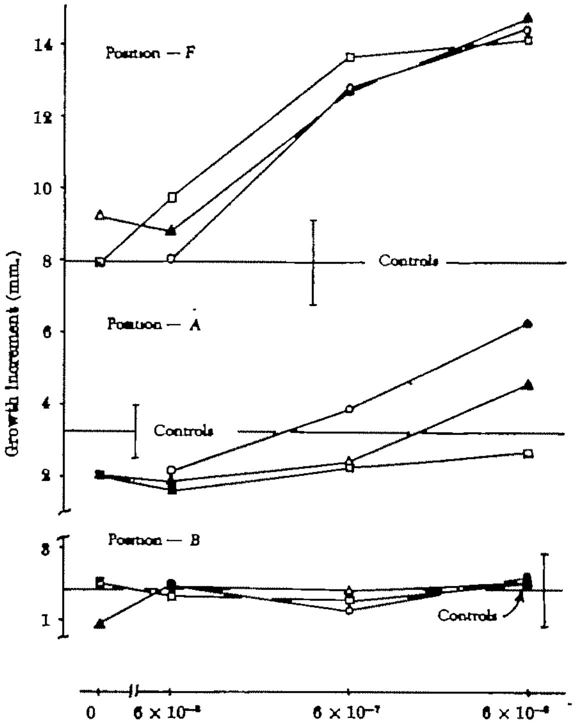


Fig. 1. Interaction of indolyl acetic acid and tri-iodobenzoic acid in growth of coleoptile sections.
Concentration of tri-iodobenzoic acid: ○, nil; △, 2×10^{-7} *M*; □, 2×10^{-6} *M*

Ten 1·0-cm. coleoptile sections cut from standard dark-grown wheat seedlings are supported upright inside a 1 in. × 1 in. vial containing 1·0 ml. of sucrose-buffer solution[3] with or without auxin, and in the presence and absence of a second substance such as 2,3,5-tri-iodobenzoic acid. The sections are placed so that the apical end (*A*-position), or the basal end (*B*-position), of each is just below the surface of the liquid. In addition, in certain experiments, sections are floated on the solutions (*F*-position). No special precautions are taken to guard against surface creep of solution along the sections, or against capillary rise between the coleoptile and the included leaf. Growth increments are measured after 18 hr. in darkness at 25° C. at high humidity.

Sections in the *A*-position consistently show a greater growth response to indolyl acetic acid than sections in the *B*-position. This differential response is still apparent when: (*a*) the portion of leaf is removed, (*b*) the sucrose buffer is omitted from the medium (in which case all responses are lower), (*c*) each of the sections is cut into two 5-mm. portions, and both of these tested in both positions, and (*d*) oat coleoptile sections are used.

Fig. 1 shows results of an experiment on the interaction of indolylacetic acid and 2,3,5-tri-iodobenzoic acid. Points on the graphs represent growth increments found for sections in the *F*, *A* and *B* positions in different combinations of the two substances. Fiducial limits of controls, calculated from 5 sets of 10 sections, are shown.

In the *B*-position, externally applied indolyl acetic acid gives no growth response at the concentrations used. There is no significant difference between controls in the *A* and *B* positions; control growth might therefore be ascribed to the activity of endogenous auxin. In the *A*-position, growth responses to exogenous auxin do occur, although they are less than in floating sections. It is suggested that responses in the *A*-position represent an assay of transported indolyl acetic acid. Where tri-iodobenzoic acid is present, they are reduced or absent. Since these concentrations of tri-iodobenzoic acid do not interfere with growth induced by indolyl acetic acid in the *F*-position, it can be argued that the reduction they cause in *A*-position responses is due to an inhibition of auxin transport, rather than to effects of tri-iodobenzoic acid on auxin uptake and assay. Such effects have been tested and corrected for by other workers[4,5], who have likewise found that tri-iodobenzoic acid inhibits auxin transport. The same argument applies to destruction of auxin induced by tri-iodobenzoic acid, which has been shown to occur[5,6] at concentrations higher than those found here to inhibit transport.

Experiments of this type may prove suitable for the testing of tissue extracts for substances that might regulate some aspects of plant growth through their effects on the transport of auxin. There is direct evidence for the existence of transport-modifying substances[7], and their activity can be postulated as a working hypothesis to account for a variety of correlation phenomena. Substances already available in a pure form can also be examined. For example, the method has shown that colchicine, in concentrations (0·001 and 0·01 per cent) that are within the range causing apolar cell enlargement in root 'c-tumours', does not behave in the same way as tri-iodobenzoic acid.

B. E. S. Gunning

Department of Botany,
Queen's University, Belfast.

[1] Åberg, B., and Khalil, A., *Kungl. Lant. Ann.*, 21, 401 (1953).

[2] Housley, S., Bentley, J. A., and Bickle, A. S., *J. Exp. Bot.*, 5, 373 (1954).

[3] Nitsch, J. P., in "The Chemistry and Mode of Action of Plant Growth Substances" (Butterworths, 1956).

[4] Niedergang-Kamien, E., and Leopold, A. C., *Phys. Plant.*, 10, 29 (1957); 12, 776 (1959). Zwar, J. A., and Rijven, A. H. G. C., *Austral. J. Biol. Sci.*, 9, 528 (1956).

[5] Niedergang-Kamien, E., and Skoog, F., *Phys. Plant.*, 9, 60 (1956). Keitt, jun., G. W., and Skoog, F., *Plant Phys.*, 34, 117 (1959).

[6] Audus, L. J., and Thresh, R., *Ann. Bot.*, 20, 439 (1956). Sargent, J. A., in "The Growth of Leaves" (Butterworths, 1956).

[7] Leopold, A. C., and Guernsey, F. S., *Bot. Gaz.*, 115, 147 (1953).

Maternal Inheritance and Interspecific Hybrids of the Liverwort *Sphaerocarpos*

Sex determination in *Sphaerocarpos*, a genus of dioecious liverworts, is genetically controlled[1]. When the spores of a tetrad derived from a single spore mother cell are germinated, two of the sporelings develop into male and two into female gametophytes. Cytological studies have shown that there are eight chromosomes in the complement of each sex. Of these, seven of the eight chromosomes in the female are similar to seven in the male. The eighth chromosome of the female, the *X* chromosome, is larger than the seven autosomes; the eighth chromosome of the male, the *Y* chromosome, is smaller than the autosomes[2-4].

Of the seven species in the genus, there are no readily apparent morphological differences separating the male plants. Moreover, only one species is easily identified on the basis of the vegetative characteristics of its female plant[4]. Although some vegetative differences are said to exist between the female plants of the other six species, apparently these differences are difficult to ascertain in field populations. Therefore, these species are usually separated on the basis of spore characteristics, that is, the pattern of spore markings and whether or not the four spores remain adherent in a tetrad after meiosis. Recently, in the work reported here, it was found that these spore characteristics are isolated from the effects of hybridization. That is, hybrid spores are not intermediate between the two parents, but closely resemble the maternal species.

Three species of *Sphaerocarpos* were used during the present work: *S. donnellii* Austin (from Florida), *S. drewii* Wigglesworth (from California) and *S. cristatus* Howe (from California). The spores of *S. drewii* and those of the particular race of *S. donnellii* used in this work are adherent in a tetrad; those of *S. cristatus* are separate. Sexual reproduction between these species is normally precluded by geographical isolation. Clonal cultures of each sex, derived from single-spore isolates, were grown separately. Two separate matings involving reciprocal crosses between the three species were attempted. Simultaneous intraspecific matings served as controls and also indicated the number of archegonia with eggs receptive to fertilization at the time of each mating. Between 60 and 105 archegonia contained receptive eggs in each control culture.

Of concern here are only those crosses which resulted in the development of mature sporophytes and thus mature spores. Mature hybrid sporophytes resulted from the following matings: *S. cristatus* ♀ × *S. donnellii* ♂; *S. drewii* ♀ × *S. cristatus* ♂; and *S. donnellii* ♀ × *S. cristatus* ♂. Only in matings of *S. cristatus* ♀ × *S. donnellii* ♂ did the number of sporophytes produced compare to that for the control, *S. cristatus* selfed. Considerably fewer sporophytes resulted from the mating between *S. drewii* ♀ × *S. cristatus* ♂ than from the control, *S. drewii* selfed. The second mating between *S. donnellii* ♀ × *S. cristatus* ♂ resulted in a single sporophyte which produced morphologically normal spore tetrads.

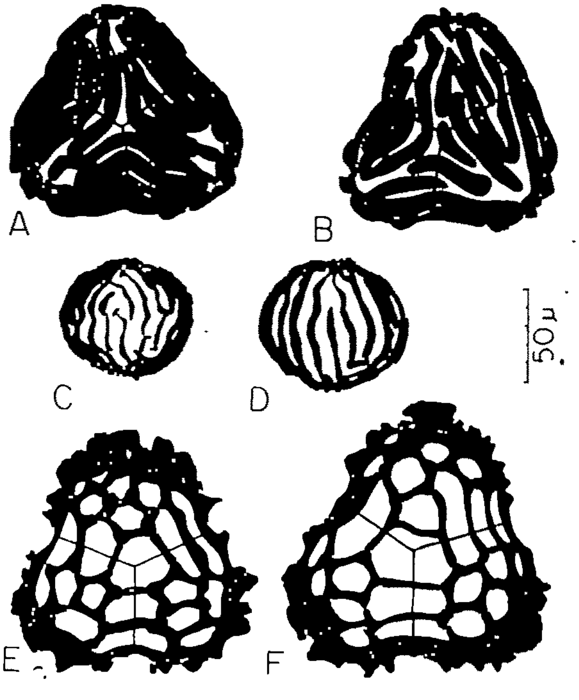


Fig. 1. Spores and spore tetrads of *Sphaerocarpos*. Spores of the maternal species are on the left; those of the hybrids on the right. *A*, *S. drewii*; *B*, *S. drewii* ♀ × *S. cristatus* ♂; *C*, *S. cristatus*; *D*, *S. cristatus* ♀ × *S. donnellii* ♂; *E*, *S. donnellii*; *F*, *S. donnellii* ♀ × *S. cristatus* ♂

Spore characteristics of the parent species and the hybrids are depicted in Fig. 1. All hybrid spores within a single sporophyte and in different sporophytes of the same mating are essentially similar to those shown. It is evident that the hybrid spores have both the general and the definitive characters of the maternal species. Similar results were reported by Allen[5] in the cross between *S. texanus* Austin ♀ × *S. donnellii* ♂. In addition, Allen[6] found that within the species *S. donnellii* the character of adherent versus separate spores followed the line of descent of the *X* chromosome. Although the possibility of cytoplasmic inheritance through the egg cannot be entirely disregarded (see Wettstein[7] for cytoplasmic inheritance in mosses), the most plausible explanation for this pattern of inheritance is that the spore morphology is determined by the genetic composition of the *X* chromosome.

Naturally occurring hybrids have not been found in liverworts[8]. In *Sphaerocarpos* it is clear that naturally occurring hybrids would not be recognized as long as spore characteristics are equated with specific identity. These hybrids would routinely be referred to the maternal species. This means that hybridization will have no taxonomic meaning until species identification includes the use of additional, non-spore characters. It would be of interest to learn how many of the reported differences between the female plants of the species of *Sphaerocarpos* are sex-linked, how many are determined by autosomes and how many are determined by the environment. A critical re-examination of the genus is indicated, utilizing cultures grown under uniform laboratory conditions.

WILLIAM T. DOYLE

Northwestern University,
Evanston, Illinois.

[1] Allen, C. E., *Proc. Amer. Phil. Soc.*, 58, 289 (1919).

[2] Allen, C. E., *Science*, N.S., 46, 218 (1917).

[3] Allen, C. E., *Bot. Gaz.*, 97, 846 (1936).

[4] Proskauer, J., *J. Linn. Soc. Lon., Bot.*, 55, 143 (1954).

[5] Allen, C. E., *Science*, N.S., 71, 197 (1930).

[6] Allen, C. E., *Genetics*, 10, 72 (1925).

[7] Wettstein, F. von, *Z. Ind. Abst. Vererb.*, 73, 349 (1937).

[8] Muller, K., *Rabenh. Krypto. Flora*, 6, 169 (1951).

Significance of the Type of Host Plant Crop in Successful Biological Control of Insect Pests

RECENT publications[1-3] on the status of biological control of insect pests have revealed widely divergent opinions on the potentialities of this method of pest suppression. The fact that in the past a high percentage of successful results has occurred in tropical islands led Taylor[1] to conclude that "there is little future for it in continental areas", and to re-emphasize an earlier thesis of Imms[4], to the effect that only such insular conditions are basically suited for this technique. This opinion was rejected by Simmonds[5], whose point of view is supported by Clausen[2,6] on the basis of reviews of work done in North America during the past twenty-five years.

In these and other publications[6-8] bearing on the prerequisites of successful biological control practice, no reference is made to an environmental factor which appears to have been of significance in island and continental experiments. All cases where introductions of natural enemies are reported by competent authorities[9,10] to have given full commercial control of the pests, and the majority of those where control has been partial pertain to perennial crops. More specifically these plants have been sugar-cane, alfalfa, coconut, citrus, coffee and sundry deciduous fruit, forest or shade trees. The following examples may be cited: the sugar-cane weevil *Rhabdoscelus obscurus* (Boisduval) and the leaf-hopper *Perkinsiella saccharicida* Kirkaldy by *Microceromasia sphenophori* (Villeneuve) and *Cyrtorhinus mundulus* (Breddin) in Hawaii; the coconut moth *Levuana iridescens* Bethune-Baker, the scale *Aspidiotus destructor* Signoret, and the leaf-miner *Promecotheca reichei* Baly by *Ptychomyia remota* Aldrich, *Cryptognatha nodiceps* Marshall, and *Pleurotropis parvulus* Ferriere, respectively, in Fiji; the citrus pests *Icerya purchasi* Maskell, and *Pseudococcus gahani* Green by *Rodolia cardinalis* (Mulsant), *Coccophagus gurneyi* Compere and *Tetracnemus pretiosus* Timberlake in California; the citrus blackfly *Aleurocanthus woglumi* Ashby by *Eretmocerus serius* Silvestri in the West Indies and by *Amitus hesperidum* Silvestri and *Prospaltella* spp. in Mexico; the citrus whitefly *Aleurocanthus spiniferus* (Quaintance) by *Prospaltella smithi* Silvestri in Japan; the coffee mealybug *Planococcus kenyae* Le Pelley by *Anagyrus kivuensis* Compere in Kenya; the woolly apple aphid *Eriosoma lanigerum* (Hausmann) by *Aphelinus mali* (Haldeman) and the blue gum scale *Eriococcus coriaceus* Maskell by *Rhizobius ventralis* Erichson in New Zealand; the larch sawfly *Pristophora erichsonii* (Hartig) by *Mesoleius tenthredinis* Morley in Canada; and the eucalyptus snout weevil *Gonipterus scutellatus* Gyllenhall, by *Anaphoidea nitens* Girault in New Zealand, South Africa, Madagascar and Mauritius.

Consideration of these and the many other attempts to utilize biological agents leads to the conclusion that these agents have been particularly effective where the host plants are trees or other perennials maintaining their geographical locations over periods of many years. The case of sugar-cane is somewhat exceptional in that there is frequent cutting to ground-level. But since maturity is reached 10–20 months after planting, crops overlap, and ratooning is common at least under moist tropical conditions, the plants provide an approach to the more stable and permanent conditions in the tree crops. Indeed, some authors[11] have actually suggested that tall canes maintain an environment more in common with a forest than a savannah since many sugar-cane pests appear to have been originally forest inhabitants. Where sugar-cane is grown in marginal climatic areas such as Louisiana and Argentina, the length of the frost-free season is critical and the crop is cut annually. Under these conditions control of pests by natural enemies has not matched that obtained in the tropics.

The special suitability of tree crops as environments for the action of biological agents is seen also in the results of long-term field studies on biological balance in California avocado orchards by Fleschner[12,13]. It is seldom necessary to apply chemical pest control treatment in these orchards; but Fleschner showed by numerous experiments that when entomophagous insects were excluded from trees in any area phytophagous mite and insect populations increased to damaging levels. A further illustration of the great significance of stable environments in control programmes involving living organisms is apparent on examination of experiments in the biological control of weeds by insects. Outstanding successes to date have been against perennial weeds of undisturbed lands[14].

In contrast to pests of tree or other perennial crops, field and garden insects attacking plants such as cereals, maize, crucifers, legumes, etc., have proved to be far more refractory to adequate control by biological agents. So much so that in published lists of pests brought under full commercial control by biological means the omission of examples from these crops is striking. Of course, partial control of a quite valuable nature has been obtained in some field crops, but here again the importance of the perennial plant is evident. The introduction of *Pteromalus puparum* (Linnaeus) and *Angitia* spp. against the cruciferous pests *Pieris rapae* (Linnaeus) and *Plutella maculipennis* (Curtis) in New Zealand ; *Ascogaster quadridentata* Wesmael and *Glypta haesitator* Gravenhorst against pea moth *Laspeyresia nigricana* (Stephens) in British Columbia ; *Euplectrus plathypenae* Howard and *Archytas cirphis* Curran against pasture cutworms *Pseudaletia unipuncta* (Haworth), etc., in Hawaii ; and *Praon palitans* Muesebeck, *Trioxys utilis* Muesebeck and *Aphelinus semiflavus* Howard against spotted alfalfa aphid *Therioaphis maculata* (Buckton) in California[15], are cases in point. Biological control programmes against pests of field and garden crops have often been pursued with a vigour equalling efforts applied to programmes against tree crop pests, as may be seen by the examples cited in Clausen's review of biological control work in the continental United States[5]. The sharp differences in the end-results of these numerous empirically conducted projects during the past seventy years thus suggest a real limitation in the biological control method. Until research shows how such environments may be made more favourable for the action of biological agents, major attention might profitably be directed to pests of perennial crops, where full commercial control is sometimes attainable.

The reasons for these different results are not immediately apparent, although the differences are understandable when the projects are considered from behaviouristic and ecological points of view. The effective environment of an organism has been defined as that containing everything of direct importance to the particular organism. It is probable that tree and other perennial crops provide better approximations to this environment than do field crops because of their fortunate combination of extension, continuity and fixity. These relatively stable and undisturbed conditions year after year must inevitably facilitate sensory reactions of biological agents such as adult entomophagous insects. The overall capacity of an environment to meet the specialized requirements and limitations of these adults may well be a critical, even decisive, factor in the ultimate success of a biological control programme. Really effective natural enemies have been shown to disperse rapidly and have good host-searching capacities. These faculties involve many sense organs, and prevailing opinion is that the adult is attracted first to the type of environment or host area, and then to the host insect[16]. The relative failure of biological control agents against field and garden crop pests suggests the possibility that the organic sensory equipment of the adult entomophagous insect lacks the capacity to cope with the constant disruptions of these plant environments by the cropping and other sequences of present-day agricultural systems. Continuous cultivation under one crop has long been known to favour accumulation of pests, whereas a shifting cultivation or rotation system helps check them. It is to be expected that these same practices create corresponding difficulties in the maintenance or augmentation of the natural enemy populations of the pests. Successful attempts to alter these environments in favour of the biological agents might well follow from an increased knowledge of the factors controlling the orientation and movement patterns of the entomophagous insects and other natural enemies.

D. C. Lloyd

Commonwealth Institute of Biological Control,
P.O. Box 575, California Station,
Fontana, California.

[1] Taylor, T. H. C., *Ann. App. Biol.*, **43**, 190 (1955).

[2] Simmonds, F. J., *Canad. Ent.*, 88, 553 (1956).

[3] Clausen, C. P., "Ann. Rev. Ent.", **3**, 291 (1958).

[4] Imms, A. D., "Recent Advances in Entomology" (Churchill, London 1931).

[5] Clausen, C. P., U.S. Dept. Agric. Tech. Bull., 1139 (1956).

[6] Thompson, W. R., *Ann. App. Biol.*, 17, 307 (1930).

[7] Sweetman, H. L., "The Principles of Biological Control" (Brown, Dubuque, 1958).

[8] Flanders, S. E., *J. Econ. Ent.*, **52**, 71 (1959).

[9] Clausen, C. P., *J. Econ. Ent.*, **44**, 1 (1951).

[10] Fleschner, C. A., *Science*, **129**, 537 (1959).

[11] Myers, J. G., *Trop. Agric.*, **12**, 114 (1935).

[12] Fleschner, C. A., "Calif. Avocado Soc. Yearbook", **38**, 125 (1954).

[13] Fleschner, C. A., "Calif. Avocado Soc. Yearbook", **39**, 155 (1955).

[14] Huffaker, C. B., "Ann. Rev. Ent.", **4**, 251 (1958).

[15] Stern, V. M., Smith, R. H., Van den Bosch, R., and Hagen, K. S., *Hilgardia*, **29**, 81 (1959).

[16] Lloyd, D. C., *Canad. Ent.*, **90**, 450 (1958).

Diplodiscus Species Parasitic in the Snail *Paludina vivipara* Lm.

While engaged in researches on larval trematodes in The Netherlands, I collected specimens of the snail *Paludina vivipara* Lm. from a dried-up waterway in the vicinity of Houten (Province of Utrecht). In the course of routine examination, no cercariae having been given off by the snails under laboratory conditions, they were dissected and large numbers of rediae found which proved, by their structure and measurements, to be the larval stage of an amphistome. This is in itself unusual as *P. vivipara* is not recorded as acting as intermediate host for this group of trematodes.

Further dissection and investigation revealed in two of the snails the presence of active trematodes, associated with the tissues of the gut-wall. On investigation, these proved to be adult amphistomes of the genus *Diplodiscus* Diesing 1836, known previously only from vertebrates (Amphibia). Of the members of the genus, the new amphistome most closely resembles *Diplodiscus subclavatus* (Pallas).

The accompanying photograph (Fig. 1) shows the structure and state of development of the amphistome, and its resemblance to *Diplodiscus* sp. is clear. A feature of interest is that only one testis is present, which indicates that the trematodes are in fact adults, young specimens having a double testis which later fuses. The dark paired structure (black in the photograph) is the excretory system.

The measurements of the trematode shown are as follows (in microns) :

Body-length	2,320
Breadth, at *A*	710
Oral sucker	290 × 260
Acetabulum	860 × 610
Testis diameter	300

At present, there appear to be two explanations for the occurrence. One one hand, it is possible that the larval stages of the amphistome have taken place in another mollusc, for example *Planorbis* sp., and that the subsequent eating by *Paludina vivipara* of encysted metacercariae (perhaps by eating a dead

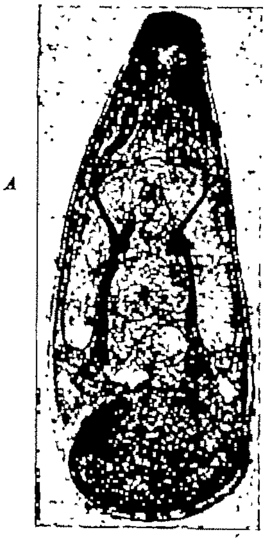


Fig. 1. Measurements given in text

frog or another mollusc) has given the opportunity for full development within a molluscan host, in place of one of the expected vertebrate host (that is, one of the Amphibia).

On the other hand, the presence of amphistome rediæ raises the possibility that the whole of the life-cycle may occur, by means of a type of 'short-circuiting', within the (former) intermediate host, which would account for the lack of free-swimming cercariæ. The cercaria of *Diplodiscus subclavatus*, in contrast, is well known under the name *Cercaria diplocotylea* Fil. Although this has a period of development external to the redia (that is, in the tissues of the snail *Planorbis umbilicatus* L.), it later leaves the intermediate host, and encysts externally.

It is of interest to speculate on the definitive host for this species of *Diplodiscus*, and whether it is a parasite of molluscs, in contrast to all other members of the group, or a parasite of vertebrates that, in exceptional circumstances, has adapted itself to a molluscan host. Whatever the answer to this problem may prove to be, it is the first known case of an amphistome parasitizing an invertebrate.

For the opportunity and facilities to carry out further work on the life-cycle and identification of this trematode, the results of which it is hoped to publish at a later date, I am indebted to the Institute mentioned below and in particular to its director, Prof. D. Swierstra.

M. R. HONER

Institute for Parasitology and Parasitic Diseases,
State University, Biltstraat 172,
Utrecht.

Effect of Pyruvate upon Nucleated and Enucleated Fragments of *Amoeba proteus*

THE detection of metabolic differences between nucleated and enucleated fragments of *Amoeba proteus* suffers from the fact that the amounts involved are often minute[1]. In a search for the effect of enucleation upon cellular metabolism, the sensitivity of nucleated and enucleated fragments, respectively, towards selected metabolites may serve as a guide.

The effect of pyruvate on nucleated and enucleated fragments of *Amoeba proteus* was tested as one example. Since enucleated cells are unable to take up food particles, both the controls and the fragments were kept in non-nutrient salt solution without the addition of food particles throughout the experiment. The *Amoebas* were cut into nucleated and enucleated halves with a glass needle. Nucleated fragments as well as whole cells tolerated concentrations of sodium pyruvate up to $2 \cdot 5 \times 10^{-3}$ m*M*/ml. for 24 hr. without appreciable changes either in their mode of movement, or in the morphology of the pseudopodia. However, about 90 per cent of the enucleated fragments were cytolysed within the first 10 hr. of exposure to the same concentration. This difference is the more remarkable since both nucleated and enucleated fragments survive starvation for more than a week.

Since synthesis of protein and ribonucleic acid is dependent on the nucleus, the higher toxicity of the pyruvate for the enucleated fragments might reflect an intracellular increase in lactic acid, caused by a change in the reduced diphosphopyridine nucleotide/diphosphopyridine nucleotide ratio as a result of an insufficient consumption of chemically bound energy[2,3]. It is interesting that a similarly increased sensitivity of enucleated fragments towards 'natural' precursors of proteins and nucleic acids has been found in *Acetabularia*[4].

EDMUND GUTTES
SOPHIE GUTTES

Department of Biology,
Brown University,
Providence,
Rhode Island.

[1] Baltus, E., *Arch. Internat. de Physiol. et de Biochim.*, 64, 124 (1956).

[2] Chance, B., "Enzymes: Units of Biological Structure and Function", edit. by Gaebler, O. H., 447 (Academic Press, New York, 1956).

[3] Lardy, H. A., Proc. Third Internat. Congr. Biochem. Brussels, 1955, edit. by Liébecq, C., 287 (Academic Press, New York, 1956).

[4] Brachet, J., *Exp. Cell Res.*, 14, 650 (1958).

BACTERIOLOGY

Egg-Yolk Reactions of *Pseudomonas* Species

VARIOUS bacteria are known to produce opalescence in egg-yolk emulsions due to lecithinase or lipase activity. Among these are the lecithinase-producing clostridia and aerobic spore-forming bacilli, and the lipolytic clostridia and staphylococci. Little attention seems to have been paid to the effects produced by Gram-negative organisms growing on egg-yolk media. Felsenfeld[1] showed that the opalescence produced by four strains of *Vibrio comma* and one strain of *Vibrio el tor* was due to lecithinase activity, and Crook[2] made a passing reference to one strain of *Pseudomonas pyocyanea* (*Ps. aeruginosa*) which produced an opalescence on egg-yolk agar. Willis[3] noted the opalescence changes produced by four strains of *Ps. pyocyanea*.

This communication presents briefly the results obtained in a study of the cultural reactions of *Pseudomonas* species on egg-yolk agar and other lecithin and fat-containing media. Thirty strains were examined, of which 15 were strains of *Ps. pyocyanea* isolated from human infections; the remainder consisted of a number of species other than *Ps. pyocyanea*.

All organisms were examined for lipolytic activity by growing them on fat-containing media (tributyrin agar ('Oxoid'), cream agar, monostearate agar and tristearate agar), and for lecithinase activity on egg yolk agar and lecithin agar. Fat-free milk agar was used to determine proteolytic activity, and nutrient agar without other additions was used as a control medium. Some of these media have been described by Willis[3]. In addition, the strains were cultured on phenolphthalein phosphate agar to determine their phosphatase activity, and a note was made of their temperature requirements, pigment production and pathogenicity for mice.

All the strains of *Ps. pyocyanea* produced marked clearing on tributyrin agar in 48 hr., and obvious lipolysis on cream agar, monostearate agar and tristearate agar as indicated by positive results in the copper soap test for lipase[3,4]. Pancreatic lipase (Light and Co.) and four known lipolytic coagulase-positive strains of *Staphylococcus aureus* produced identical results. All strains were proteolytic on milk agar, and, apart from pigment production which varied from strain to strain, they produced no change on nutrient agar. Most strains were phosphatase-positive and were pathogenic for mice.

On the lecithin-containing media—egg-yolk agar and lecithin agar—all strains produced an opalescence and commonly a pearly layer also. On egg-yolk agar the opalescence was almost always confined to the limits of growth; but on lecithin agar it commonly extended away from the edge of the growing colony for some distance into the medium. After treatment with saturated copper sulphate solution the central parts of the opalescence in all cases stained greenish blue, whereas the peripheral parts remained unstained. This was most obvious in the cultures on egg-yolk agar. Pancreatic lipase and the four strains of *Staph. aureus* produced no change on lecithin agar, but produced an intense opalescence on egg-yolk agar and a strongly positive result in the copper soap test on this medium. Pancreatic lipase and the staphylococci also gave positive results in the copper soap test on lecithin agar which had been treated with *Cl. welchii* α-toxin (lecithinase *C*).

Pseudomonas species other than *Ps. pyocyanea* acted variously on the different media. In general, those which grew at 37° C. gave similar results to those outlined for *Ps. pyocyanea*, while those which grew at 25° C. but not at 37° C. were comparatively inactive.

There is no doubt that many of the strains of *Pseudomonas* species examined are lipolytic, and this activity would account for the opalescence produced by them on egg-yolk agar. However, the fact that these organisms produce an opalescence on lecithin agar which stains with copper sulphate solution, whereas lipolytic staphylococci and pancreatic lipase produce no change in the medium, suggests that they produce also a lecithinase *C*. Lipolysis of the diglyceride liberated from the lecithin molecule by attack by lecithinase *C*, as occurs in the case of *Clostridium oedematiens* type *A*[2], provides the simplest explanation of the results obtained.

Further investigations along these lines are at present being carried out and a detailed report will be published elsewhere.

A. T. WILLIS
G. GOWLAND

Department of Bacteriology,
School of Medicine,
Leeds. March 18.

---

[1] Felsenfeld, O., *J. Bact.*, 48, 155 (1944).

[2] Crook, E. M., *Brit. J. Exp. Path.*, 23, 37 (1942).

[3] Willis, A. T., *J. Path. Bact.* (in the press).

[4] Willis, A. T., *Nature*, 185, 943 (1960).

Two Types of Catalase-like Activity in Lactic Acid Bacteria

WHEN heterofermentative lactic acid bacteria were being tested for hydrogen peroxide production, using adaptations of Kneteman's[1] pyrolusite medium and the blood benzidine medium of Kraus, Nickerson, Perry and Walker[2], it was noted that one group showed a positive reaction on both media, and another group produced peroxide on the pyrolusite medium only. Later, it was found that the latter group, but not the former, possessed a strong catalase-like activity when hydrogen peroxide (10 vol.) was added to the cultures grown on blood media; no such reaction was observed when the cultures were grown on blood-free media. Further experiments were carried out with a basal medium (0·5 per cent Evans peptone, 0·5 per cent 'Lab-Lemco', 5·0 per cent yeast autolysate, 0·05 per cent manganese sulphate, 0·05 per cent 'Tween 80', 0·5 per cent potassium citrate, 1·5 per cent agar, and 0·5 per cent glucose, unless otherwise stated, *p*H 6·5 and autoclaved at 15 lb. for 20 min.) to which blood, lysed by the addition of an equal amount of sterile tap water, was added (5 per cent final concentration). This medium, boiled for 15 min. to destroy the blood catalase before pouring into plates, was inoculated by streaking the surface and incubated aerobically at 30° C. for two days. The evolution of bubbles from bacterial cells on the addition of hydrogen peroxide was accepted as an indication of catalase-like activity. Again the cultures were strongly catalase-positive; the medium itself did not decompose peroxide. Catalase-like activity could also be induced by flooding with hæmin (50 μgm. per ml. hæmatin–hydrochloric acid) catalase-negative cultures, grown on the basal medium, and testing after incubation for a further hour.

A selection of lactic acid bacteria was then examined for catalase-like activity on heated-blood agar and on the basal medium, inoculated and incubated as before. Glucose was replaced by arabinose, fructose, or xylose for certain strains which grew feebly with glucose as the energy source. The identity of the heterofermentative lactobacilli, the *casei-plantarum* group of lactobacilli, the leuconostocs, and the pediococci, was determined so far as possible by physiological and morphological tests. The remaining organisms are listed under the names they had when received from the sources indicated in Table 1. The results (Table 1) show that the property of forming a catalase-like system, in the presence of heated blood, is possessed by a number of strains. A few strains of pediococci, however, were weakly catalase-positive on both heated-blood and blood-free media and are not, therefore, recorded in the table as having catalase-like activity only on heated-blood medium. All other strains of lactic acid bacteria examined were either catalase-negative on the heated-blood and on the basal media or developed a catalase-like activity on the heated-blood medium only. A few strains of *Leuconostoc* and *Lactobacillus plantarum*, National Collection of Dairy Organisms (N.C.D.O. 704), were inhibited in the presence of blood. In these cases cultures on the basal medium were flooded with hæmin and tested as described previously. All were catalase-negative.

These results led to further work on the nature of the hæm-requiring catalase-like system. A washed cell suspension of *L. plantarum*, National Collection of Industrial Bacteria (N.C.I.B. 5914), which is

Table 1. Catalase-like Activity on Heated-Blood Agar

Organism and No. of cultures	Source	No. catalase-positive
Genus *Lactobacillus*		
L. acidophilus (2)	N.C.I.B.	0
L. bulgaricus (1)	,,	0
L. lactis (1)	,,	0
L. thermophilus (1)	,,	0
L. leichmannii (3)	,,	0
L. delbrueckii (4)	,,	0
L. helveticus (1)	N.C.D.O.	0
L. salivarius (2)	Dr. M. Rogosa and Dr. M. E. Sharpe	0
L. casei (8)	N.C.I.B., N.C.D.O., Dr. R. M. Keddie and own isolates	1 (N.C.D.O. 161)
L. plantarum (22)	N.C.I.B., N.C.D.O., Dr. R. M. Keddie and own isolates	20 (N.C.I.B. 6105, N.C.D.O. 704, negative)
L. buchneri (22)	N.C.I.B. and own isolates	0
L. brevis (30)	N.C.I.B., Dr. M. E. Sharpe and own isolates	28 (N.C.I.B. 4036, 4617, negative)
L. fermenti (4)	N.C.I.B. and N.C.D.O.	0
L. cellobiosus (2)	Dr. M. Rogosa	2
L. viridescens (2)	Dr. M. E. Sharpe	0
L. fructivorans (2)	N.C.I.B.	2
L. hilgardii (1)	,,	0
Unidentified (18)	Dr. T. Gibson and own isolates	0
Genus *Leuconostoc*		
L. mesenteroides		
Non-slime formers (16)	N.C.D.O., Dr. T. Gibson and own isolates	8 (own isolates)
Slime formers (60)	N.C.I.B., N.C.D.O. and own isolates	0
L. dextranicum (7)	N.C.I.B., N.C.D.O. and own isolates	0
L. citrovorum (4)	N.C.D.O.	0
Genus *Streptococcus*		
S. faecalis (12)	N.C.I.B., N.C.D.O., Dr. P. M. F. Shattock and own isolates	0
S. faecium (10)	N.C.D.O., Dr. P. M. F. Shattock and own isolates	0
S. liquefaciens (3)	N.C.D.O. and own isolates	0
S. zymogenes (2)	N.C.D.O.	0
S. durans (2)	,,	0
S. thermophilus (2)	,,	0
S. lactis (4)	,,	0
S. cremoris (4)	N.C.D.O. and N.C.I.B.	0
Genus *Pediococcus*		
Various strains (21)	N.C.I.B., stock cultures and own isolates	3 (N.C.I.B. 8018 and two stock cultures)

catalase-positive on heated-blood agar, was prepared from an aerobic culture on the basal medium; the cells then showed no catalase activity. Within 5 min. of the addition of hæmin solution (5 μgm. per ml. hæmatin–hydrochloric acid) they developed a strong catalase-like activity. Holding the cells alone in boiling water followed by the addition of hæmin, or boiling the cells 10 min. after the addition of hæmin, resulted in their failure to acquire a catalase-like activity. Cell suspensions of *L. casei* N.C.I.B. 4113, which is catalase-negative on the heated-blood medium, did not become catalase-positive in the presence of hæmin. These findings suggest that certain lactic acid bacteria possess a protein capable of coupling with a hæm compound to form a system which actively splits hydrogen peroxide. This system did not appear to be sensitive to acidity, since a representative selection of strains exhibited a strong catalase-like activity when they were grown aerobically on heated-blood media at an initial pH of 7·0, 5·4 and 4·5. Anaerobic cultural conditions, however, did lessen the peroxide-splitting activity of a few strains of heterofermentative lactic acid bacteria.

As mentioned earlier, some pediococci were weakly catalase-positive on several media. Therefore all the heterofermentative organisms, the *plantarum-casei* group of lactobacilli, the streptococci, and the pediococci, were examined for catalase activity on the basal medium containing 0·05 per cent glucose. Only six slime-forming strains of *Leuconostoc mesenteroides*, and ten of the pediococci showed catalase activity, the leuconostocs being less active than the pediococci. The catalase activity of all six leuconostocs and five of the pediococci decreased as the glucose concentration was increased. This decrease in catalase activity agrees with previous findings for pediococci[3] and *Lactobacillus plantarum*[4]. The presence of heated-blood or hæmin had no effect upon the activity, which suggests that two distinct catalase-like systems occur in the lactic acid bacteria. A study of the effect of initial pH and oxygen, using 0·05 per cent glucose basal medium, revealed that the catalase-like activity of the leuconostocs diminished with lowering of pH and was absent altogether in anaerobically grown cultures, except for one strain which exhibited a very weak activity after being allowed to stand for 1 hr. in contact with the atmosphere before the addition of peroxide. The catalase-like activity of the pediococci was just as apparent in cells grown aerobically or anaerobically; it was influenced by pH but not uniformly in all strains. The strains showing activity in 0·5 per cent glucose media were only slightly affected by a pH (initial) as low as 4·5. Other strains, catalase-negative in 0·5 per cent glucose media, were as sensitive as the leuconostocs to pH.

There appears, therefore, to be at least two recognizable forms of catalase-like activity in the series of lactic acid bacteria examined. The first is a vigorous hydrogen-peroxide destroying system, not sensitive to acid and requiring an external source of hæm. It is possessed by certain strains of homo- and heterofermentative lactobacilli, pediococci, and leuconostocs. The second is a much weaker, often acid-sensitive system, possessed by further strains of leuconostocs and pediococci. A catalase-like activity similar to the latter type has been recorded previously for the pediococci[3], strains of *L. plantarum*[4], and possibly, though no details were given[5], for non-slime and slime-forming strains of *Leuconostoc mesenteroides*, and additional strains of *L. plantarum*.

This, and further work, will be reported in more detail elsewhere. I wish to express my thanks to Dr. T. Gibson for his advice during this work, to Dr. R. M. Keddie for his criticism, and to those who kindly sent me cultures.

R. Whittenbury

Department of Bacteriology,
Edinburgh School of Agriculture,
West Mains Road,
Edinburgh 9.

[1] Kneteman, A., *Antonie van Leeuwenhoek J. Microbiol. Serol.* 13, 55 (1948).
[2] Kraus, F. W., Nickerson, J. F., Perry, W. I., and Walker, A. P., *J. Bact.*, 73, 727 (1957).
[3] Felton, E. A., Evans, J. B., and Niven, C. F., *J. Bact.*, 65, 481 (1953).
[4] Dacre, J. C., and Sharpe, M. E., *Nature*, 178, 700 (1956).
[5] Langston, C. W., and Bouma, C., *Bacterial Proc.*, 17 (1959).

Production of Tuberculin Sensitivity

Delayed, or tuberculin-type, sensitivity occurs in the course of many bacterial infections. It is characterized by skin reactions appearing with 24–48 hr. after intracutaneous injections of bacteria or their soluble products. Like immunological reactions, delayed skin reactions are highly specific, but the products eliciting the reactions need not be antigenic *per se*. Circulating antibodies have not been demonstrated to play a part. Delayed sensitivity is not transferable passively by serum, but can be transferred with the cells of sensitized organisms.

Table 1. TUBERCULIN REACTIONS IN GUINEA PIGS SENSITIZED WITH PURIFIED PROTEIN DERIVATIVE OF TUBERCULIN ADSORBED TO EXUDATE CELLS

Guinea pig No.	0 hr.	4 hr.		24 hr.		Active cutaneous anaphylaxis†	Passive cutaneous anaphylaxis
	Skin thickness*	Skin thickness	Diameters of erythema (mm.)	Skin thickness	Diameters of erythema (mm.)		
1	30	36	9 × 10	42	12 × 14	—	—
2	24	29	10 × 11	31	10 × 12	—	—
3	27	34	7 × 7	36	16 × 16	—	—
4	30	32	6 × 7	35	8 × 10	—	—
5	32	44	10 × 12	44	9 × 11	—	—
6	30	35	8 × 9	42	11 × 12	—	—
7	27	29	5 × 5	30	9 × 11	—	—

* The thickness of a skin-fold was measured with callipers. The calliper readings which appear in the table are multiples of 0·1 mm.
† This test was performed on a different set of animals immunized in exactly the same way. — indicates that the test was negative.

Delayed sensitivity to tuberculin occurs regularly after infection with virulent or attenuated tubercle bacilli as well as after the injection of killed mycobacteria. It can also be produced by injecting native tuberculo-protein along with certain wax fractions of tubercle bacilli[1].

Delayed sensitivity seems to occur mainly when the antigenic materials have been phagocytosed (as is the case in bacterial infections) and there appears to exist a certain correlation between the intracellular state of micro-organisms and their ability to cause delayed sensitivity. An attempt was therefore made to sensitize animals with tuberculin by binding it firmly to phagocytes and using these treated cells to sensitize animals. For these experiments, a purified protein derivative of tuberculin, batch *RT 23* (Statens Seruminstitut, Copenhagen, Denmark), was chosen. This preparation is widely used for tuberculin testing of humans.

A typical experiment is described. Normal guinea pigs were injected intraperitoneally with 10 ml. of a 0·0001 per cent solution of glycogen in saline. Four days later, the exudates consisting mainly of monocytes were collected from the peritoneal cavities. The cells were washed with heparinized Tyrode solution and resuspended in Tyrode. The average yield was about 1 × 10^8 cells per guinea pig. 10 ml. of pooled exudates from 4–6 animals were incubated with 10 mgm. purified protein derivative of tuberculin for 40 min. at 37° C. The cells were then washed five times in Tyrode to remove all non-adsorbed derivative. Studies with the purified protein derivative of tuberculin labelled with chromium-51 (ref. 2) showed that 10^8 cells adsorbed about 0·1 mgm. of the derivative. The washed, sensitized cells were suspended in Tyrode, and new guinea pigs, weighing about 350 gm., were injected into the footpads with approximately 10^8 cells in 1·0 ml. Tyrode.

Twelve days later the guinea pigs were tested intracutaneously with 250 T.U. purified protein derivative of tuberculin. Reactions were read at 4–5, 24 and 48 hr. Table 1 shows the results. The majority of the reactions had all the characteristics of tuberculin reactions. They were indistinguishable in their appearance from the reactions observed in control guinea pigs which had been sensitized at the same time with living *BCG*.

Two guinea pigs (Nos. 2 and 5) had reactions which seemed to be mixed Arthus and tuberculin reactions, appearing earlier but persisting as long as the pure delayed reactions. In another, similar experiment 31 days were permitted to elapse between sensitization and tuberculin testing. The guinea pigs, there too, showed typical delayed reactions.

Similar skin reactions were observed when guinea pigs were tuberculin tested 12 days after they had been injected with purified protein derivative of tuberculin (0·1 mgm. in 0·1 ml. saline) into the centre of a sterile abscess produced four days previously by an intramuscular injection of 0·1 ml. turpentine into the thigh. However, tuberculin sensitivity failed to occur when normal guinea pigs were injected with the derivative directly into the footpads, or into the skin or, intraperitoneally, into preformed four-day-old exudates. Injection of the derivative adsorbed to guinea pig cells from one day-old polymorphonuclear exudates gave irregular results. Four-day exudate cells from rabbits, or red blood cells from guinea pigs, sheep or rabbits, when sensitized with the derivative and injected into guinea pigs, failed to induce delayed reactions. In those instances where no delayed reactions occurred, the guinea pigs developed immediate-type Arthus reactions. Intense local bluing was observed in these animals when they were injected intravenously with Evans blue ½ hr. before skin testing. This reaction is characteristic of active cutaneous anaphylaxis[3]. The presence of antibodies to the derivative in some of these guinea pigs could be detected by passive cutaneous anaphylaxis as described by Ovary[3]. Antibodies appeared more frequently after repeated skin testing with 250 T.U. purified protein derivative of tuberculin.

Animals with characteristic tuberculin reactions did not show active cutaneous anaphylaxis. Circulating antibodies could not be detected and tests for passive cutaneous anaphylaxis were negative.

Histologically, the reactions showed the characteristic features of delayed reactions, that is, infiltration with mononuclear cells, oedema, absence of perivascular infiltrations, few polymorphonuclear leucocytes.

The absorption of soluble antigens to autologous or homologous cells might provide useful experimental models for the study of delayed sensitivity. A variety of systems with different purified protein preparations is currently being investigated.

This work is supported by research grant No. *E*-2104 from the National Institutes of Allergy and Infectious Diseases. We are grateful to Dr. S. V. Boyden for helpful discussions.

HUBERT BLOCH
ALBERT A. NORDIN

Department of Microbiology,
School of Medicine,
University of Pittsburgh,
Pittsburgh, Pa.

March 15.

[1] Raffel, S., *J. Infect. Dis.*, 82, 267 (1948).

[2] Braude, A. I., "A Comparison of Sensitivity to Tuberculin and Bacterial Endotoxin by means of Isotopes", Ann. Rep. Research and Development Division, Office of the Surgeon General, October 31, 1958, pp. 27–52 (Department of the Army, Washington 25, D.C.).

[3] Ovary, Z., *Prog. Allergy*, 5, 459 (1958).

SOIL SCIENCE

Potassium-supplying Power of Some British Soils

British soils containing similar amounts of total potassium can vary greatly in their ability to release non-exchangeable potassium, but the reasons for this are not well understood. The non-exchangeable potassium reserves in many soils become available to plants as the exchangeable and water-soluble potassium is removed. Some soils can provide amounts of potassium adequate for crop growth during many years, but the release from reserves in others is too slow to meet crop requirements. The nature of the potassium-containing minerals and their amount and distribution of particle size are undoubtedly important; the past cropping history and the nature and amount of potassium fertilizer residues also influence the release of potassium from soils.

Continuous cropping without potassium fertilizer was used successfully in glasshouse experiments to measure releases of non-exchangeable potassium[1]; the total amount released is termed here the potassium-supplying power of the soil. For 19 different arable top soils, releases of non-exchangeable potassium to perennial ryegrass during 18 months in the glasshouse ranged from none to the equivalent of 2,000 lb. potassium per acre (Arnold, P. W., and Close, B., unpublished results). The soils, all of which contained more than 1·0 per cent total potassium, are divided in Table 1 into poor, moderate and good releasers (< 200, 200–1,000 and > 1,000 lb. potassium per acre, respectively) of non-exchangeable potassium. Only soil 19 is known to have received heavy potassium fertilization. Soils of poor and moderate potassium-supplying power were exhausted before the end of 18 months in the glasshouse, whereas the good releasers continued to provide potassium satisfactorily for grass. The clay (particles < 2μ) obtained from uncropped soils after treatment with hydrogen peroxide and dispersion in sodium hexametaphosphate was divided into parts: < 0·1, 0·1–0·3 and 0·3–2·0μ separates with a Sharples supercentrifuge. The oven-dry weights (104° C.) and the total potassium contents (hydrogen fluoride–sulphuric acid digestion, *EEL* flame photometer) of each clay separate were determined.

The potassium contents of the < 0·1μ separates and their proportions in the soils, plotted in Fig. 1, show that 17 of the 19 soils fall clearly into three categories corresponding to poor, moderate and good rates of release of potassium. High percentages of potassium in the fine clay and/or large proportions of fine clay were associated with large releases of potassium. Two soils were atypical. Soil 16, overlying glauconitic Malmstone, released considerable amounts of potassium to H-resin from silt-size particles[2]. No. 19 is a soil heavily fertilized with potassium from the Broadbalk wheat field (Plot 13); the accumulated fertilizer residues have changed the soil from a poor source of potassium, typified by soil 7 (Broadbalk Plot 11, cropped without potassium fertilizer), to a good source without increasing the potassium content of the fine clay by more than 0·2 per cent. These facts account for the good potassium-supplying powers of the two soils not being reflected in the analysis of their fine clay separates. Results for the 0·1–0·3μ clay separates were almost equally satisfactory for grouping the soils into poor, moderate and good release categories. Again, soils 16 and 19 were atypical. The potassium contents of the 0·3–2·0μ separates and their proportions in the soils, plotted in Fig. 2, showed a less well-defined relationship with the potassium-supplying power of the soils.

Table 1. Soils of Poor, Moderate and Good Potassium-supplying Power

No.	Soil series	Clay < 2μ per cent	Substratum	
1	Oak	19	Boulder Clay (non-calcareous or decalcified)	Poor potassium-supplying power, < 200 lb./acre
2	Hatfield	14	Brick-earth	
3	Thorne	24	Weald Clay	
4	Nordrach	15	Silty drift over Carboniferous Limestone	
5	Gaerwen	18	Micaceous Schist	
6	Woburn	9	Lower Greensand	
7	Batcombe	22	Clay-with-flints	
8	Hanslope	27	Chalky Boulder Clay	Moderate potassium-supplying power, 200–1,000 lb./acre
9	Hanslope	21	Chalky Boulder Clay	
10	Windsor	38	London Clay	
11	Bromyard	21	Red Marl (Downtonian)	
12	Lilleshall	20	Red Marl (Upper Coal Measures)	
13	Wicken	50	Gault Clay (resorted)	
14	Brenzett	37	Silt (marine) from Romney Marsh	Good potassium-supplying power, > 1,000 lb./acre
15	Denchworth	35	Oxford Clay	
16	Harwell	17	Malmstone (Upper Greensand, glauconitic)	
17	Evesham	35	Calcareous Lower Lias Clay	
18	Worcester	38	Red Marl (Keuper)	
19	Batcombe (potassium-fertilized annually)	21	Clay-with-flints	

Soil 7: Broadbalk, Plot 11, no potassium.
Soil 9: Saxmundham long-term experiment, Plot 4, no potassium.
Soil 19: Broadbalk, Plot 13, fertilized with potassium.

Because low potassium in the fine clay (< 0·3μ approximately) and small contents of fine clay were associated with poor releasers, fine clay particles are usually more important than coarse clay in releasing potassium in these soils. Fine distinctions between soils cannot, however, be expected, nor can it be assumed that in good releasers the coarse clay is unimportant. A detailed study of soil 9 before and after continuous cropping showed that about 40 per cent of the potassium released came from the

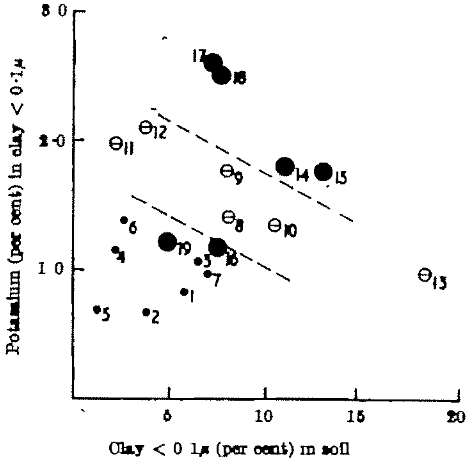


Fig. 1. Percentage and potassium content of clay < 0·1μ in relation to the potassium-supplying power of soils: •, poor; ϴ, moderate: ●, good

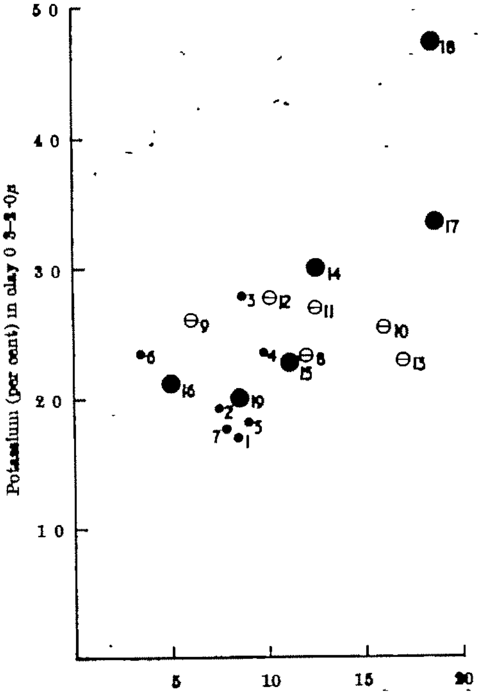


Fig. 2. Percentage and potassium content of clay 0·3–2·0μ in relation to the potassium-supplying power of soils: •, poor; Θ, moderate; ●, good

< 0·1μ clay and 40 per cent from the 0·1–0·3μ clay, there being approximately 7 per cent of each fraction in the soil. The remaining 20 per cent was released from > 0·3μ particles which contained 75 per cent of the total potassium in the soil.

Rouse and Bertramson[3] obtained a positive correlation between the area under the 'illite' peak on X-ray spectrograms of the fine clay separates (< 0·2 and 0·2–1·0μ) and the potassium-supplying power, assessed by chemical means, of several Indiana soils. In general, however, there have been few successful attempts to relate the mineralogical composition of soils to their ability to release potassium. This is not unexpected because, as Reitemeier[4] has stated, even for the most important group of potassium-containing soil minerals, the micas and hydrous micas, their behaviour in soils is little known.

Progress in this subject needs appropriate mineralogical studies in association with simple chemical work designed to reveal trends in soil behaviour, and equally important, to recognize soils that are atypical. Without adequate physical and chemical work, mineralogical studies are likely to be unnecessarily complex, particularly on soils of diverse origin and variable age.

Thanks are due to members of the staff of the Soil Survey of England and Wales, who provided most of the soils used in the work.

P. W. ARNOLD

Rothamsted Experimental Station,
Harpenden,
Hertfordshire.

---

[1] Bear, F. E., Prince, A. L., and Malcolm, J. L., *Soil Sci.*, 58, 139 (1944).

[2] Rep. Rothamsted Exp. Sta. for 1958, p. 55.

[3] Rouse, R. D., and Bertramson, B. R., *Proc. Soil Sci. Soc. Amer.*, 14, 113 (1950).

[4] Reitemeier, R. F., "Advanc. Agron." 3, 113 (1951).

STATISTICS

Analysis of Small Experiments

CONSIDERATIONS set out below suggest that unless we can justify certain assumptions, quantitative inferences based on the results of single small experiments may be misleading. Workers who claim they are only interested in clear-cut effects should consider carefully what they mean by this before the experiment starts. There is a danger that if a test gives a statistically significant result this will be regarded *a posteriori*, even if not *a priori*, as establishing an important effect.

Despite certain criticisms made here, small experiments have an undoubted use for suggesting further lines of research. It is also true that a series of small experiments may be more informative than one large experiment.

Significance tests and estimation procedures are commonly based on normal distribution theory, and departures from assumptions will often have more effect in small experiments than in large ones.

We consider this matter in relation to three logically distinct practical situations of common occurrence.

Situation 1. The size of the experiment is limited by the number of experimental units available. Unless we have knowledge gained from previous experience with similar material there is insufficient information in this case to postulate a particular parent distribution. Distribution free randomization tests as developed by Pitman[1] and others are appropriate, but in very small experiments they do not provide tests at a practically useful level. For example, with three replicates of each of two treatments, tests for differences between means can only be performed at certain discrete values exceeding the 10 per cent significance-level. For larger experiments this difficulty does not arise.

Situation 2. Ample potential units are available, but other factors limit the size of the experiment; the units actually used are selected on some criterion of uniformity. Normal distribution theory tests can then be justified if selection is based on standardization of a quantity about which the experimental variate is known to be normally distributed; but it is seldom that such precise knowledge is available. However, selection for uniformity usually invalidates normal distribution theory tests. If we select about average material we may obtain something like a sample from a rectangular distribution, while selection of the best available material will often lead to an upper tail sample not unlike one from an exponential distribution. Incidentally, with selection for uniformity observations need to be taken with a very high degree of accuracy, or the clustering together of values may give rise to large rounding off errors in variance estimates.

Situation 3. Ample potential units are available, other factors once more limiting the size of the experiment; the units actually used are selected at random. Normal distribution theory procedures are correct in this situation providing the variate has an approximately normal distribution over all potential units, but we can expect large standard errors. For other parent distributions sampling theory based on those distributions can be used; but this is seldom done in practice, either because of difficulty in specifying the parent distribution, or on account of complexities in the sampling theory of all but a few distributions.

As alternatives to normal distribution theory tests are not readily available in practice, it is of interest to know something of the effects of using them when they are not theoretically justifiable. I have carried out a series of sampling trials simulating the various situations above for an experiment with three replicates of each of two treatments, there being zero treatment difference. A normal distribution theory t-test was used to detect significant differences, and too high a proportion of significant results was nearly always obtained at both the 1 per cent and 5 per cent levels when normal distribution theory assumptions did not hold. Twelve batteries, each of 200 or more tests, were performed. In only one case, corresponding to random sampling from an exponential distribution, were too few significant results obtained. When testing at the 5 per cent level the proportion of significant results was as high as 10 per cent in one battery. With another battery the proportion of results significant at the 1 per cent level was as high as 5·7 per cent. The last two cases involved samples corresponding to situations 1 and 2, respectively. When normal distribution theory assumptions held, the proportion of significant results was generally close to the test-level, for example, between 5 and 6·7 per cent when testing at the 5 per cent level.

When the alternatives to a small experiment are no experiment or a long wait, it seems clear that a decision on the course of action should not be divorced from statistical considerations associated with the logical situation. The situations discussed are not exhaustive, but cover a wide range of practical cases.

The points raised apply both to estimation and significance testing, and some of them are worthy of consideration in correlation and regression problems with few pairs of observations.

My thanks are due to Dr. S. C. Pearce for stimulating discussions on the logical status of small experiments.

P. SPRENT

East Malling Research Station,
Maidstone,
Kent.

[1] Pitman, E. J. G., *J. Roy. Statist. Soc.*, Supp., 4, 119 (1937).

Significance of the Difference between Two Means when the Population Variances may be Unequal

THE purpose of this communication is to present a simple test applicable at the 5 per cent level to the general case of the significance of the difference between two means. If we have two samples of n_1 and n_2 variates from normal populations with the same, though unknown, scale factor, that is, $\sigma_1 = \sigma_2$, the significance of the difference between the means can be tested by the criterion:

$$t = (\bar{x}_1 - \bar{x}_2) \Big/ \sqrt{\left\{ \frac{\Sigma_1 + \Sigma_2}{n_1 + n_2 - 2} \left(\frac{1}{n_1} + \frac{1}{n_2} \right) \right\}}$$

where Σ_1 and Σ_2 represent the sums of squares from the respective means and t is referred to Student's integral with $n_1 + n_2 - 2$ degrees of freedom. If the scale factors are unequal the use of this criterion involves a bias[1] which is small if $n_1 = n_2$ but which can be large if $n_1 \neq n_2$. When the relative scale factor of the two populations is known, appropriate weighting of the sums of squares gives an exact solution. In the case where the relative scale factor is unknown, Fisher[2,3] advocates the use of a different criterion, Behrens' d[4], which can be expressed as:

$$d = (\bar{x}_1 - \bar{x}_2) \Big/ \sqrt{\left\{ \frac{\Sigma_1}{n_1(n_1 - 1)} + \frac{\Sigma_2}{n_2(n_2 - 1)} \right\}}$$

and tables[5,6] are available for the 5 per cent and 1 per cent points of this distribution for a lattice of values of n_1 and n_2 both greater than 6.

In a previous communication[7] it was pointed out that when Student's t is standardized by dividing it by its own standard deviation, the variability of the tails with the number of degrees of freedom is greatly reduced and in particular the 5 per cent values of standardized t, denoted t_s, for 4 or more degrees of freedom all lie within the limits 1·96 and 2·0. With reference to the present problem:

$$t_s = (\bar{x}_1 - \bar{x}_2) \Big/ \sqrt{\left\{ \frac{\Sigma_1 + \Sigma_2}{n_1 + n_2 - 4} \left(\frac{1}{n_1} + \frac{1}{n_2} \right) \right\}}$$

Behrens' d can be adjusted in a similar way giving:

$$d_s = (\bar{x}_1 - \bar{x}_2) \Big/ \sqrt{\left\{ \frac{\Sigma_1}{n_1(n_1 - 3)} + \frac{\Sigma_2}{n_2(n_2 - 3)} \right\}}$$

From the relationship between Behrens' d and its adjusted value d_s, implicit in the above formulæ, the value of d_s corresponding to each value of d in the 5 per cent table was calculated with the remarkable result that all these values of d_s lie within the range 1·96 to 2·0 whereas d itself ranges from 1·960 to 2·447. Hence, provided that n_1 and n_2 are both greater than 6, if $d_s > 2$ the difference between the means is significant at the 5 per cent level; if $d_s < 1·96$, the difference is not significant. The formula was suggested by Welch but he did not give numerical values.

When $n_1 = n_2 = n$, say, the formulæ for t and d are identical but the numerical values for a given level of significance are different; d is more stringent. The corresponding adjusted criteria are:

$$t_s = (\bar{x}_1 - \bar{x}_2) \Big/ \sqrt{\left\{ \frac{\Sigma_1 + \Sigma_2}{n(n - 2)} \right\}}$$

and

$$d_s = (\bar{x}_1 - \bar{x}_2) \Big/ \sqrt{\left\{ \frac{\Sigma_1 + \Sigma_2}{n(n - 3)} \right\}}$$

Both lie between 1·96 and 2·0 at the 5 per cent point for $n > 6$. The factor $n - 3$ compared with $n - 2$ reflects the absence of information about the relative scale factors of the two populations.

JOHN B. DE V. WEIR

University of Glasgow,
Glasgow, W.2.

[1] Welch, B. L., *Biometrika*, 29, 350 (1938).

[2] Fisher, R. A., *Ann. Eugen.*, 6, 391 (1935).

[3] Fisher, R. A., "Statistical Methods and Scientific Inference", 94 (1956).

[4] Behrens, W.-U., *Landw. Jb.*, 68, 807 (1929).

[5] Sukhatme, P. V., *Sankhya*, 4, 39 (1938).

[6] Fisher, R. A., and Yates, F., "Statistical Tables for Biological, Agricultural and Medical Research", fifth ed. (1957).

[7] Weir, J. B. de V., *Nature*, 185, 558 (1960).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT (honours graduate) IN THE DEPARTMENT OF BOTANY—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (August 5).

ASSISTANT LECTURER IN PURE MATHEMATICS—The Registrar, The University, Sheffield (August 6).

UNESTABLISHED ASSISTANT EXPERIMENTAL OFFICER (with a degree in agriculture or pure science with main subject zoology) IN THE DEPARTMENT OF AGRICULTURE AND FISHERIES FOR SCOTLAND, PERTH—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G265/OA (August 6).

RESEARCH ASSISTANTS (3) IN THE DEPARTMENT OF METALLURGY, County Technical College, Wednesbury, to work on one of a variety of research projects, several of these being within the field of atomic energy—The Director of Education (Staffing), County Education Offices, Stafford (August 9).

ASSISTANT (with special interest in pig husbandry) IN ANIMAL HUSBANDRY—The Secretary, The University, Aberdeen (August 12).

RESEARCH STUDENTS (with a good honours degree in chemistry or biochemistry) IN THE BIOCHEMISTRY DIVISION OF THE PHYSIOLOGY DEPARTMENT, for investigation on the chemistry and biochemistry of lipids, leading to a M.Sc. or Ph.D.—Dr. C. Long, Biochemistry Division, Physiology Department, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2 (August 13).

TEMPORARY ASSISTANT LECTURER IN PURE MATHEMATICS—The Registrar, University College, Singleton Park, Swansea (August 13).

LECTURER IN THE DEPARTMENT OF METALLURGY for duties primarily concerned with teaching and research in diffraction metallography with particular reference to X-ray work—The Registrar, The University, Liverpool, quoting Ref. CV/T (August 15).

LECTURER OR ASSISTANT LECTURER IN ZOOLOGY with special reference to vertebrate zoology or genetics, at the University of Malaya (Singapore Division)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 15).

LECTURERS or ASSISTANT LECTURERS (3) IN THE DEPARTMENT OF GEOGRAPHY, University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Kuala Lumpur and London, August 15).

LIBRARIAN (man or woman graduate with a library qualification and preferably a scientific background)—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1 (August 15)

NEUROPHYSIOLOGIST (with Ph.D. or equivalent) IN THE DEPARTMENT OF ZOOLOGY for research on central nervous physiology of the Lepidoptera—The Secretary, University College, Gower Street, London, W.C.1 (August 15).

LECTURER OR VISITING LECTURER IN GEOGRAPHY at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, August 19).

FOUNDATION CHAIR OF PHILOSOPHY in Monash University, Clayton, Victoria, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 22).

JUNIOR LECTURER IN ZOOLOGY—The Registrar, Trinity College, Dublin (August 22).

SENIOR LECTURER IN CROP HUSBANDRY—The Principal, Seale-Hayne Agricultural College, Newton Abbot, Devon (August 22).

ASSISTANT LECTURER IN CHEMICAL PATHOLOGY—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (August 26).

SENIOR LECTURER, and a LECTURER IN SOIL SCIENCE at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 30).

KEEPER (graduate) OF THE SCIENCE BOOKS in the University Library—The Librarian, Durham University Library, Palace Green, Durham (September 3).

LECTURER IN THE DEPARTMENT OF GEOLOGY—The Secretary, The University, Aberdeen (September 3).

ASSOCIATE PROFESSOR (with special interests in ballistics) IN THE DEPARTMENT OF MATHEMATICS; an ASSOCIATE PROFESSOR (with special interests in applied mechanics, including fluid dynamics) IN THE DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING; and an ASSOCIATE PROFESSOR (with special interests in applied thermodynamics) IN THE DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING, Royal Military College of Science, Shrivenham—Civil Service Commission, 17 North Audley Street, London, W.1, quoting Ref. 8/5156/60 (September 5).

LECTURER IN PSYCHOLOGY at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 7).

LECTURER or SENIOR LECTURER IN FLUID DYNAMICS at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 7).

LECTURER/SENIOR LECTURER (preferably with experience in medical bacteriology) IN BACTERIOLOGY at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 9).

UNIVERSITY LIBRARIAN (university graduate with appropriate professional experience)—The Registrar, The University, Liverpool (September 10).

SENIOR LECTURER (with a degree in dairying or a degree in pure science or agriculture with a diploma in dairying or in dairy technology) IN DAIRYING—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (September 14).

LECTURER/SENIOR LECTURER (qualified in grassland management) IN ANIMAL HUSBANDRY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 15).

SENIOR LECTURER and a LECTURER (with an honours degree, preferably in chemical engineering, with research and/or industrial experience) IN CHEMICAL ENGINEERING at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 15).

SENIOR LECTURER IN CLINICAL BIOCHEMISTRY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 30).

CHAIR OF CHEMISTRY at the School of Pharmacy—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 14).

AGRICULTURAL OFFICER (Tobacco Research) (with an honours degree in natural science (botany), or a degree in horticulture, with suitable postgraduate training or experience), in Nyasaland for experimental work on tobacco including agronomy trials and plant breeding—The Director of Recruitment, Colonial Office, London, S.W.1, quoting Ref. BCD.63/4/04/T.

AGRONOMIST (Livestock), (with a good honours degree in agriculture and postgraduate experience or training in animal genetics) in Uganda, to take charge of a large breeding scheme designed to produce improved beef cattle utilizing local and imported stock—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/9/038.

ASSISTANT LECTURER or LECTURER (with qualifications in zoology with biochemistry or physiology)—The Principal, Derby Training College, Uttoxeter New Road, Derby.

CENTRAL ELECTRICITY BOARD RESEARCH FELLOW (with a good degree in electrical engineering or physics of a British university or an equivalent qualification, and preferably experience of vacuum electronics) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING for work on thermo-electron engines—The Secretary, University College, Gower Street, London, W.C.1.

LECTURER IN TROPICAL HYGIENE—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

LECTURER or ASSISTANT LECTURER IN MATHEMATICS at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

LECTURER (with an honours degree in chemical engineering or Corporate Member of the Institute of Chemical Engineers) IN CHEMICAL ENGINEERING—The Registrar, The University, Nottingham.

LECTURERS (2) IN ZOOLOGY, one to teach histology and microtechnique, and the other to teach ornithology (and if possible animal behaviour)—McGill University, Montreal, Quebec, Canada.

PROFESSOR or ASSOCIATE PROFESSOR (male graduate of a British university with appropriate teaching experience) OF BIOLOGY at Nanyang University, Singapore—The Director, Recruitment Department, British Council, 65 Davies Street, London, W.1, quoting Ref. N.11 T(60).

SENIOR DEMONSTRATOR IN THE DEPARTMENT OF PHYSICS—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 1015, Vol. 252 (5 May 1960): The Multiple Scattering of Waves by Weak Random Irregularities in the Medium. By I. D. Howells. Pp. 431–462. 10s. No. 1016, Vol. 252 (5 May 1960): A Theory of the Filament Temperature Distribution of the Tungsten Vacuum-Lamp, with special reference to Optical Pyrometry. By D. O. Russell and F. H. Schofield. Pp. 463–498. 11s. 6d. No. 1017, Vol. 252 (5 May 1960): A Kinematical Theory of Diffraction Contrast of Electron Transmission Microscope Images of Dislocations and other Defects. By P. B. Hirsch, A. Howie and M. J. Whelan. Pp. 499–520. 22s. (London: Royal Society, 1960.) [55

Tropical Aquaria. Pp. 51. (London: London County Council, Horniman Museum and Library, 1960.) 1s. [55

Edwards High Vacuum Limited. Report of the Director and Statement of Accounts for the year ended 31st December, 1959. Pp. 14. (Crawley: Edwards High Vacuum Limited, 1960.) [55

The British Rayon Research Association. (A general view of the research activities of the technological, machinery development and fundamental research departments, and of the amenities which the Association offers.) Pp. 28. Information Leaflets. No. 1: Speedframe Roller Vibration. P. 1. No. 2. Surveys of Automatic Looms. P. 1. No. 3: Yarn Structure. P. 1. No. 4: Fluid Beds—Drying. P. 2. No. 5; Machinery in the Spinning Department. P. 1. No. 6: Weft Supply: a Costing Assessment of the Various Methods Applicable to Conventional Automatic Looms. P. 1. No. 7: Research on Nylon. P. 1. No. 8. Surveys of Fibro Spinning. P. 1. No. 9: Improving Cellulosic Fibres. P. 1. No. 10: Fluid Beds—Dyeing. P. 1. No. 11: The Flow Properties of Solutions. P. 1. No. 12: The Projectoset: An Aid to Achieve Accurate Settings on Warp Knitting Machines. Pp. 2. (Wythenshawe, Manchester: British Rayon Research Association.) [55

Building Research Station Digest. No. 133 (April 1960): Domestic Heating and Thermal Insulation. Pp. 7. (London: H.M. Stationery Office, 1960.) 4d. [65

Ciba Foundation for the Promotion of International Co-operation in Medical and Chemical Research. Report for 1959. Pp. 52. (London: The Ciba Foundation, 1960.) [95

Society for Freedom in Science. Occasional Pamphlet No. 19 (December, 1959): Opposition Aroused in China by Marxist Planning of Scientific Research. Pp. 16. (Oxford: Dr. John R. Baker, Editor, Department of Zoology, University Museum, 1959.) 1s. 9d. [95

University of Reading. National Institute for Research in Dairying—Report 1959. Pp. 154. (Shinfield, Reading: National Institute for Research in Dairying, 1960.) 4s. [95

Journal of Reproduction and Fertility, Vol. 1, No. 1 (February 1960.) Pp. viii+120. Published quarterly. Annual subscription post free 70s.; U.S.A. and Canada 12 dollars. Single issues 20s. (Oxford: Blackwell Scientific Publications, 1960.) [95

Johnson Matthey and Co., Ltd. Silver Star Capacitors. Pp. 10. (Publication 1461.) (London. Johnson, Matthey and Co., Ltd., 1960.) [95

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 45. Breeding and Rearing Pigs. Pp. 12. (Belfast: Ministry of Agriculture, 1960.) [95

Illustrated Newspapers Limited. Report of the Directors to the Thirty-fourth Annual General Meeting of Shareholders and Statement of Accounts for the year ended 30th November, 1959. Pp. 8. (London. Illustrated Newspapers, Ltd., 1960.) [95

International Council for Bird Preservation, British Section. Annual Report for 1959. Pp. 36+4 plates. (London: International Council for Bird Preservation, British Section, c/o British Museum (Natural History), 1960.) 2s. [105

A Review of the Biological Control of Insects and Weeds in Australia and Australian New Guinea. By Frank Wilson. (Technical Communication No. 1 of the Commonwealth Institute of Biological Control, Ottawa, Canada.) Pp. viii+102. (Farnham Royal: Commonwealth Agricultural Bureaux; Ottawa: Commonwealth Institute of Biological Control, 1960.) 25s.; 3.75 dollars. [105

British Association for Commercial and Industrial Education. A Guide to the Writing of Business Letters. Fifth edition. Pp. 20. (London: British Association for Commercial and Industrial Education, 1960.) 2s. [105

Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act 1954, for 1959. Northumberland and Cumberland Division. By H. F. Wilson. Pp. iv+25+4 plates. (London: H.M. Stationery Office, 1960.) 2s. 6d. net. [105

Oundle School Natural History Society Report 1959. Pp. 41. (Oundle, Peterborough: Oundle School Natural History Society, 1960.) [105

The British Non-Ferrous Metals Research Association. Annual Report for 1959. Pp. 43. (London: British Non-Ferrous Metals Research Association, 1960.) [125

The Empire Cotton Growing Corporation. Progress Reports from Experiment Stations, Season 1958–1959. Tanganyika Territory, Lake Province. By J. M. Munro. Pp. 16. 1s. Nyasaland. Pp. 12. 1s. Northern Nigeria. Pp. 17. 1s. The West Indies. By J. R. Spence, C. T. Cave, W. B. Charles and M. A. Archibald. Pp. 18. 1s. (London: Empire Cotton Growing Corporation, 1960.) [125

National Society for Clean Air. Clean Air Year Book, 1960. Pp. 76. (London: National Society for Clean Air, 1960.) 2s. [125

The Research Association of British Flour-Millers, 1923–1960. Pp. xii+144. (St. Albans. Research Association of British Flour Millers, Cereals Research Station, 1960.) [125

Other Countries

Canada: Department of Northern Affairs and National Resources. National Museum of Canada. Bulletin No. 160: Contributions to Botany, 1958. Pp. iii+148 (3 plates). 2 dollars. Bulletin No. 162: Contributions to Anthropology, 1957. Pp. iii+203 (28 plates). 2 dollars. Bulletin No. 166: Contributions to Zoology, 1958. Pp. ii+59. 1 dollar. (Ottawa: Queen's Printer, 1959 and 1960.) [95

United States Department of the Interior: Fish and Wildlife Service. Fishery Bulletin No. 168: Oceanography of the East Central Equatorial Pacific as Observed during Expedition Eastropic. By Thomas S. Austin. Pp. iv+257–282. (Washington, D.C.: Government Printing Office, 1960.) 35 cents. [95

Smithsonian Institution, Washington, D.C. Proceedings of the United States National Museum. No. 3420: Mammals of Northern Columbia, Preliminary Report No. 8: Arboreal Rice Rats, a Systematic Revision of the Subgenus *Oecomys*, Genus *Oryzomys*. By Philip Hershkovitz. Pp. 513–568+12 plates. No. 3426: A Synopsis of the Atopetholidae, a Family of Spirobolid Millipeds. By Richard L. Hoffman and Barbara S. Orcutt. Pp. 95–165. No. 3427: Centipedes of the Smithsonian-Bredin Expeditions to the West Indies. By Ralph E. Crabill, Jr. Pp. 167–195. No. 3428: Meloid Beetles (Coleoptera) of the West Indies. By Richard B. Selander and John K. Bouseman. Pp. 197–226. (Washington, D.C.: Smithsonian Institution, 1960.) [95

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 41 (March 1960): Mortality Among Overweight Women. Disability Experience in 1959. Reduction in Premature Death. The Frequency of Accidental Poisoning. Pp. 12. (New York: Metropolitan Life Insurance Company, 1960.) [95

United States Department of Agriculture. Technical Bulletin No. 1211: The Anoplura of African Rodents and Insectivores. By Phyllis T. Johnson. Pp. iii+116. (Washington, D.C.: Government Printing Office, 1960.) 50 cents. [95

United States Department of Agriculture in co-operation with the Texas Agricultural Experiment Station. Production Research Report No. 34: Survival of the Pink Bollworm under Various Cultural and Climatic Conditions. By A. J. Chapman, L. W. Noble, O. T. Robertson and L. C. Fife. Pp. ii+21. (Washington, D.C.: Government Printing Office, 1960.) 15 cents. [95

University of South Carolina Publications. Series 3, Biology, Vol. 3, No. 1: Distribution and Bibliography (1892–1957) of the Fresh Water Sponges. By J. T. Penney. A Unique Environmental Situation in Steed's Pond, Savannah River Plant Area, South Carolina. By Harry W. Freeman. Pp. ii+111. (Columbia, S.C.: Department of Biology, University of South Carolina, 1960.) 1 dollar. [95

Institute of the National Parks of Belgian Congo, Brussels. Take Care of the National Parks. Pp. 22. (Brussels: Institute of the National Parks of Belgian Congo, 1960.) [95

Sandia Corporation, Albuquerque, New Mexico. Bibliography and Symposium Papers received from the Heat Engineering Research Institute (Státni Výzkumný Ustav Tepelné Techniky) in Prague, by Technical Information Division, Sandia Corporation. Pp. 21. (SCR-160. TID-4500 (15th edition). Mathematics and Engineering.) (Albuquerque. Sandia Corporation, 1960. Available from the Office of Technical Services, Department of Commerce, Washington, 25, D.C.) 0.75 dollars. [105

Chemical Titles: Current Author and Keyword Indexes from Selected Chemical Journals. No. 1, April 5, 1960. Published twice each month. Pp. ii+101. (Washington, D.C.: American Chemical Society, 1960.) [105

Biologisch Bundesanstalt fur Land- und Forstwirtschaft in Berlin-Dahlem. Bibliographie der Pflanzenschutzliteratur, 1958. Bearbeitet von Regierungsrat Dr. J. Bärner. (Bibliography of Plant Protection, 1958.) Pp. xii+527. (Berlin-Dahlem: Biologische Bundesanstalt für Land- und Forstwirtschaft, 1960.) [105

Ceylon. Administration Report of the Director of Fisheries for 1958. Pp. 82. (Colombo: Government Publications Bureau, 1960.) Rs. 2/05. [105

United States Department of the Interior: Geological Survey. Water-Supply Paper 1457: Ground-Water Conditions in the Avenal-McKittrick Area, Kings and Kern Counties, California. By P. R. Wood and G. H. Davis. Pp. iv+141+5 plates. Water-Supply Paper 1458: Geology and Ground-Water Resources of the Rawlins Area, Carbon County, Wyoming. By Delmar W. Berry. Pp. iv+74+1 plate. Water-Supply Paper 1484: Geology and Ground-Water Features of Shasta Valley, Siskiyou County, California. By Seymour Mack. Pp. v+115+2 plates. Water-Supply Paper 1553: Surface Water Supply of the United States, 1958. Part 2–A: South Atlantic Slope Basins, James River to Savannah River. Prepared under the direction of J. V. B. Wells. Pp. viii+273. 1 dollar. Water-Supply Paper 1559. Surface Water Supply of the United States, 1958. Part 6–A: Missouri River Basin above Sioux City, Iowa. Prepared under the direction of J. V. B. Wells. Pp. x+434. 1.50 dollars. Water-Supply Paper. 1564: Surface Water Supply of the United States, 1958. Part 10: The Great Basin. Prepared under the direction of J. V. B. Wells. Pp. viii+279. 1 dollar. Water-Supply Paper 1566: Surface Water Supply of the United States, 1958. Part 12: Pacific Slope Basins in Washington and Upper Columbia River Basin. Prepared under the direction of J. V. B. Wells. Pp. ix+381. 1.25 dollars. Water-Supply Paper 1567: Surface Water Supply of the United States, 1958. Part 13. Snake River Basin. Prepared under the Direction of J. V. B. Wells. Pp. ix+273. 1 dollar. Water-Supply Paper 1568: Surface Water Supply of the United States, 1959. Part 14: Pacific Slopes Basin in Oregon and Lower Columbia River Basin. Prepared under the direction of J. V. B. Wells. Pp. viii+292. 1 dollar. (Washington, D.C.: Government Printing Office, 1959 and 1960.) [105

United States Department of the Interior: Geological Survey. Bulletin 1028–O: Geological Reconnaissance of Semisopochnoi Island, Western Aleutian Islands, Alaska. By Robert R. Coats. Pp. vi+477–519+plates 59–68. 1.25 dollars. Bulletin 1028–P: Geology and Submarine Physiography of Amchitka Island, Alaska. By Howard A. Powers, Robert R. Coats and Willis H. Nelson. Pp. v+521–554+plate 69. Bulletin 1028–Q: Geology of Rat Island, Aleutian Islands, Alaska. By Richard Q. Lewis, Willis H. Nelson and Howard A. Powers. Pp. v+555–562+1 plate. 35 cents. Bulletin 1071–D: Geology of the Huerfano Park Area, Huerfano and Custer Counties, Colorado. By Ross B. Johnson. Pp. iii+87–119+plates 4–9. 1.25 dollars. Bulletin 1072–L: Distribution of Silica Resources in Eastern United States. By T. D. Murphy. Pp. iii+657–665+plates 30–38. Bulletin 1072–M: Geology and Fuel Resources of the Mesa Verde Area, Montezuma and La Plata Counties, Colorado. By Alexander A. Wanek. Pp. iv+667–721+plates 39–51. Bulletin 1098–D: Geology and Uranium Deposits of Monument Valley, San Juan County, Utah. By Richard Q. Lewis, Sr., and Donald E. Trimble. Pp. iv+105–131+plates 10–13. 1 dollar. (Washington, D.C.: Government Printing Office, 1959 and 1960.) [105

United States Department of the Interior. Geological Survey. Bulletin 1095: Bibliography of North American Geology, 1957. By Ruth Reece King, Virginia M. Jussen, Elisabeth S. Loud and Georgianna D. Conant. Pp. iii+551. 1.75 dollars. Bulletin 1105: Selected Annotated Bibliography of Gypsum and Anhydrite in the United States and Puerto Rico. By Charles F. Withington and Marion C. Jaster. Pp. iii+126. 50 cents. Bulletin 1106–D: Geophysical Abstracts 179, October–December, 1959. By Dorothy B. Vitaliano, S. T. Vesselowsky and others. Pp. iii+407–531. 40 cents. Bulletin 1109: Geologic Appraisal of Dimension-Stone Deposits. By L. W. Currier. Pp. iv+78+7 plates. Bulletin 1112–A: Selenium in Some Epithermal Deposits of Antimony, Mercury, and Silver and Gold. By D. F. Davidson. Pp. iii+16. 15 cents. Professional Paper 272–C: Review of Literature on Evaporation Suppression. By George E. Magin and Lois E. Randall. Pp. iii+53–60. 20 cents. Professional Paper 354–C: Giant Waves in Lituya Bay, Alaska. By Don J. Miller. Pp. iii+51–86+plates 2–10. (Washington, D.C.: Government Printing Office, 1960.) [105

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2.
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

EDUCATIONAL CO-OPERATION IN THE COMMONWEALTH

THE Commonwealth Teachers Bill, which received a second reading in the House of Commons on May 17 and the Royal Assent on June 2, gives effect to the second of the undertakings given by the United Kingdom Government at the Commonwealth Education Conference at Oxford last year. Steps have already been taken to give effect to the decisions relating to the Commonwealth Scholarship and Fellowship Plan, arrangements for the administration of which were outlined in a White Paper issued last November, and a Bill establishing the Commonwealth Scholarship Commission to administer the Plan in the United Kingdom was passed by Parliament in December 1959 (see *Nature*, 185, 214, 271, 505; 1960). On that Plan and on schemes for the training of teachers and for promoting recruitment of United Kingdom teachers for service in Commonwealth countries overseas, the Government proposes to spend £6 million during the next five years to fulfil the undertakings assumed at the Conference; of this sum, about £3·75 million will be required for the purposes of the new Act.

These latter schemes are described in a further White Paper on Commonwealth Educational Co-operation issued in May*. While in the long term the training of sufficient teachers to meet normal requirements can be achieved only by the efforts of the countries themselves, the Oxford Conference agreed that, in the short term, help from other Commonwealth countries could be decisive if carefully chosen and directed towards the most influential parts of the educational system of the recipient country. The United Kingdom Government, therefore, undertook to take steps, in co-operation with the responsible authorities, to make available to Commonwealth teachers additional places in teacher-training institutions in Britain and, within the limits of the funds available for the purpose, to provide grants covering fees and full maintenance to Commonwealth teachers nominated by their respective Governments, so as to enable them to take up these places. The sending country will normally bear the cost of travel to and from the training institution and the British Council will act as agent of the Commonwealth Relations Office and the Colonial Office for the payment of students' fees and allowances, and will be responsible for their reception on arrival in the United Kingdom and for their general welfare. They will be placed by a Commonwealth Bursary Unit in consultation with the training institutions. Provision will be made in the estimates of the Commonwealth Relations Office and the Colonial Office for expenditure of about £285,000 a year, and also some financial provision to afford opportunity to members of the staffs of teacher-training institutions in Britain at which such Commonwealth teachers study, to visit parts of the Commonwealth to see something of the environment in which these teachers will work on completing their training.

The Government also agreed at the Oxford Conference to endeavour to increase the number of teachers who take up posts overseas by special encouragement of recruitment for posts in those areas of the Commonwealth where the shortage of teachers is most acute. Steps are already being taken in co-operation with local education authorities and other responsible bodies to improve the arrangements for seconding and re-employing teachers, for safeguarding their promotion prospects and superannuation benefits in the United Kingdom, and for promoting wider recognition both by teachers and their employers of the value of service overseas in the Commonwealth. The Government has also undertaken to provide, at the request of certain Commonwealth countries unable to offer salary and conditions of service to meet the reasonable needs and expenses of expatriate teachers, special financial assistance to United Kingdom teachers volunteering to fill approved key teaching posts overseas. Such posts may be in primary and secondary schools, teacher-training institutions, technical colleges and universities, and, as defined by the Conference, are, broadly speaking, posts which require teachers with qualifications not locally available in sufficient numbers, or posts in which the teachers will be able to play a creative part in the educational progress of the country concerned.

The measures proposed will include payment of special allowances to bring the salary offered by the local employer up to the level which would have been received in the United Kingdom, and to offset higher living costs and local taxation, as well as payment of fares to and from the United Kingdom and other miscellaneous forms of assistance. Arrangements for posts in universities and university colleges will be drawn up on the advice of a sub-committee of the Universities Advisory Committee of the British Council on which, besides the Council, the universities, the Inter-University Council for Higher Education Overseas, the Commonwealth Relations Office and the Colonial Office will be represented. It will not be made a condition of posts attracting these special allowances that Commonwealth authorities should use an officially recognized United Kingdom recruitment agency; but in view of the considerable experience of the British Council in this field, it is hoped that the services of the Council will be widely used. The White Paper estimates that recruitment of teachers under this scheme will increase from about 75 in 1960 by about 20 a year to 135 in 1963 and succeeding years, and that the cost of this programme to be borne on the estimates for the Commonwealth Relations Office and the Colonial Office will rise to about £700,000 a year by the end of the five-year period.

---

* Commonwealth Relations Office: Colonial Office. Commonwealth Educational Co-operation. Pp. 7. (Cmnd. 1032.) (London: H.M. Stationery Office, 1960.) 6*d*. net.

Apart from these measures, the White Paper points out that the Government hopes to make available a substantial number of additional places for Commonwealth students in technical colleges in Britain during the next decade, and to expand training facilities for Commonwealth students in British industry. The Government is represented on the Commonwealth Education Liaison Committee, set up, together with the Commonwealth Education Liaison Unit, to improve and further Commonwealth collaboration in education. The United Kingdom is also participating in a meeting, probably early in 1961, of Commonwealth experts in teaching English as a second language to study the problems in this relatively unexplored field. The White Paper confirms the acceptance of the Government of India's invitation to attend the next Commonwealth Education Conference at New Delhi in 1961.

In presenting the Bill, which received a remarkable welcome in both Houses of Parliament, the Minister of State for Commonwealth Relations, Mr. C. J. M. Alport, said that in February the Minister of Education, at a Conference on Teachers for the Commonwealth, had advanced several proposals, including the formation of a national council for the supply of teachers overseas, the preparation of a code of secondment for teachers going overseas, and a code of terms for the appointment of such teachers; and it was hoped that in this way and through the provisions of the Bill it would be possible to provide teachers of the calibre and experience required. Mr. Alport said that the Minister was much encouraged by the response at the Conference to his appeal, and Mr. Alport himself repeated the appeal he had made in the debates on the Commonwealth Scholarships Act to employers and to teachers to consider the value and importance of service overseas both to themselves as individuals and to the countries of the Commonwealth.

Mr. Alport emphasized that the success of the scheme would depend primarily on the willingness of individuals to serve abroad for two or three years; but despite the shortage of teachers in Britain he did not believe the numbers required are beyond our capacity. As regards the provision of training facilities in the United Kingdom, Mr. Alport anticipated that the full number of some 400 Commonwealth bursars would be coming to the United Kingdom in the first year of operation. Dealing with the Bill itself, he explained that its provisions had been so drafted as to include bursars who were not actually British subjects or Commonwealth citizens, and to enable the United Kingdom to provide experts other than those of the teaching profession but whose services in Commonwealth countries could be of great material advantage to their educational system as a whole. He estimated that there are at present about 30,000 Commonwealth students in the United Kingdom, of whom about 12,000 come from independent member countries and 18,000 from dependent territories. Of the total, 7,000 are at universities, about 7,000 at technical colleges and 730 already at teacher-training colleges, for which already there has been demands for 300–400 places.

Afterwards, in a written answer to a question in the House of Commons on May 27, Mr. Alport stated that so far some 350 applications had been received for bursaries under the scheme described in the White Paper. The largest group would be experienced teachers taking a wide range of one-year courses in educational theory and practice. Another large group would be taking courses in technical teacher-training and other specialized subjects, and a third group would be receiving courses of initial teacher-training. It was hoped that the first teachers would go overseas under the second scheme during the latter part of this year and that these teachers would cover a wide range of subjects. The United Kingdom authorities are at present assessing the needs of the overseas Commonwealth countries in the light of the information so far received.

Some misgivings were expressed during the debate, and again on May 23 in committee, when the establishment of an Overseas Education Service was suggested, as to whether, in view of the difficulty so far experienced in persuading teachers already teaching in Britain to go abroad for a time, the scheme is likely to succeed. It was emphasized, however, that the posts in question are key posts and in places where recruitment is particularly difficult. Mr. R. Thompson, the Under-Secretary of State for Commonwealth Relations, replying for the Government, said he thinks it unlikely that the allowances would lead to anomalies or create a privileged group or an aristocracy among teachers: the real safeguard, he said, lies in the eligibility of those returning at the end of a contract for re-employment under the scheme. Nevertheless, it was appreciated that, particularly for senior university teachers, there are real difficulties to be overcome in regard to promotion prospects, and much will obviously depend on the interest taken in the scheme by the universities and the reality of their support in such matters.

One point raised in the debate, by Dr. Alan Thompson, concerned the participation of the Union of South Africa. As Dr. Thompson remarked, the educational system of South Africa seems to be in conflict with some of the objectives of the White Paper. Nevertheless, as was pointed out by Mr. I. F. A. de Villiers in *Nature* of March 26, p. 893, South Africa proposes to take part in both the Commonwealth Scholarship Plan and the Commonwealth Education Liaison Committee. This was later confirmed in the House of Commons (*Nature*, July 9, p. 113). Clearly, difficulties must arise, not simply because of the way in which apartheid is practised and the educational principles of the Act are violated in South Africa, but also quite as much through the rejection by the Union Government of the idea of university autonomy. As Sir David Eccles emphasized, this is partly a matter of creating an appropriate climate of opinion, not only to ensure that those who teach overseas suffer no professional handicap on their return, but also to help teachers who are seeking information before they go abroad and to keep local education authorities and the universities continually aware of what is going on and the various needs. In this connexion, Sir David indicated that something like ten visits abroad a year from members of the staffs of training colleges to enable them to familiarize themselves with the local conditions and needs of the teachers they are training in Britain are planned.

Little was added to all this in the debate in the House of Lords on May 30. In moving the second reading, the Earl of Home expressed the Government's appreciation of the co-operation which had been shown by the teachers' representatives, by the local authorities, by the churches, and by the teacher-training institutions, which had pledged themselves to make this scheme work. They had devised a draft scheme of secondment to which the Government hoped all the education authorities would subscribe and which it hoped they would all adopt. Lord Home also said that Dr. V. S. Jha, lately vice-chancellor of Banares Hindu University, would be the first director of the Commonwealth Liaison Unit. In both Houses of Parliament there was thus evidence of the imaginative response and enthusiasm for which Lord Home appealed at the time of the Conference last year, and that in Parliament at least it is fully realized that assistance in educational development is one of the most important forms in which technical aid can be given to the under-developed countries, within and without the Commonwealth.

That this is not more generally recognized is unfortunately only too true, as the reluctance of the Federal Government to take over the Copperbelt Technical Foundation set up three years ago by the Anglo-American Corporation and the Rhodesian Selection Trust shows. The second of these two mining groups was concerned with the great need to train Africans for more responsible work, but when the Technical Foundation was launched it admitted, and still admits, Europeans only. When, during the copper slump, the Government of Northern Rhodesia was approached for a grant, it made such a grant contingent on the Foundation becoming multi-racial and admitting Africans, as the Rhodesian Selection Trust had desired from the start. The Federal Government made such a grant, however, without any conditions but did not desire to take over the running of the institution. The Government of Northern Rhodesia is debarred, however, from taking over the Foundation as it stands, because European education is a Federal responsibility; but it could, and is willing to, do so if the Foundation is thrown open to suitably qualified youths on merit and regardless of colour, since African education, including apprenticeship and the type of instruction given at this institution, is a territorial responsibility.

Meanwhile, the importance of trained man-power generally and of technical education in particular in like territories is emphasized from one source after another—by Mr. Kenneth Younger in his Sydney Ball Lecture at Oxford last November, and in a subsequent book, by Dr. B. V. Bowden, in articles on the universities' task in Ghana and on technical education there, based on his recent visit, and in the latest report from the Colonial Development Corporation. Dr. Bowden believes, indeed, that if there were an adequate supply of technologists, Ghana need not look elsewhere for most of its professional administrators. He anticipates that if its universities in the next few years can educate the scientists and technologists who are needed in ever-increasing numbers as the country takes its place in modern society, a vital intellectual stimulus would be provided to both staff and students, apart from the benefit of its impact on industry, agriculture and public health; but an essential part of that programme is an active programme of research, especially in agriculture, medicine and engineering, into the formidable technological programmes which confront the country to-day.

In fact, however, Dr. Bowden regards technical education in Ghana as essentially a pyramid without a base, because there is no adequate provision for the education of the craftsmen, charge-hands, foremen, under-managers, etc., whom the graduate engineers, for whom educational facilities are provided, will need. If Ghana is not to use most of its graduates as technicians and clerks, he believes that country will need to spend very much more on non-university education than it does on the universities, and it may well be that in this field of technical education the help which could be forthcoming through the schemes outlined in the White Paper on Commonwealth Educational Co-operation may be most valuable and most needed. Dr. Bowden refers, moreover, to the need for more opportunities for engineering graduates in Ghana to gain practical experience; and it would seem that his suggestion that the Government of Ghana should arrange for its graduates to go abroad to join one of the great firms that have organized postgraduate apprenticeships for many years is at least possible, under the further measures contemplated in the final paragraph of the White Paper.

THE GALATHEA EXPEDITION

Galathea Report

Scientific Results of the Danish Deep-Sea Expedition round the World, 1950–52. Edited by Dr. Anton F. Bruun, Captain Sv. Greve and Prof. R. Spärck. Vol. 1: Pp. 260+8 plates. 90 D.kr. Vol. 2: Pp. 253+4 plates. 75 D.kr. Vol. 3: Pp. 87+85 plates. 60 D.kr. (Copenhagen: Galathea Committee, 1956–1959.)

When the Galathea Expedition was planned, the deepest parts of the ocean floor had yet to be explored. Accordingly, the main aim was to sample the benthic fauna, if indeed this existed, at levels beyond 6,000 m. Such deep regions, in the form of trenches, are found principally in the Indonesian area and in the Western Pacific Ocean.

These three volumes and the narrative published in 1956[1] contain ample evidence that this exacting task was accomplished with conspicuous success. This work (and that carried out by the Russians since 1949) has shown that the deep-sea trenches contain limited but distinct communities of invertebrates. Dr. Anton Bruun, the leader of the Galathea Expedition, refers to such animals as the hadal fauna[2]. The recent dive of the U.S. Navy Bathyscaphe *Trieste* in the Challenger Deep (Marianas Trench) has now revealed that fishes may also range into the hadal regions.

Most of the papers in these reports deal with groups of benthic invertebrates taken at depths beyond 6,000 m. (Volume 1: Actiniaria (Carlgren); hydroids (Kramp); Echinoidea, Asteroidea and Ophiuroidea (Madsen); Holothuroidea (Hansen); Crinoidea (Gislén); Polychaeta (Kirkegaard); Isopoda and Tanaidacea (Wolff).) Volume 1 also contains a full report on the deep-sea Ascidiacea (Millar) and papers on two bathypelagic groups (Vampyromorpha (Pickford) and whale-fishes (Rofen)). A complete account of the Pycnogonida (Fage) will be found in Volume 2, which also contains papers on free-living nematodes (Wieser) and on certain new species.

Considering only the papers concerned with animals from the hadal zone, nearly half the species (40 out of 87) have proved to be new. This certainly suggests that the deep-sea trenches contain a special fauna, although certain contributors point out that this idea may need to be qualified when the abyssal regions of the deep-sea floor (2,000–6,000 m.) have been more thoroughly explored. The trophic structure of the hadal fauna also seems to be distinctive. It appears from these and Russian reports that predatory animals such as the asteroid and ophiuroid echinoderms and the decapod crustaceans are scarce or absent in extreme oceanic depths. The greater part of the benthic biomass generally consists of the ooze-eating holothuroid echinoderms. Where conditions favour higher rates of sedimentation, the particle-ingesting pogonophorans may be very abundant.

The station list in Volume 1 will reveal that the expedition devoted much time to trawling and dredging in the Philippine Trench. But before this could be attempted, the trench was thoroughly surveyed by echo-soundings, and an account of this work is given by Kiilerich. Volume 1 also contains the results of two other important aspects of the expedition's programme, the measurement of oceanic productivity (Steemann Nielsen and Jensen) and the study of deep-sea bacteria (ZoBell and Morita).

The radioactive carbon technique now widely used for measuring marine plant productivity was developed just in time for the expedition. A full account of the method and measurements, which were made in all three oceans, is given, and the report ends with a comprehensive and valuable survey of the physical and biological background to oceanic productivity.

Deep-sea bacteria obtained from sediments in the trenches were found to look very like common soil forms, but were shown to grow preferentially or exclusively at the pressure and temperature of their environment. ZoBell and Morita calculate that the carbon content of the standing crop of bacteria in a square metre of sediment (1 centimetre in thickness) is about 2 milligrams. Since marine bacteria are able to oxidize most kinds of organic matter, the authors suggest that these organisms may well be an important food source for mud-eating and filter-feeding invertebrates. But they also remark that nothing is known of the productivity of deep sea bacteria.

Zoologists and palæontologists will welcome the superbly illustrated, detailed account of the anatomy of *Neopilina galatheae* by Lemche and Wingstrand, which takes up most of the third volume. The authors clearly show that this mollusc belongs to the class Monoplacophora, order Tryblidiacea, a group represented at the time of writing by two species, but otherwise known only as fossils in Cambrian, Silurian and Devonian deposits. The metameric repetition of organs, which is most marked beyond the third pedal retractor nerve, is well demonstrated. The systematic and phylogenetic implications of these and other findings are to be considered in a later report.

The last paper in Volume 3 is a short but interesting study by Munk of the pair of plate-like head organs in the abyssal myctophoid fish, *Ipnops murrayi*. The cellular make-up of these structures plainly shows them to be modified eyes, a most curious transformation, but one that may not be confined to the genus *Ipnops*. There is evidence that some parallel may be found in the eyes of the bathypelagic whale-fish, *Ditropichthys storeri*[3]. Closer investigation of this species would now be of great interest.

To conclude, these handsomely produced reports are striking proof of what has been accomplished in oceanic biology during the past ten years. But they are also bound to be a measure of what remains to be done. The thorough, large-scale investigation of the ocean that is now required is beyond the resources of any single nation. It is to be hoped that international effort, such as that being contemplated for the Indian Ocean, will meet this need.

N. B. MARSHALL

---

[1] Bruun, A. F., *et al.*, The Galathea Deep Sea Expedition, 1950–52, Pp. 296. (London: Allen and Unwin, 1956).

[2] Bruun, A. F., *Nature*, 177, 1105 (1956).

[3] Harry, R. R., *Zoologica*, **37** (1), 55 (1952).

STABILITY AND CONTROL OF FLIGHT

Dynamics of Flight

Stability and Control. By Prof. Bernard Etkin. Wiley Books in Space Technology. Pp. xiv + 519. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 120*s*. net.

THIS is a modern treatment of the fundamental theory of the stability and control of aircraft. Performance and flutter issues have been specifically excluded. Numerical examples are used to illustrate applications and typical results.

The reader is assumed to be familiar with basic mechanics, aerodynamics and with complex numbers and differential equations. An appendix gives a résumé of vector analysis. On this basis the static stability of an aircraft in its equilibrium states is first analysed and the influence on the stability of various controls, etc., is discussed. The general equations of unsteady motion are then developed in a systematic way. The author starts with the aircraft as a single rigid body and then elaborates on the equations so obtained by adding in turn the effects introduced by the presence of spinning rotors, the control surface movements and finally the effects of elasticity in the system. An attractive feature of the presentation is the fact that from time to time the reader is reminded of the assumptions behind the various sets of equations by having these collected and listed for him.

Each of the stability derivatives contained in the general equations of motion is discussed next. Formulæ for their evaluation are given or, where this is not possible, the qualitative dependence of the derivative on the perturbation quantity is described. Three appendixes give about sixty pages of formulæ, tables and graphs relevant to stability derivatives, the standard atmosphere, mean aerodynamic chord and centre, etc. The data quoted are taken mainly from the National Advisory Committee for Aeronautics Reports and Royal Aeronautical Society Data Sheets. The National Advisory Committee for Aeronautics notation of stability derivative is used throughout the book. The author directs attention to certain differences in definitions used in Great Britain and the United States.

In successive chapters the stability of small perturbations in the longitudinal and the lateral motions is analysed using the differential form of the equations of motion. Since the subject-matter of the remainder of the book can only be treated fully by the use of mathematical techniques based on Laplace transforms, frequency responses and random functions, a chapter is devoted to an explanation of these techniques. The Laplace transform and frequency response-approach is then used to study the response of the aircraft to actuation of its control surfaces.

The next topic to be treated is that of flight in turbulent air, and here the approach is centred on analysis in terms of the power spectrum of the turbulence.

On the assumption that the aircraft motion is known, there may be occasion to determine (*a*) the input action, given the aircraft parameters, or (*b*) the aircraft parameters given the input action. A chapter is devoted to such inverse problems. This is a topic of considerable practical interest and the value of the short outline given would have been greater had some notes been included on some of the practical difficulties involved.

The last three chapters give the reader an outline of up-to-date applications and techniques by discussing in turn, automatic stability and control by means of feed-back devices, specialization to missiles, and finally the fundamentals of machine computation and simulation. These chapters are brief but nevertheless valuable introductions to very large subjects. This is a carefully prepared and well-presented book which covers a very wide field in a very competent manner.

REFERENCE BOOK OF THEORETICAL PHYSICS

Manual of Mathematical Physics

By Paul I. Richards. Pp. xi+486. (London and New York: Pergamon Press, 1959.) 110*s*. net.

THE author states in his preface: "The goal of this book is to condense established theoretical physics, its applications and its mathematical equipment into a single reference volume of reasonable size without sacrificing either logical continuity or fundamentals".

This seems to be a hopeless attempt. The book has, however, a distinguished German predecessor. "Die mathematischen Hilfsmittel des Physikers", by E. Madelung, is a collection of formulæ and theorems concerning a wide field of advanced topics in theoretical physics which for four decades has been of invaluable assistance to research workers. The influence of Madelung's work on the present book is obvious and beneficial, but emphasis is now shifted to some extent from formulæ to verbal argument.

A 'physics' section covers classical mechanics, electrodynamics and optics; thermodynamics and statistical physics; relativity and the quantum theory of matter and radiation. Both the general principles of the theories and their applications to special problems are taken into account. In addition a number of recent branches of theories are included, and circuit theory and other subjects of technological importance are added. A 'mathematics' section deals with the calculus, complex functions, series expansions and differential equations; integral equations and Hilbert spaces; modern algebra, vectors and tensors; numerical methods, probability and linear programming, to name the most important headings.

It need scarcely be said that the accommodation of this vast amount of material is possible only by very concise wording. This obviously renders the volume unintelligible to all but fairly expert readers. The value of the book should accordingly be assessed by its possible use to competent research workers.

This use is unfortunately somewhat limited because the presentation of the subject does not conform with the author's claim in the preface. The 'physics' section does not show much logical continuity; rather it would appear to be an assemblage of unconnected and incomplete statements. The shortage of space does not prevent the author from indulging in unnecessary verbosity whereby significant points in explanations are lost.

The 'mathematics' section is on the whole better presented, but is burdened by numerous formulæ the origins, applicability and significance of which are not given. 1,200 words are used for the subsection 'signal flow diagrams', which appears to be a method for solving simultaneous equations. I was unable to derive from the text any instruction for operating by this method; nor is there any result shown from which the principles of this method could be inferred. Contour integration is dealt with in 100 words, no result or example being presented. The Lebesgue integral is discussed in 250 words—which should be sufficient for a book of this kind—but no definition of that concept is included. There is an adequate table of Laplace transforms, but no corresponding table of Fourier transforms. These examples may show that also the 'mathematics' section is of limited use only.

So far as the verbal text is concerned the book is scarcely any better than a list of technical terms of theoretical physics and applied mathematics. This shortcoming is all the more surprising as the author repeatedly shows that he has mastered the subject and would be capable of saying much in few words. Presumably he believes that his source book is of interest to some class of readers, whoever they may be.

If the book is regarded as a collection of formulæ it may still be useful to research workers. They may save appreciable time and effort if a formula can be found in the present volume and need not be searched for in some treatise. R. EISENSCHITZ

EVOLUTIONARY DIVERGENCE

Evolution above the Species Level

By Prof. Bernhard Rensch. Pp. xvii+419. (London: Methuen and Co., Ltd., 1959.) 63*s*. net.

THE distinguished author of this book has long been known for his extensive studies on the island distribution of birds and other vertebrates, and of land snails. This work was done especially in the Malay Archipelago, on which he wrote a valuable treatise in 1936 (which for some reason he has omitted from the bibliography). It led him to take a profound interest in the formation of races and species, and their evolution. The word 'Rassenkreis' was coined by him. His monograph in 1929 on "Das Prinzip geographischer Rassenkreise und das Problem der Artbildung" is a classic. Later on he became engrossed with wider questions about the natural processes of evolution, not only in races and species, but also in the divergence and segregation, if that is the right word, of higher taxonomic groups.

The German edition of "Evolution above the Species Level" was published in 1947, but enhanced in a later version in 1954, of which this English edition is essentially a direct translation by Dr. Altevogt. It is a very solid book, crammed with argument and cited evidence, and well illustrated with text drawings. Though its style is certainly pretty heavy and liberally laced with ponderous terms like kladogenesis, archallaxis, bradytely and hylopsychic, the argument is clearly and powerfully developed. The central idea that the author seeks to prove is that the higher grades of phylogenetic branching can be explained by the same orthodox beliefs about natural selection as can race formation and speciation. This involves him naturally in an all-out attack on such directional theories as orthogenesis, which he takes considerable trouble to demolish.

Prof. Rensch has an enormous acquaintance with the literature on evolution, including many aspects of comparative anatomy and development, and he uses many different sectors of zoology as channels of argument, which are gradually united to try to prove the central theme. Although the general integrity of this sifting and assembling process is obviously high, there is a tendency to accept other people's facts and conclusions at their face value, instead of critically testing their authenticity. I was, for example, startled at being quoted in support of the view that there is no natural population balance in animal communities. The reader may perhaps feel as if he were walking through a very well-arranged museum, in which the tickets on each exhibit instruct him clearly what to believe. But the theories are put forward logically, and on the whole cogently. If one believes mutation and natural selection to be the sole basis of race and species formation, the rest of the argument follows fairly convincingly. But one should remain at liberty to wonder if the first assumption contains the whole truth about evolution. The evidence against such ideas as orthogenesis is powerfully marshalled and convincing, though it could partly stand alone on its own merits.

Two special chapters may be mentioned that are interesting, but slightly out of the main stream of argument: one on the absolute rate of evolution in producing taxonomic groups of different levels (that is to say, species, family, order), and another about the evolution of higher psychic processes. But the main message is continually hammered at us: "The evolution of new structural types and of new organs needs no other explanation than specific and generic differentiation, i.e. the combined effect of mutation and selection". The book is beautifully printed, and there is a vast and useful bibliography.

C. S. Elton

THE TWO HEREDITIES

The Future of Man

By Prof. P. B. Medawar. (The B.B.C. Reith Lectures, 1959.) Pp. 128. (London: Methuen and Co., Ltd., 1960.) 10*s*. 6*d*. net.

GOOD lectures when published often make poor reading. The 1959 Reith Lectures make good reading, though as lectures the author views them unfavourably: "they were too closely reasoned", he writes, "and often made unfair demands on the listener's attention". The conciseness of expression and the balance of phrases in neat antithesis, qualities which make listening difficult, are a virtue in print and in scientific writing a rare merit. Explaining the concept of 'fitness', for example, he writes: "All the people alive 100 years from now will be our descendants, but not all of us will be their ancestors". The reader can pause and look again—and often will in reading this text: the spoken sentence is past before the listener is aware that something important has been said.

The approach in the earlier lectures may have discouraged some of the less-sophisticated among his audience. "I decided that these lectures were to be about the process of foretelling (the future of man) rather than about what is actually foretold." In each of various aspects of forecasting human development, Prof. Medawar shows the complexity of the mechanisms involved. For example, on the relation between intelligence and fertility his lecture opens with five possible explanations of this relation and proceeds to show that the inference of a decline in national intelligence is equally complicated by difficulties. But this kind of discipline in thinking about the implications of the past half-century of research in human biology is precisely what is most needed. Since so few biologists have been willing to discuss their subject on this scale and in this strict way, the field has been left to the naïve thinkers and the propagandists to proclaim that medical science is preserving an unfit population, that birth control is bound to have evil consequences, that the laws of genetics have an over-riding authority. The positive contribution of these lectures is in their demonstration of the muddled thinking of the upholders of the doctrine of 'geneticism'—"the idea that man's genetic constitution is not merely important but all-important".

Do genetical laws set predictable limits to man's future development? This is the central theme of the lectures, and Prof. Medawar's position is in sharp contrast to that of the older social biology. The answer, introduced in the final pages, is that man has two systems of heredity, one genetical, one cultural: the interaction of these two systems changes the prospect entirely. This is really the beginning, not the end, of the topic of the future of man; but it takes the topic beyond biology into the social sciences.

The bringing together of these two systems of heredity suggests a comparison with another widely discussed lecture of 1959, the Rede Lecture, which showed the need for merging our two cultures, the scientific and the literary. Of recent years, the non-scientific world seems to be assimilating quite successfully the simpler concepts of physics, but is still far behind in its grasp of the trends in the biological sciences. These Reith Lectures provide an example of the kind of thinking and talking that must be done if the more recent developments of biology and genetics are to win their proper place in the general education and the intellectual culture of our population.

J. D. NISBET

BIOCHEMISTRY AND HEREDITY

The Chemistry of Heredity

By Prof. Stephen Zamenhof. (Publication No. 365, American Lecture series. A Monograph on American Lectures in Living Chemistry.) Pp. xi+106. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas, 1959.) 34s. net.

THE great and diversified scientific effort which we are witnessing to-day all over the world has brought with it problems of communication. The expanding list of scientific journals bears witness to the volume of publications by which scientists are attempting to inform others of their discoveries. Such publications, however, may appeal only to like-minded specialists. Nevertheless, scientists of all disciplines as well as medical practitioners do, from time to time, feel the need to acquaint themselves with the state of knowledge in a particular field. Another, much larger, group of potential readers interested in the facts of scientific advance is the general public. Many of its members have helped to finance "the enlightened programs of research grants in our country" to which Prof. Zamenhof so rightly pays tribute in the dedication of his book. In the choice and presentation of the material of this monograph the author has apparently tried to aim at the professing scientists, the medical readers as well as the curious but unqualified.

In the introduction the author prepares the ground for the subsequent discussion of the possible mechanisms for the transmission of heredity by chemical compounds. Prof. Zamenhof then lists in outline required properties of heredity determinants and gives examples of classes of biological systems which must reasonably be under their genetic control. In the second chapter evidence is given for the central thesis of this book that heredity determinants are chemical substances. The non-specialist or even student is gently led towards the objective that deoxyribonucleic acid is the most plausible carrier of heredity. Due weight is here given to the direct proof for this postulate where viruses are concerned, which Prof. Zamenhof puts beside the almost incontrovertible but indirect evidence for the genetic role of deoxyribonucleic acid in higher organisms. A résumé of the structure of the nucleic acids is then followed by a discussion of the implications of those biochemical experiments by which nucleic acids have been synthesized *in vitro*. Under the heading "Mutation" the author regrettably only touches on hypotheses and on the genetic concept of carcinogenesis. Perhaps he wished to keep the account of work so close to his own promising field short for the sake of clarity. The facts of cytoplasmic inheritance are authoritatively stated and the subject well set within the context of the book. The remainder of this monograph is concerned with research in biochemical genetics: studies with micro-organisms and the examination of hereditary defects in man. The reader is given a hint of the problems, theoretical and practical, which confront investigators in this field.

This is a book that can be recommended to scientists and medical men who wish to widen their horizons, and to students providing they can persuade their library to buy it. The problem of how to present scientific facts, let alone the complexities of the chemistry of heredity, to the lay reader has not been brought closer to a solution by this volume.

The book is well produced; misprints are practically absent, but the text gives examples of bizarre notions of how to divide words. The comprehensive bibliography should be useful to all readers alike.

P. COHN

RECENT AMERICAN RESEARCH IN NEUROPSYCHIATRY

Chemical and Molecular Basis of Nerve Activity

By David Nachmansohn. Pp. xi+235. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 7.50 dollars.

International Review of Neurobiology

Vol. 1. Edited by Carl C. Pfeiffer and John R. Smythies. Pp. xii+383. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 10 dollars.

Neuropharmacology

Transactions of the Fourth Conference, September 25, 26 and 27, 1957, Princeton, N.J. Edited by Harold A. Abramson. Pp. 285. (New York: Josiah Macy, Jr. Foundation, 1959.) 5 dollars.

THESE three books cover recent American researches on various aspects of the nervous system. The emphasis is on the nature of transmission, the chemical isolation of naturally occurring substances believed to have physiological or pathological importance, and the effects of drugs. In each case, the publishers are to be congratulated on having produced a handsome volume, well illustrated and carefully indexed. The bibliographies are satisfactory. With some qualifications, it may also be said that the authors, too, have given us something of which they may be proud.

Nachmansohn's book is the only monograph. It represents the results of nearly a quarter of a century's work by the author and colleagues on the metabolism of acetylcholine and its associated enzymes. It is a well-written, interesting, and coherent account of the progress which has been achieved. Beginning with a discussion of the physical events during nerve-activity, the author successively deals with a hypothesis of chemical transmission, the high speeds at which hydrolysis can take place, and substances which are capable of inhibiting the enzymes of this system. He goes on to describe the physicochemical exchanges in the electric organs of certain fish, and then makes a bold attempt to define in detail the rôle of acetylcholine in conduction. Here, there is a useful diagram to explain the author's views. The way in which nerve-gases, insecticides, and antidotes may be fitted into this scheme is next discussed. The book closes with chapters on the complex nature of the changes in the permeability of conducting membranes and on the problems of synaptic transmission. In his concluding remarks, the author freely admits that we are only beginning to understand the "chemical forces and structural arrangements" of these membranes.

The editors of "The International Review of Neurobiology" write in their preface that their aim is to enable workers in many different, but related, fields to keep abreast of recent advances. This book is composed of eight articles, each by different authors. The first two are mainly electro-physiological. The third and fourth are neurochemical. The fifth is on the psychophysiology of vision, with particular reference to the effects of various stresses (for example, anoxia and induced hypoglycæmia) and of a number of drugs. The last three articles are concerned with metabolic studies in disease.

As is almost inevitable with such a conglomeration of contributors, the merits of the articles vary a good deal. Particularly interesting were W. R. Adey on the rhinencephalon and epilepsy, Catherine Hebb on chemical agents of the nervous system, and Carl C. Pfeiffer on parasympathetic humors. The least impressive were the last three articles, which attempt to relate products of abnormal metabolism to schizophrenia and even multiple sclerosis.

The volume entitled "Neuropharmacology" has the weighty disadvantage that it is an account, in the form of a dialogue, of a conference which was held more than two years before the book was published. For the reader to-day, it thus cannot altogether avoid the air of staleness which clings to an old newspaper discovered by chance in an attic. Such a document may, and often does, carry an absorbing transitory interest for him who vividly recalls the events described; yet may altogether fail to hold the attention of those who have not any reason to remember. In addition, dialogue is a challenging form of literary endeavour. Perhaps even Plato's genius does not always avoid stultifying thought by irritating changes of direction, as the argument is developed. A mode of human communication which is inevitable, and indeed proper, in a conference room too easily becomes irksome if it is inscribed in print.

Dr. Fremont-Smith, in explaining the scope of the book, makes a convincing plea for the usefulness of the conference which is reported; but admits that the form of the publication has already given rise to criticism and that a few critics have stated that they would have preferred a "depersonalised summary". If, by some device, the opening speakers had been allowed in this volume to complete their themes unobstructed, as, after all, usually happens in conferences, there would have been less reason to object to a subsequent discussion. In this presentation, we are not even allowed a summary of the opener's remarks.

Four subjects are discussed: (1) "The Effect of Respiratory Poisons and Anoxia on Siamese Fighting Fish in Relation to LSD–25 Reaction" (Dr. Abramson); (2) "Clinical Studies with Taraxein" (Dr. Heath); (3) "'Stop' and 'Start' Systems" (Dr. Lilly); (4) "Some Relations between Chemical Structure and Physiologic Action of Mescaline and Related Compounds" (Dr. Alles).

Dr. Abramson's article includes piscine illustrations which are intriguing, but his interlocutors are allowed to get at him too soon. Towards the end of his second page (p. 13), the dialogue runs as follows:

"*Abramson*. I might add here that we have data on what the 1-methyl and what the 1-acetyl derivatives of *LSD*–25 do to man.

Marrazzi. You must have had a reason for not using the standard presentation of the log of the dose, which would straighten out the curve.

Abramson. I prefer to deal with the actual data rather than a log.

Hoagland. Are they log relationships or semilog plots?"

Thereafter, Dr. Abramson gets hounded, so to speak, from log to log or from plot to plot for several pages, before he or the scientific dogs who pursue him return to the absorbing human trail.

Dr. Heath fails to impress with taraxein. It is clear from the voices of the hounds after him that they fully realize that the scent which he is laying is not absolutely reliable.

Dr. Lilly's 'stop' and 'start' systems are of great interest. Electrodes accurately and permanently implanted into the brains of monkeys enable him to define certain areas, the stimulation of which gives rise to characteristic behaviour. Moreover, the dogs of dialogue let him run longer distances before bringing him to bay.

Dr. Alles gets the fairest start of all, and is extremely informative on the structure and action of phenylethylamines for 20 or 30 pages, before the pack catch up with him and pull him down. Thereafter, the run of the argument deteriorates, until he escapes with a second wind for five or six pages towards the end.

This book would have much to be said for it, were it not for its regrettable art-form. D. H. BRINTON

ADVANCES IN VETERINARY SCIENCE

Advances in Veterinary Science

Vol. 5. Edited by C. A. Brandly and E. L. Jungherr. Pp. xi+450. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 14 dollars.

THE fifth volume of "Advances in Veterinary Science" embraces seven chapters of varying interest to veterinary surgeons in Great Britain and Overseas.

The first chapter, dealing with the examination of the eye and eye operations in animals, breaks new ground as well as consolidating knowledge gathered from a wide range of experience. Surgeons, especially those interested in small-animal surgery, will find in this chapter a wealth of valuable information. In the second chapter, '*Q*' fever is dealt with in all its aspects and, being a relatively 'new' disease, will be studied with more than topical interest by both medical and veterinary workers interested in public health.

Rabies forms the subject of the third chapter. While it might have been thought that everything about this, one of the oldest diseases known to mankind, was already understood, readers will find in this chapter much new information on the diagnosis and control of the disease. New human rabies vaccines of duck-embryo and chicken-embryo origin are discussed and their promise in general use assessed. Of special interest to workers in Africa are the chapters on eradication of the tsetse fly from Zululand and that on theilerioses.

To those working in the North American continent the subject of infectious bovine rhinotracheitis, which is dealt with in the sixth chapter, will be of special interest. The virology of this disease is dealt with at some length, and the interesting and fundamental observations that viruses are able to mutate and modify their tissue affinity and host specificity will no doubt be welcomed by many workers in this field. The last chapter deals with tissue culture in veterinary medical research, and in the discussion on this chapter a number of vital questions are posed, prominent among them being the question of the simultaneous vaccination of cattle against a number of viral diseases and the possible interference between viral agents in a mixed vaccine.

The subjects embraced in this volume do not lend themselves to profuse illustration except that covered by the first chapter, in which a number of excellent photographs and diagrams are supplied. The references and indexes are, as in the previous volumes, most comprehensive and leave nothing to be desired. This fifth volume is a worthy companion to its predecessors and will further enhance both the academic and practical value of the series.

H. BURROW

FLORA OF THE ZAMBESI BASIN

Flora Zambesiaca

Mozambique, Federation of Rhodesia and Nyasaland, Bechuanaland Protectorate, Vol. 1, Part 1. Edited by A. W. Exell and H. Wild. Pp. 336. (London: Crown Agents for Oversea Governments and Administrations, 1960. Published on behalf of the Governments of Portugal, The Federation of Rhodesia and Nyasaland, and the United Kingdom.) 25*s*.

THE publication of the first part of the "Flora Zambesiaca" is the first fruit of many years of co-operation between botanists and administrators of several botanical institutions and almost as many governments; the second part is already in the press and should appear later this year.

The area covered includes the vast territories of Africa to the south of the former Congo Belge and Tanganyika, to the east of Angola and South West Africa, and north of the Union of South Africa, and, as is claimed in the introduction, the aim of uniformity of treatment within certain limits of freedom has been admirably attained. This in itself is a remarkable testimony to the practical uniformity of taxonomic methodology. In no family or genus treated in this first part is there any evidence of mere specimen—as distinct from species—description, but at the same time all the contributors have taken care to avoid inclusion of discontinuous variables in the same taxon.

During the preparation of the work, all contributors have published necessary notes, nomenclatural and taxonomic, in a series of papers in the *Boletim da Sociedade Broteriana*; there are only four 'new' names in the Flora. The introduction is printed in English and Portuguese and the glossary, adapted from that of the "Flora of West Tropical Africa", although arranged according to the English entries, includes also the Portuguese equivalents. The key to families has been produced by J. E. Dandy following the pattern of, and adapted from, Hutchinson's "Families of Flowering Plants". The second edition of the latter was not available when the key was prepared. The key occupies twenty-four pages, and Portuguese readers may think that a version in their language might be an improvement, though it is understood that the English key has been reprinted and has found a ready market among them.

The general text follows the well-tried system of Bentham and Hooker, with some modifications. The gymnosperms, by J. Lewis, with two genera and six species of cycads, two species of *Podocarpus* and one each of *Widdringtonia* and *Juniperus*, presented no great taxonomic difficulty, but a uniformity of treatment with that of Melville in the "Flora of Tropical East Africa" is readily discernible. The two texts were prepared independently, one at the British Museum and one at Kew. The treatment of the Ranunculaceae by Exell and Milne-Redhead is essentially the same as that of the earlier flora, some of the errors of the latter being now corrected. Dr. Robson is to be congratulated on his bold treatment of the difficult family Annonaceae. There is no evidence that his new synonymy is too extensive; it is a clear testimony to his painstaking examination of all relevant available literature and specimens with a view to determination of real specific limits and intraspecific variation. The same author is also responsible for the family Violaceae. The Menispermaceae, by Dr. G. Troupin, follow the same general pattern as the same author's treatment of the family in the "Flora of the Belgian Congo", but he has not been afraid to introduce improvements and corrections wherever these have become necessary.

Of the other larger families included in the present part of this Flora one might mention Capparidaceae and Flacourtiaceae by Dr. Wild, and Cruciferae and Polygalaceae by Mr. Exell. Other contributors are Dr. F. A. Mendonça (Nymphaeaceae), Mr. P. Taylor (Resedaceae) and Dr. G. Cufodontis (Pittosporaceae).

Several artists have contributed to the 58 plates of very fine line drawings illustrating no fewer than 80 genera. (It should be noted that the figure and text concerning *Cladostemon kirkii* are erroneous. The fruit of this species is some 22 cm. in diameter.) Most of these have been prepared specially for the Flora by Miss L. M. Ripley and Miss G. W. Dalby; some have been reproduced from Hooker's "Icones Plantarum" by permission of the Bentham-Moxon Trustees; some are reproduced from the "Flora of Tropical East Africa". All of them are well chosen, beautifully executed and printed and should help considerably in generic identification. The coloured frontispiece depicting *Cleome diandra* Burch. is a most satisfying picture; it was adapted from a field water-colour sketch made by the late Mrs. E. J. Lugard (not "H. E." as in the legend) when she accompanied her husband on his expedition to Ngamiland in 1898.

One could wish that Mr. Exell's account (pp. 23–34) of the history of botanical exploration in the area had been much more extensive. Although detailed itineraries such as that given for Sir John Kirk by Miss Hayes (pp. 35–37) may be unnecessary, more details concerning other collectors would have been of considerable interest and permanent value. One feels that undue attention has been given to limiting the size of this part, without due regard to the possible value of recording much of the bibliographical and biographical research which the contributors must have carried out. In view of the fact that the complete Flora will run to some thousands of pages, the editors might well have used more than a mere 78 pages for introductory matter which includes title-page, preface, glossary and key to families, as well as a brief selected bibliography and list of abbreviations. An opposite policy has been followed by the editors of "Flora Malesiana", in which some hundreds of pages have been devoted to introductory matter in each of the two volumes so far published. It is understood, however, that Mr. Exell proposes to rectify this in a separate work.

The lay-out of the general text is a compromise between completeness and utility. The descriptions of families, genera and species have been pruned to essentials, with emphasis on characters that are regarded as diagnostic for each category. References to the literature are also pruned to avoid mere repetitions; in the case of genera only the original place of publication is given, though many readers might have been pleased to have also a reference to a recommended later work. No reference at all is given for families. Specimen citation also is limited to a single specimen from each of the large areas marked on the folded map provided in a cover pocket, and this is followed by a brief indication of total distribution and habitat.

Dichotomous keys to genera and to species need to be tested over a long period before their true value can be assessed, but it is usually possible to estimate their workability by inspection. In this Flora considerable pains have been taken to use absolute contrasting characters; mere size differences have been used but rarely. Such treatment inspires a confidence which in the tests I have made has been shown to be well founded.

The text and illustrations have been carefully edited, and typographical errors are few and unimportant; even on p. 332, where the two lines appearing at the top of the page have jumped from the bottom, no inconvenience will be caused. The book is dedicated to the memory of the pioneer collectors in the area, Loureiro, Baines and Kirk. Everyone concerned is to be congratulated on the production of a really useful modern Flora. A. A. BULLOCK

CELLS AND THEIR ENVIRONMENT

Cell, Organism and Milieu

Edited by Prof. Dorothea Rudnick. (Seventeenth Symposium on the Society for the Study of Development and Growth.) Pp. v+326. (New York: The Ronald Press Company, 1959.) 8 dollars.

The Relationship between Nucleus and Cytoplasm

Proceedings of the Symposium held June 9–13, 1958, at l'Université Libre de Bruxelles, Belgium. Edited by Dr. R. J. C. Harris. (*Experimental Cell Research*, Supplement 6.) Pp. viii+276. (New York: Academic Press, Inc., 1959.) Cloth bound 12 dollars; paper bound 10 dollars.

THE value of symposia increases with the amount of organization and integration of the topics which are discussed, and, all too frequently, so-called symposia become exercising grounds for well-trained hobby-horses. In "Cell, Organism and Milieu" are gathered together ten papers given at the seventeenth symposium of the Society for the Study of Development and Growth. Certainly the papers all deal with aspects of development or growth, but that is almost the beginning and the end of their connexion with each other. The book has little more coherence than a single volume from almost any scientific journal. Individually some of the papers are of great interest, but it is unlikely that they will all appeal equally to any one reader.

A review article on the physiology and biochemistry of the mammalian blastocyst rubs shoulders with papers on auxins in relation to fruit-growth and on polyploidy in root development. The first paper in the symposium, by Wilde, makes some attempt at a synthesis of the actions of some of the internal and external biochemical factors on the behaviour and development of cells, and the article ends with a description of the remarkable formation of hybrid multinucleate muscle fibres by the fusion of the cytoplasms of mouse and chick myoblasts. Hoffmann-Berling directs attention to the similarities and differences among the various cellular elements responsible for muscular contraction and other forms of cell movement, and emphasizes by models the universality of the relationship between adenosine triphosphate and contractile proteins. The problems of contraction and the control of contractile processes are taken up again by Csapo in relation to uterine muscle. This involves a discussion of the actions of the gonadal steroids on the cell membranes of the uterine muscle. Moog continues with a discussion of the action of cortisol on the development and activity of phosphatases, and Schneiderman and Gilbert make the suggestion that the 'juvenile hormone' in insect development is a steroid. Finally, a paper by Loomis emphasizes how science advances in water-tight compartments. The importance of carbon dioxide tension has been part of the stock-in-trade of mammalian physiologists since the days of J. S. Haldane, Sir Joseph Barcroft and L. J. Henderson. Its importance is now emphasized in relation to the growth and development of *Hydra* and other organisms.

"The Relationship between Nucleus and Cytoplasm" again emphasizes the diversity of approaches to a subject which might at first sight appear to be more restricted. The twenty papers range from a study of truth and artefact in electron-micrographs of the nuclear membrane and the mitotic spindle (Lehmann), and of the various cytomembranes and their associated granules (Bernhard), through the fascinating story of the injection of ordered genetic material into bacteria during the mating process of *Escherichia coli* (Jacob), the results of the transfer of nuclei of different ages of embryo (Fischberg, Gurdon and Elsdale) and of different species (Moore) to enucleate ova, to studies of the different cytochemically distinguishable constituents of the nucleus during development and in different functional states of a wide variety of cells (Alfert). Other papers include one on the use of autoradiographs to determine the pattern of keratin synthesis in an epithelium by the use of sulphur-35-DL-cystine, in which there is some evidence that the nucleus is the first part of the cell to be involved (Pelc), another on their use in the synthesis of chromosome material (Ficq, Pavan and Brachet), and another on the use of chromatography to determine the patterns of amino-acids which develop in normal sea-urchin embryos and in those resulting from interspecific crosses. In the last, the amino-acid pattern is shown to be primarily maternal, even though paternal morphological characters may have appeared.

The dominant note which resounds from both symposia is that cellular behaviour and development result from a very intimate inter-relationship between nucleus, cytoplasm and environment, and that cells can no longer be regarded as being dominated entirely by nuclear influences.

E. N. WILLMER

Evaporation and Droplet Growth in Gaseous Media

By N. A. Fuchs. Translated from the Russian by J. M. Pratt. Edited by Dr. R. S. Bradley. Pp. vii+72. (London and New York: Pergamon Press, 1959.) 30*s*.; 5.50 dollars.

DROPLET evaporation in gaseous media is important in a wide range of problems such as the formation of cloud droplets, the evaporation of fuel in the internal combustion engines and in particular in fogs and atmospheric pollution. This book is a translation from a Russian paper by N. A. Fuchs, who himself has made most important contributions towards this subject. The treatment is largely mathematical, but a particularly valuable aspect of the work is the critical review of the whole of the experimental work in this field.

Fuchs considers evaporation and droplet growth in three chapters, of which the first is concerned with drops which are motionless with respect to the gaseous medium and thus no hydrodynamic factor is present. Chapter 2 deals with drops moving in relation to the gaseous medium—described as quasi-stationary evaporation—while the final chapter deals with non-stationary evaporation of drops in which the droplet is moving about in the gaseous medium.

In the first chapter, the basis of the theory is that put forward by Maxwell in an article on diffusion written in 1877 for the "Encyclopædia Britannica", and from this a rate of evaporation equation is developed. The influence of the Stefan flow on the rate of evaporation of drops is discussed, and also the influence of concentration change at the surface on the rate of evaporation. The fall in temperature is next considered both for freely evaporating drops and for supported evaporating drops with a very complete review of the experimental work.

As regards evaporation and the growth of drops moving relatively to the medium, Fuchs used the relationship which has been developed between the Sherwood and the Reynolds and Schmidt groups and discusses the effects of the diffusion and the rate-boundary layers.

F. H. GARNER

Boundary Problems in Differential Equations

Proceedings of a Symposium conducted by the Mathematics Research Center at the University of Wisconsin, Madison, April 20–22, 1959. Edited by Rudolph E. Langer. Pp. x+324. (Madison, Wisc.: University of Wisconsin Press, 1960.) 4 dollars.

THE Mathematics Research Center of the United States Army, founded in 1957, is directed by Prof. R. E. Langer of the University of Wisconsin; it has its permanent home in a new building in the center of the campus of that University. The scientific staff of the Center, numbering about thirty, consists in the main of mathematicians (not all American citizens) on leave from other institutions, who are free to work in any fields they please, though they may be called on by the U.S. Army for professional advice.

The principal interests of the Center are in numerical analysis, statistics and probability, analysis and classical applied mathematics, operations analysis. To increase interest in these fields, the Center held a three-day symposium in 1958 on numerical approximation, another in 1959 on boundary problems in differential equations, and proposes to hold more on similar subjects. The papers read at the 1959 symposium are now available in book form. Because of the shortage of time, the field of discussion was restricted to boundary problems for ordinary and partial differential equations. Even though initial value problems were excluded, the field is very wide. The nineteen papers, six of which were given by visitors from Europe, differ greatly in outlook. Some deal with numerical methods, others are in the strict tradition of classical analysis; a few made use of the more modern approach using fixed-point theorems for operators on a topological space. While some of the work has been published in more detail elsewhere, the book is, nevertheless, a useful addition to the literature of differential equations.

E. T. COPSON

Topographical Anatomy of the Dog

By Dr. O. Charnock Bradley. Sixth edition, revised by Prof. Tom Grahame. Pp. xiv+332+21 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1959.) 36*s*. net.

THIS well-known book, now in its sixth edition has retained its essential character as a systematic guide to the dissection of the dog. The general plan consists of a description of the various anatomical regions, including short, easily followed, dissection instructions. Thereafter the spinal cord, brain and lymphatic system are described, and finally useful tables of arteries and cranial nerves are added. The nervous system has been elaborated in the present edition, and there is an excellent brief account of the autonomic system. The text is concise and easily followed, and there are numerous illustrations, many of which are in colour. There is also a considerable number of radiographic plates of high quality, including several excellent injected specimens.

Prof. Grahame has to be congratulated for successfully revising this work to meet the requirements of modern veterinary practice, and there is no doubt that it will retain its established position as an essential text-book and guide to dissection. The book is very well produced, and the publishers are also to be congratulated for the high quality of their work.

T. NICOL

Ecological Processes

By Dr. Alan Mozley. Pp. xi+68. (London: H. K. Lewis and Co., Ltd., 1959.) 9*s*. net.

THE title of this book somewhat belies its contents. Far from being a generalized account, it is concerned with a few specific ecological problems considered mainly in the light of their influence on molluscs. These problems include certain aspects of ecological succession, population ecology and animal movement. The length of the book (68 pages) gives a fair indication of the depth of treatment: the text is almost entirely descriptive. Various references to other works are included, but these are few in number and scarcely make up for the general superficiality of the writing. It is somewhat surprising to find that the splendid work of Goodhart, Cain and Sheppard on populations of *Cepaea* is not even mentioned.

All things considered, it is a little difficult to see what prompted the writing of this book. Nor does the author's final "conclusion" help to throw much light on the matter—"study the ecological organization of the community, then alter it. In other words, study the ecological processes, plot their course, and modify them as necessary".

W. H. DOWDESWELL

THE INTERNATIONAL CO-ORDINATION OF TIME SIGNALS AND STANDARD FREQUENCY TRANSMISSIONS

By DR. L. ESSEN, O.B.E., F.R.S.
National Physical Laboratory, Teddington, Middlesex

IT was announced recently that plans have been made to co-ordinate the time-signals and standard frequencies transmitted in the United Kingdom and the United States. Such co-ordination has become possible as a result of the steady and remarkable developments in the precision of time-keeping which have taken place during the past decade. A recapitulation of these developments will show how co-ordination has now become possible and why it will be advantageous.

Observatory Time Signals

Time signals have been transmitted from powerful radio stations for more than thirty years. The Royal Greenwich Observatory signals, for example, are transmitted from Rugby on a number of wave-lengths. They consist of a five-minute series of seconds dots from 0955 to 1000 G.M.T. and from 1755 to 1800 G.M.T., the minute signals being lengthened for identification purposes. Such signals serve two functions. They give the time of day, which is a measure of the position of a point on the Earth's surface relative to the Sun, and also the unit of time, which is required for a wide field of physical measurements. The determination of time and the unit from astronomical measurements are complex processes. The observations need to be smoothed by means of clocks, such as quartz clocks, and many corrections have to be applied. The exact times represented by the signals can only be published in retrospect; the final values are to some extent an estimate, depending on personal judgment, and they are not necessarily the same for all observatories. Nevertheless, the unit of time has for many years been known to about 1 part in 10^8, or 0·001 sec. per day.

Standard Frequency Transmissions

Frequencies cannot easily be measured by means of the ordinary time signals. For example, if the seconds dots are accurate to 1 m.sec. it would be necessary to count vibrations for a whole day to obtain their frequency with an accuracy of 1 part in 10^8, which is the order of accuracy now required in the control of radio stations. Standards of frequency are therefore maintained in continuous operation and calibrated in terms of time signals extending over periods of months. Any other frequency can be measured in terms of the standard by simple techniques, which give a high precision in a short time. For example, two frequencies of nominal value 10^6 c./s. but differing by 1 c./s. can be compared with a precision of 1 part in 10^8 in a measurement time of a few seconds.

Standards of frequency have become elaborate pieces of equipment requiring careful maintenance, and there are therefore good grounds for making them serve a wide area by means of radio transmissions. Experimental transmissions were made in both Great Britain and the United States in the period between 1920 and 1930, and at the International Telecommunications Conference in 1947 the frequencies 2·5, 5, 10, 15, 20, and 25 Mc./s. were allocated to standard frequency services. There are now a number of continuous programmes of transmissions on some of these frequencies, the best known of which are those from Beltesville (near Washington, D.C.), having the call sign *WWV*, and from Rugby, having the call sign *MSF*. Such transmissions have been actively encouraged by the International Union of Scientific Radio with the ultimate object of giving a well-received signal anywhere in the world at any time.

The carrier frequencies are controlled by a standard of frequency and various modulation tones are added. It is generally found that the most useful of these are the 1-sec. timing pulses consisting of 5 cycles of a 1,000 c./s. tone obtained by dividing the frequency of the standard. The seconds intervals thus represent 10^6 cycles of the standard (when as in Britain it consists of a 10^6 c./s. quartz oscillator) and they can under good conditions be read with a precision of 10 μsec.

Doppler Effects and Very Low Frequency Transmissions

The full accuracy of the transmissions in the allocated high-frequency bands is obtained only in the small areas near the transmitters where the ground wave is received. At greater distances, where the wave is received after reflexion from the ionosphere, the received frequency may differ from the transmitted frequency by as much as several parts in 10^7 owing to Doppler effect changes caused by movements of the reflecting layers[1]. The effects are particularly severe at sunrise and sunset, and are least when there is a complete daylight path between the transmitter and receiver.

It is known that the propagation conditions for very low frequencies are relatively stable, and a transmission of 60 kc./s. was added to the *MSF* (Rugby) programme in 1951. In early measurements it was shown to have a stability of ±2 parts in 10^9 at Teddington (distance 120 km.), and Pierce[2] later estimated that the average frequency for the whole transmission period of 1 hr. was accurate to ±3 parts in 10^{10} at Cambridge, Mass., U.S.A. (distance 5,200 km.).

In view of these encouraging results, the Post Office Engineering Department controlled the carrier frequency of the powerful *GBR* 16 kc./s. transmitter from the quartz oscillator used for the *MSF* transmissions, and the signals received from this station have been studied in detail by Pierce[3]. He concluded that the Doppler shifts at sunset and sunrise were about 2 parts in 10^9, and that in the daytime the mean

Doppler shift is probably less than 1 part in 10^{10}. Somewhat greater Doppler shifts were, however, found with this transmission received in New Zealand.

At the beginning of 1960, a stable very low frequency transmitter was put into operation by the United States. This is a station at Summit in the Canal Zone with the call sign *NBA* and a frequency of 18 kc./s. Precision measurements can now be made, therefore, on signals crossing the Atlantic from west to east as well as from east to west.

The Atomic Clock

The high accuracies achieved over great distances using very low frequency transmissions were at first only accuracies of comparison, absolute values being limited by the uncertainty of the value of the unit of time. This situation was changed by the introduction of the atomic clock[4,5], which enabled frequency and time intervals to be determined and made immediately available with an accuracy of ±2 parts in 10^{10}. It thus became possible to express frequency and time directly in terms of an atomic constant. It is obviously important to ascribe a value to this constant which makes the units of atomic and astronomical time agree. The variations of the mean solar second (or, more precisely, the unit of the time system U.T.2) are, however, more than a hundred times greater than the accuracy already achieved with the atomic standard, and a more important relationship is therefore that between the atomic standard and the second of Ephemeris Time[6,7]. This has been determined by a joint programme[8] between the U.S. Naval Observatory and the National Physical Laboratory extending over three years, and the value for the cæsium F, m (4,0) $\rightleftharpoons$ F, m (3,0) resonance at zero field is 9 192 631 770 ± 20 c./s. The cæsium standard can be used with the precision of ±2 c./s. and the above value of frequency with these closer limits is being used as a unit of atomic time, although a value must ultimately be adopted by international agreement. Corrections for time signals in terms of a scale of atomic time have been published by the U.S. Naval Observatory since January 1957.

Co-ordination of Time and Frequency Services

As we have seen, the two kinds of service were developed independently to serve different purposes, but the 1 c./s. pulses on the standard frequency services became increasingly used as time signals and the times of the leading edge of the pulse in terms of U.T.2 were therefore published by the observatories. There were thus in the United Kingdom, for example, two systems of time signals in operation, and it would clearly be advantageous to the user if they could be co-ordinated. Such co-ordination, however, presented some difficulties because the second of Ephemeris Time, on which the frequency transmissions are based, differs considerably from the unit of the scale of uniform time (U.T.2), on which the time signals are based. This problem was discussed at the General Assembly of the International Astronomical Union at Moscow in 1958, and a method suggested there was put into operation on *MSF* (Rugby) in April 1959 (ref. 9). The frequency was offset by −170 parts in 10^{10}, the difference between Ephemeris Time and U.T.2 during 1958. Since the offset was previously announced, it presented no inconvenience to those wanting the time intervals in Ephemeris Time, or atomic time, and the 1 c./s pulses remained fairly close to U.T.2.

The co-ordination was taken a stage further in April 1959 through the co-operation of the Royal Greenwich Observatory, the Post Office Engineering Department, and the National Physical Laboratory[10]. The 1 c./s. pulses from the *MSF* quartz standard are now used to generate the Observatory time signals, so that all the signals from the United Kingdom mark identical intervals of time and, apart from the slightly different delay times in the control circuits, are accurately in synchronism. If the difference between the units of Ephemeris Time and U.T.2 is not equal to the predicted value, there will be a cumulative deviation from U.T.2 of the time pulses on all the services. These deviations will be removed by a step adjustment of 50 m.sec. made at 0000 G.M.T. on the first of the month. It is not anticipated that there will be more than one or two such adjustments per annum, and they can easily be taken into account in the determination of atomic time.

Similar steps have been taken to co-ordinate the time and frequency services in the United States[11].

International Co-ordination

It would be a great convenience to users if there could be a single service having a world-wide coverage; but although this is approached by stations such as *GBR*, the highest precision is obtained only when there is a daylight path between the transmitter and the receiver. A number of stations spaced at, say, 120 degrees of longitude around the Earth and all having exactly the same frequency and sending 1 c./s. pulses with a fixed phase relationship would resemble a single station and would overcome the Doppler effect at sunrise and sunset.

If the controlling standards are governed by a cæsium atomic standard, it should ultimately be possible to ensure that the frequencies are equal to within ±1 part in 10^{10}, but at present they may differ by a few parts in 10^{10}. The authorities in the United Kingdom and the United States will remove any such difference by mutual agreement.

The propagation time of the time signals makes it impossible to synchronize them at every point. It has been agreed, however, that the times of emission should be the same. If, for example, a step adjustment is found to be necessary, it will be made at an agreed time and by the same amount.

The experimental co-ordination now in progress will reveal any small residual propagation errors and give valuable information on the feasibility of providing time and frequency services which can be utilized throughout the world without the application of subsequent corrections.

This article is published by permission of the Director of the National Physical Laboratory.

[1] Essen, L., *Proc. Inst. Elec. Eng.*, **101**, Pt. III, 249 (1954).

[2] Pierce, J. A., Mitchell, H. T., and Essen, L., *Nature*, **174**, 922 (1954).

[3] Pierce, J. A., *Proc. Inst. Rad. Eng.*, **45**, No. 6, 794 (1957).

[4] Essen, L., and Parry, J. V. L., *Phil. Trans. Roy. Soc.*, A, **250**, 45 (1957).

[5] Holloway, J. A., Mainberger, W. A., Reder, F. H., Winkler, G. M. R., Essen, L., and Parry, J. V. L., *Proc. Inst. Rad. Eng.*, **47**, 1730 (1959).

[6] Spencer Jones, H., *Nature*, **177**, 744 (1956).

[7] Clemence, G. M., *Science*, **123**, 567 (1956).

[8] Markowitz, W., Hall, R. G., Essen, L., and Parry, J. V. L., *Phys. Rev. Letters*, **1**, 105 (1958).

[9] NPL Announcement, *Electronic and Radio Engineer*, **36**, 117 (1959).

[10] NPL Announcement, *Electronic Technology*, **37**, 90 (1960).

[11] NBS Announcement, *Proc. Inst. Rad. Eng.*, **48** (Jan. 1, 1960).

THE NATIONAL PHYSICAL LABORATORY

THE work of the National Physical Laboratory, on show to visitors from industry, the universities and Government departments during May 25–26, covered a wide field in basic, chemical and engineering physics, metallurgy and mathematics. Items of both fundamental and applied research in all these branches were displayed.

The Laboratory is best known for its work in establishing and maintaining the fundamental British standards of various physical quantities, but in fact this only accounts for a small proportion of the total effort, and much of the work of the nine scientific Divisions is concerned with basic research on topics of immediate or potential value to industry.

The subject of noise measurement, for example, is becoming of public importance, and in the Applied Physics Division the problem of predicting the relative annoyance of sounds to the average listener is being tackled. For traffic noise a sound-level meter, using a microphone, amplifier and output meter, and with the subjective aspect covered by a frequency weighting arrangement, is likely to be the subject of an international agreement. Such a method is, however, a compromise between accuracy and expediency. Work at the National Physical Laboratory shows that the meter agrees with subjective measurements only within a restricted frequency-range. Subjective records of aircraft noise, made at last year's Farnborough Air Show, showed that for a given loudness a large number of observers judged a jet plane to be more disturbing than a piston-engined machine. This result could only have been predicted by a method of sound analysis requiring a number of different noise groupings, and therefore too elaborate for general practical testing. Work is also in progress to establish an International Standard for the normal threshold of hearing, the first necessity being an agreed design for a pure-tone audiometer.

In most fields the aim of research is to eliminate the subjective judgment, and in the Autonomics Division an interesting exhibit on the mechanical recognition of printed characters was shown. Previous systems for doing this have relied on a comparison of the specimen with ideal letter forms. In the exhibit, however, the degree of register between the unknown and its own image is continuously measured (*a*) in a rotary, and (*b*) in a transverse scan, by a light-transmission system. The output from a photocell then gives a characteristic wave-form for each character.

The possibility of an ultra high-speed computer is dependent upon reducing the switching-time in the individual elements, and work on cryotrons at liquid-helium temperature was shown. These devices depend on the difference in temperatures at which two metallic elements, in this case lead and tin, become superconducting. The magnetic field set up by a current through one of them restores resistivity in the other. Switching times as low as 10^{-8} sec. have been recorded. The devices are prepared by metal evaporation as in printed circuit techniques, silicon monoxide being laid down for intermediate insulating layers. The main problem is to achieve reproducibility in performance for large numbers of a single design. A possible computer element embodying about 170 cryotrons on a sheet 5 in. × 2¼ in. was shown.

Operation of the Laboratory's existing computer facilities, *Ace* and *Deuce*, is in the hands of the Mathematics Division, and several excellent examples of fruitful collaboration with other Divisions were displayed. For example, a statistical analysis of performance and design data from trawlers at sea, collected by the Ship Division, has been made on *Deuce*. As a result, six parameters have been defined, from which it is possible to predict the effective horse-power-speed curve for a given design. Trawlers have already been built incorporating improvements indicated by these same parameters, and these have shown outstanding rough-weather performance. In a similar way, improvements of 10–20 per cent in resistance have been obtained in the case of models. Computer work is also being done on curve-fitting to the hull surface of a ship, with the view of eliminating the full-scale fairing of a ship's lines on the mould loft floor.

The behaviour of ships in rough sea conditions is also being studied in a 100-ft.^{2} sea-keeping basin at the new Ship Hydrodynamics Laboratory at Feltham. A 10-ft. radio-controlled model of a trawler design was shown in operation at speeds up to 10 ft. per sec. in a wave system from a wave-maker along one side of the basin. Ultimately, it is intended to fit a transverse wave-maker for the generation of confused sea states. The model makes simultaneous records—film or digital—of roll, pitch, heave, torque, time, thrust, shaft speed, helm and heading. At the same time, the position of the model is fixed by means of an ultrasonic pulse, which by time of transit gives a bearing to three shore stations.

The Aerodynamics Division, in addition to fundamental work on high-speed flight, also devotes a considerable effort to industrial aerodynamics, and a low-speed wind tunnel, with 7-ft.^{2} section and a balance for simultaneous measurement of pitching, rolling and yawing, has been converted for such tests. The phenomenon of 'vortex shedding' can, at particular wind velocities, lead to dangerous oscillations of structures, and models of two tall chimneys were shown in an airstream. One of these was fitted with three helical strakes and the oscillation was shown to be eliminated. A similar type of problem is the oscillation of banks of parallel tubes such as heat exchanger tubes in a high-velocity gas stream. By means of films of a scale model of such a bank, studies have been made of the nature of the oscillation and its relation to various parameters.

A model of a single span of the proposed Severn suspension bridge was shown under test. The design is one of several possible ones which are being tested for compatibility between simplicity of construction and aerodynamic stability. The model itself is rigid, but on a damped free suspension, and is scaled for mass and inertia (1 : 48) and also for the frequency ratio of vertical to torsional oscillation. Under these conditions the air-speed at which oscillations occur is directly related to the air-speed at which they

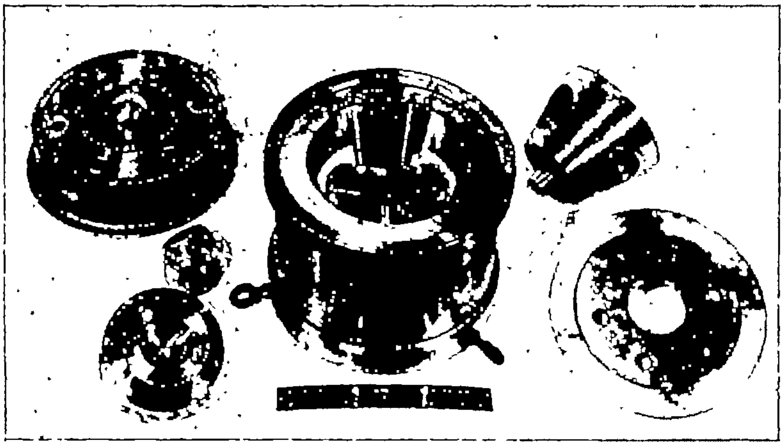


Fig. 1. Ultra high-pressure apparatus. This photograph shows the construction of the apparatus used to generate ultra high-pressures. The upper anvil is removed and the tetrahedral chamber is exposed. Crown copyright reserved

occur in the model. The latter has, in fact, been found to be stable at speeds up to 80 ft. per sec., corresponding to actual wind-speeds of 100 m.p.h.

The work in the Metallurgy Division on the fundamental mechanism of brittle cleavage fracture in single crystals of iron has been followed up by studies of the effect of orientation on the mechanical properties of polycrystalline iron. At right angles to the direction of plastic flow in rolling, the metal is not only brittle at room temperature, but also becomes progressively weaker as the temperature is lowered. This behaviour is not directly explicable in terms of the orientation effects in single crystals. The dislocation pattern of such cold-worked iron is being investigated by the examination of thin films on the electron microscope.

Brittleness in antimony–copper alloys has been connected experimentally with the presence of surface layers of high antimony concentration. The latter have been demonstrated by radioactivation, followed by the removal of successive 500-Å. layers with emery. After three such treatments both the surface composition and the mechanical properties of the metal correspond with those of the bulk material. After heat treatment for 20 hr. at 950° C., brittleness and the presence of one-third of a monolayer of antimony at the surface are restored.

Nuclear magnetic and electron-spin resonance are being used for studies of the fundamental properties of materials, particularly polymers, in the Basic Physics Division. Preliminary work on solids at extremely high pressures has been carried out in an apparatus consisting of a tetrahedral arrangement of four tungsten carbide anvils (Fig. 1) subjected to hydraulic pressure (200 tons load). The centre tetrahedron (side-length 0·75 in.) of pyrophyllite, which transmits the pressure hydrostatically to the specimen (0·3 in. × 0·1 in. diam.), can be seen dismantled in Fig. 2. Connexions for measuring resistance, temperature, or for heating the specimen, are made via the anvils. In preliminary work pressures of 77,000 atm. have been attained, as shown by observation of the resistivity transition point of barium metal. With the apparatus it is intended to study the effect of pressure on the properties of semiconductors.

For pressures of more normal industrial interest, in the 5–10,000 atm. region, pressure balances have been calibrated to a few parts in 100,000. The correction to be applied for elastic deformation of the piston–cylinder assembly has been determined by measurements with two assemblies of materials of different elastic constants (steel and aluminium bronze) in opposition, and also by determining the rate of flow of liquid between piston and cylinder at different pressures. The two methods give very closely agreeing results. This work will also be used to study the crystal and electronic transitions of the various elements under pressure.

Engineering requirements have always been prominent in the programme of the Standards Division. A 450 tonf. secondary standard load cell incorporates nine 50 tonf. struts, each of which is calibrated on a deadweight machine. Each strut has eight strain gauges connected in pairs to bridge circuits, the outputs from which are fed to a digital recording circuit capable of an accuracy of ± 5 μV. in 2,500 μV.

The same Division, with its tradition of high-precision metrology, is well equipped for the construction of a new primary standard of mutual inductance, one of the two basic instruments for deriving electrical quantities from the fundamental units of length and time. The design follows the

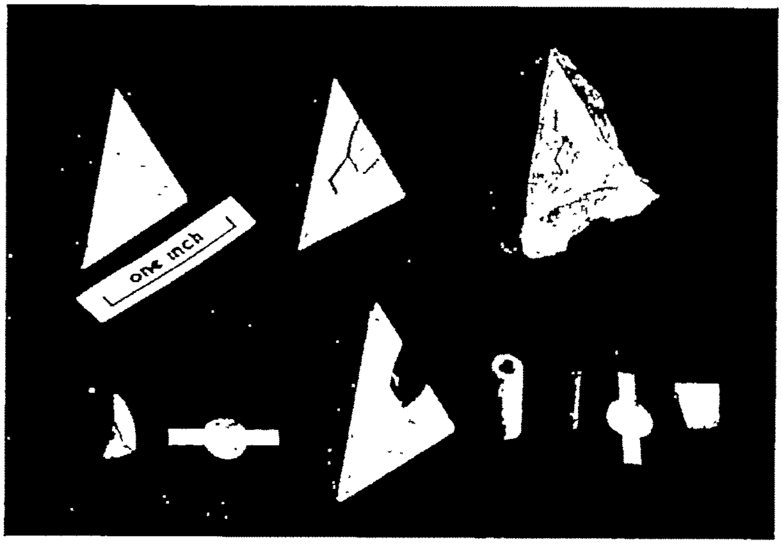


Fig. 2 Ultra high-pressure apparatus. This photograph shows samples of the pyrophyllite tetrahedra. At the upper right is one which has been loaded and shows the gasket formation; the lower position is an exploded view of the assembly and shows the test samples, the silver chloride sleeve, electrical contacts and the completing pieces of the pyrophyllite tetrahedon. Crown copyright reserved

original one of A. Campbell, with two coaxial helices, separated by a gap equal to their combined length, wound on a helical groove in a fused quartz former. A secondary of many turns is situated in a plane midway between the helices. With modern methods of metrology, including interferometric techniques for length, it is hoped to realize considerably greater accuracy in the dimensions of the complete assembly than in the earlier standard.

A new field in which there is a growing demand for a high precision is the measurement of temperatures in the region 10–90° K., and a helium gas thermometer used for such purposes was on show. The helium is contained in a constant volume, changes in pressure being measured as changes in capacity by movement of a thin metal diaphragm. Fixed points are the boiling points of oxygen (c. 90° K.) and hydrogen (c. 20° K.), and work is in progress to realize the triple point of oxygen (c. 54·4° K.). It is thus hoped to extend the International Temperature Scale below the present limit of 90° K. Platinum resistance thermometers, calibrated against the helium thermometer, have been compared with others from the National Bureau of Standards, Washington, and from Pennsylvania State University with an agreement between laboratories of ± 0·02° over the range 20–90° K.

In the Light Division an attempt is being made to establish an absolute standard of luminous intensity without reference to a black body radiator. The response of a photocell is calibrated in volts per watt of incident radiation in an absolute radiometer. The same photocell is then used to measure the output from a secondary standard lamp (2,042° K.), using a liquid filter designed to give, in combination with the photocell, the same relative spectral response as the standard photometric eye. The same experiment has also been carried out with a filter–thermopile combination (the lamp temperature being 2,854° K.). Values of 673 and 676 lumens per watt at 0·555μ were obtained. The theoretical figure, depending on the values accepted for various constants in the temperature scale, is within the range 670–686.

The foregoing are chosen from more than 170 topics on display, which in turn represented only a proportion of the wide range of the total programme of the Laboratory. H. G. Short

FINAL MONTHS AND DESCENT OF SATELLITE *SPUTNIK* 3

By B. R. MAY and D. E. SMITH

Radio Research Station, Department of Scientific and Industrial Research, Slough

NOW that the satellite *Sputnik* 3 has descended, it is possible to review the last months of this satellite's existence, which ended on April 6, and to outline the main features of its 692-days lifetime, in which it performed some 10,037 revolutions and travelled more than 280 million miles.

Previous articles[1,2] reviewed the satellite's progress up to the end of April 1959, and we may now show the mean nodal period–time curve from the beginning of May 1959 until its descent (Fig. 1). It follows generally the expected shape, the slope increasing steadily from about 1·0 sec./day on June 31, 1959, to 1·8 sec./day on October 31, and to 2·5 sec./day on January 31, 1960. Since the beginning of May 1959 the perigee moved (in a direction opposed to the orbital motion of the satellite) from southern apex towards the equator, where it was on January 11, 1960, and had reached nearly 40° N. when the satellite descended.

Table 1 gives the orbital elements for *Sputnik* 3 from June 1.00, 1959, to April 1.00, 1960, obtained in the same manner as before[1]. The calculations have been made for only one value of scale height instead of two, since more reliable values for the scale height at the perigee height (also included in Table 1) are now available.

The period–time curve for the complete lifetime of this satellite has been plotted in Fig. 2, and the variations in the slope of the curve indicate the constantly changing atmospheric density encountered by the satellite at its perigee. The shape of the curve is affected by the rotation of the orbit, and its departure from a regular form has created difficulties in producing predictions the accuracy of which is better than 2–3 min. at the end of a period of a week, and in estimating the date of descent of the satellite[3]. The curve also displays irregularities lasting only a few days—those which occurred during

Table 1. Orbital Elements for 1958 δ_2 (Figures in brackets are probable errors)

Date	Nodal period of revolution (min.)	Semi-major axis (km.)	Eccentricity	Perigee distance (km.)	Apogee distance (km.)	Orbital inclination (deg.)	Rate of rotation of orbital plane (deg./day)	Argument of perigee (deg.)	Scale height at perigee (km.)
1959									
June 1.00	99·127 (0·005)	7096·1 (0·2)	0·0721 (0·0005)	6584·4 (3)	7607·9 (3)	65·10 (0·01)	2·91 (0·02)	273 (1)	37 (4)
July 1.00	98·703 (0·005)	7075·7 (0·2)	0·0695 (0·0005)	6583·8 (3)	7567·6 (3)	65·10 (0·01)	2·94 (0·02)	261 (1)	37 (4)
Aug. 1.00	98·206 (0·005)	7051·7 (0·2)	0·0665 (0·0005)	6583·1 (3)	7520·8 (3)	65·09 (0·01)	2·98 (0·02)	248 (1)	36 (4)
Sept. 1.00	97·650 (0·005)	7024·9 (0·2)	0·0630 (0·0005)	6582·3 (3)	7467·5 (3)	65·09 (0·01)	3·02 (0·02)	235 (1)	36 (4)
Oct. 1.00	96·959 (0·005)	6991·6 (0·2)	0·0587 (0·0005)	6581·1 (3)	7402·0 (3)	65·08 (0·01)	3·07 (0·02)	223 (1)	36 (4)
Nov. 1.00	96·089 (0·005)	6949·6 (0·2)	0·0533 (0·0005)	6579·4 (3)	7319·9 (3)	65·07 (0·01)	3·13 (0·02)	210 (1)	36 (4)
Dec. 1.00	95·175 (0·005)	6906·5 (0·2)	0·0475 (0·0005)	6577·7 (3)	7233·3 (3)	65·06 (0·01)	3·20 (0·02)	197 (1)	35 (4)
1960									
Jan. 1.00	94·105 (0·010)	6853·9 (0·5)	0·0406 (0·0005)	6575·4 (3)	7132·5 (3)	65·06 (0·01)	3·28 (0·02)	183 (1)	35 (4)
Feb. 1.00	92·871 (0·015)	6794·3 (0·7)	0·0327 (0·0007)	6572·3 (4)	7016·4 (4)	65·03 (0·01)	3·37 (0·02)	170 (1)	34 (4)
Mar. 1.00	91·533 (0·020)	6728·4 (1·0)	0·0239 (0·0008)	6567·9 (5)	6889·0 (5)	65·02 (0·01)	3·50 (0·02)	156 (1)	32 (4)
Apr. 1.00	89·140 (0·020)	6610·5 (1·0)	0·0106 (0·0009)	6540·8 (6)	6680·2 (6)	65·00 (0·01)	3·72 (0·02)	142 (1)	26 (4)

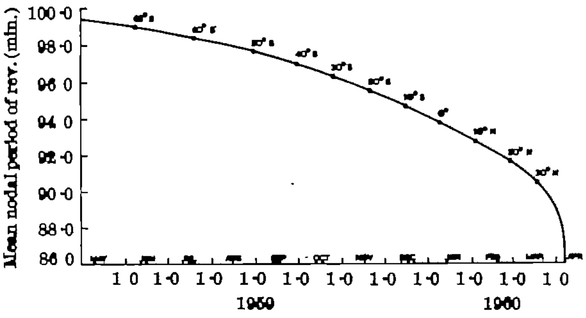


Fig. 1. Nodal period of revolution of Satellite 1958 δ_2 (*Sputnik 3*). Numbers on curve indicate latitude of perigee

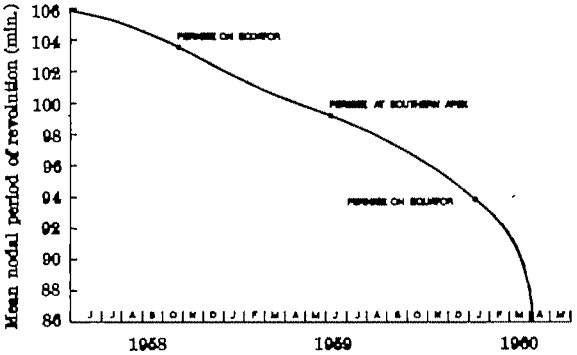


Fig. 2. Complete period–time curve for Satellite 1958 δ_2 (*Sputnik 3*)

July 15–19, August 17 and October 4–7, 1959, coincided with prominent geomagnetic storms on those dates.

The mean nodal period–time curve kept for prediction purposes, and which is accurate to 0·005 min. over the major part of the lifetime of the satellite, has been based upon optical and radio observations made mainly in the United Kingdom, Finland and France. As an object for visual observations the satellite was not very bright, and although the brightest magnitude reported was +1, the majority of observations were made at magnitudes of between +4 and +7. Due to this and the general irregularity of its brightness, the satellite was detectable only with difficulty with cameras and the more elaborate tracking instruments of small angular field, so that the majority of the 500 or so observations of time and position made in the United Kingdom were obtained by amateurs using quite modest instruments. The satellite's transmitter on 20 Mc./s. radiated during the whole of its lifetime, though after some three months it failed to transmit useful telemetry information, and from December 1959 there remained only a C.W. signal with spasmodic modulation. Since, at the time of its descent, the satellite was visible only from two narrow bands of latitudes situated near northern and southern apex, the radio transmissions provided the principal means of following its final revolutions.

Little is known about the descent of this satellite, as its suspected last transit lay mainly over the sea and unpopulated areas. The last reported visual sighting, at the time of writing, was made from Jokioinen in Finland at about 01.45 hr. U.T. on April 6, and it was unlikely that any later sighting would have been possible from consideration of the visibility conditions. Three transits later, the radio signals were picked up at Jodrell Bank, Berlin, Darmstadt and the Radio Research Station at Winkfield (where interferometer measurements were made) at about 06.11 hr.–06.15 hr. (position *A* in Fig. 3) and the last known positional radio observations were made on the following transit at about 07.30

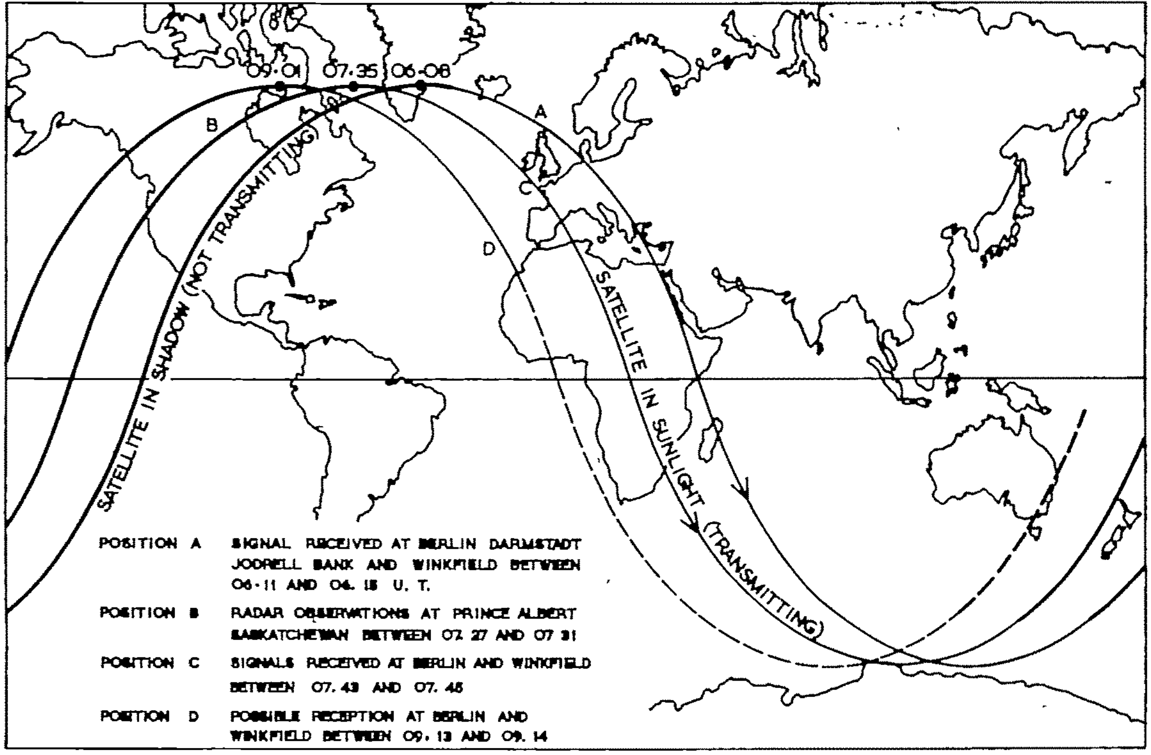

09·01
07·35
06·08
A
B
C
D
SATELLITE IN SHADOW (NOT TRANSMITTING)
SATELLITE IN SUNLIGHT (TRANSMITTING)
POSITION A SIGNAL RECEIVED AT BERLIN DARMSTADT JODRELL BANK AND WINKFIELD BETWEEN 06·11 AND 06. 15 U. T.
POSITION B RADAR OBSERVATIONS AT PRINCE ALBERT SASKATCHEWAN BETWEEN 07. 27 AND 07 31
POSITION C SIGNALS RECEIVED AT BERLIN AND WINKFIELD BETWEEN 07. 43 AND 07. 45
POSITION D POSSIBLE RECEPTION AT BERLIN AND WINKFIELD BETWEEN 09. 13 AND 09. 14

Fig. 3. Final revolutions of Satellite 1958 δ_2 (*Sputnik 3*), April 6, 1960

from Prince Albert, Saskatchewan (position *B*), and at about 07.43 from Winkfield (position *C*). At 08.00 hr. the period appeared to be 86·8 ± 0·2 min. and from theoretical considerations the satellite would have a further lifetime of about 1–2 hr. Moreover, it has been reported that a short, faint signal at the correct frequency was heard at both Berlin and Winkfield at about 09.13 hr. (position *D* in Fig. 3), when the satellite was below the horizon from both stations. A normal half-hop transmission seems to be impossible from a consideration of the position of the satellite and its transmitting frequency, but it is possible that propagation by scattering in the ionosphere may have taken place rather than reflexion, since the ionosphere was very disturbed in this region at this time. This evidence must, however, be regarded as inconclusive.

We should like to take this opportunity of thanking all those who have sent us radio and optical observations of this satellite, thus enabling a regular flow of predictions to be maintained.

This work was carried out as part of the programme of the Radio Research Board and is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

[1] King-Hele, D. G., *Nature*, 182, 1409 (1958).
[2] May, B. R., and Smith, D. R., *Nature*, 184, 765 (1959).
[3] May, B. R., *Nature*, 186, 729 (1960).

SCIENTIFIC RESEARCH AND DEVELOPMENT: A COMPARATIVE STUDY

By S. DEDIJER

Formerly Director of the Boris Kidrich Institute of Nuclear Sciences, Belgrade

THE scientific potential of Yugoslavia and the effort to increase it are to-day much greater than in 1940. Nevertheless, many Yugoslav scientists have felt for years that their country was neglecting science and that a sounder and a more vigorous research policy was needed. Owing to a lack of liaison between the embryo scientific community and the State nothing was done to back up these impressions with quantitative evidence. This happened also because the Government felt, by what it calls now "the logic of development", that the country could not concentrate both on the development of science and industrial production potential. In the latter case considerable results have been achieved; outside observers consider the economic development of Yugoslavia to be to-day among the most rapid in the world. Lately, however, a new, previously lacking awareness of the consequences of the 'logical' neglect of research has begun to appear in Government circles. The following statement[1], the first such made by a Yugoslav Government and Communist League leader, perhaps best illustrates the background of the recent trend toward a more vigorous research policy:

"We have posed ourselves the goal to catch up economically and culturally with the developed countries of the world and to do it as rapidly and as soon as possible. But how to do it when the world is striding forward at great speed in the midst of a scientific–technological revolution? The forces of organized scientific–technological creativity are continuously and rapidly growing and the developed countries are in a position to introduce incessantly ever new and more abundant knowledge and to create new productive forces. Under such dynamically competitive conditions a country which develops its production only on the basis of the existing, routine technology cannot reach the same goal as the most developed countries. On the contrary, such a country will unavoidably and 'systematically' lag. . . . In this sense, we are lagging behind the most developed countries."

Whether one defines it by generalizing Marx's definition of work or by using the broader concepts of cybernetics, a research policy calls for decisions on: (1) The principal goals which a society can and should reach by means of its research potential. (2) The magnitude of the 'physical' elements of the scientific potential: personnel, equipment, finances, etc. (3) The long-range research programme, that is, the distribution of the scientific potential with respect to the main social goals. (4) Time distribution of the scientific effort. (5) The social and political measures needed to make the potential both scientifically and socially productive.

Until recently Yugoslavia had very little of the information needed to make sound decisions on any of the above components of a research policy. The tables in this paper were prepared in order to estimate and illustrate how much Yugoslavia is "lagging behind the developed countries". This is done by comparing the orders of magnitude of the scientific effort per inhabitant of Yugoslavia and its economic potential with those of the United Kingdom, the U.S.S.R. and the United States.

The tables, with the appropriate comments, served as an introduction to the discussion between the representatives of science, industry and Government at a symposium on the organization of research of the First Yugoslav Chemical Congress, held in Zagreb during June 15–21. Some of the tables, with added comments of a more general kind, are presented here.

Looking through the various national statistical yearbooks one is impressed by how many countries have felt the need to count their donkeys and how few their scientists. This is because many countries are just beginning to consider what the current scientific revolution means to them. But even countries which gave birth to the industrial and the scientific revolutions have begun only recently the difficult task of measuring the various aspects of the interaction of science and society. As late as 1957, for example, the Advisory Council on Scientific Policy of the United Kingdom[2] pointed out that "this is a field in which it is difficult to obtain precise and comprehensive statistics", regretted "that comparable figures were not available for Western European countries" and warned that "although we have to some extent followed the American model in the presentation of our statistics, any comparison should be made with considerable reserve".

To make a comprehensive comparison of the role of science in various countries one should take into account the scientific efforts, the scientific potentials and their social and scientific productivities. Yet for most of these concepts no one has devised up to now reliable measuring rods. In the case of Yugoslavia the small amount of data existing on research was based on ill-defined (if defined at all) concepts and on criteria generally unacceptable in comparison with those adopted in the developed countries. For all these reasons, the possible field of comparison was limited to a small number of research indicators on which the most elementary statistics exist in all the countries in question and to which a common set of criteria could be applied. This also limited the comparison to the year 1957. The indicators are:

(1) The annual expenditure on research and development. (2) The number of scientists and engineers. (3) The annual production of engineers and scientists. (4) The expenditure on research in various industries.

The necessity to limit ourselves to these indicators of the scientific effort and potential has biased the comparison in favour of Yugoslavia. For they do not tell us anything about the scientific and social productivity of the research policy. The countries with which we are comparing Yugoslavia's scientific effort and potential have had experience with research for tens and even for hundreds of years, and have been aware of the economic and social consequences of the scientific revolution much longer than Yugoslavia. Let us take, for example, one hundred young men entering a branch of research in one of the three developed countries and a hundred in Yugoslavia. The first hundred were trained in universities where research has a long tradition. They are only another hundred research workers becoming a part of an existing scientific potential with a long tradition. The hundred Yugoslavs come from over-crowded, under-staffed and under-equipped universities, where, everyone in Yugoslavia readily admits, research is neglected by tradition and until recently by policy. Most likely, they are the first hundred research workers in the given branch; and they are to work as a part of an embryo scientific community with many negative and few positive inherited traits. All this is not conducive to make the Yugoslav hundred into a highly productive nucleus in the given branch. Thus, were we to compare the results obtained from a given investment in research, the comparative picture would be much less favourable to Yugoslavia than the tables indicate.

To avoid the risk of under-estimating the scientific effort of Yugoslavia, the maximum figures and the most favourable variants were taken and the same criteria as in the developed countries were applied. Thus, in estimating the number of university teachers engaged in research, the same criteria were used as in the United States and the United Kingdom, although this is quite unrealistic. Also, whenever there was any doubt if a sum of money had already found its way into the "research expenditure of Yugoslavia", it was added anew rather than risk to omit it. Hence, the probability of the error in the Yugoslav figures on research being plus is equal to 0. The probable errors for the corresponding data for other countries are not given, simply because, with a single exception, the sources do not quote them. This, however, is not vital since we are only comparing the orders of magnitude of scientific efforts.

The general sources of all the data are given at the end without quoting them for each particular figure. The Soviet data on research expenditure were taken from Western sources.

Yugoslavia's lag in research in 1960 is probably greater than Table 1 shows for 1957. For, according to one estimate, except in nuclear energy, Yugoslavia is not spending more on research in 1960 than in 1957. The United States, on the other hand, has increased its expenditure in 1959 by about 50 per cent over 1957, while the U.S.S.R. has increased it in 1960 by 15·4 per cent over 1959 [3].

Table 1. EXPENDITURE ON RESEARCH AND DEVELOPMENT PER INHABITANT (1957)

	(American dollars)	(Relative)
United States	47·9	53·2
U.S.S.R.	26·5	29·4
United Kingdom	18·2	20·1
Yugoslavia	<0·9	1
British Colonies	0·05	1/18

To illustrate the dynamics of growth of the scientific effort we have chosen the United States (Table 2) because the statistical data are most easily available.

Table 2. DYNAMICS OF GROWTH OF THE SCIENTIFIC EFFORT (UNITED STATES)

Year	Electrical energy	Steel	Expenditure on research and development
1945	1·0	1·0	1·0
1950	1·4	1·2	1·8
1951	—	1·3	2·2
1952	—	1·2	2·5
1953	—	1·5	2·6
1954	—	1·1	2·7
1955	2·3	1·5	3·6
1956	—	1·5	4·3
1957	2·6	1·4	5·4
1958	2·7	1·1	6·6
1959	—	—	8·2

Table 3 is least satisfactory from the point of view of method. It has been assumed that what in Yugoslavia is called 'social product' and 'national economy investment' corresponds to the gross national product and fixed capital formation used in the United States and the United Kingdom. Some Yugoslav economists estimate that the gross national product is by definition about 10 per cent greater than the 'social product'. If we actually used the gross national product, the figure 0·5 per cent for Yugoslavia would be even smaller. The Soviet figures were obtained from ref. 4.

It would have been illuminating if the tables contained data from countries equally or less economically developed than Yugoslavia. It is significant, although unfortunate, that such material seems scarcely to exist in the published literature—if at

Table 3. PORTION OF GROSS NATIONAL PRODUCT SPENT ON RESEARCH AND DEVELOPMENT AND GROSS FIXED CAPITAL FORMATION (1957)

	Research and development expenditure as per cent gross national product	Fixed capital formation as per cent gross national product
Yugoslavia	<0·5	27·5
U.S.S.R.	2·1(?)	15·0(?)
United Kingdom	1·7	15·5
United States	1·9	17·4

Table 4. COMPARISON OF THE ECONOMIC DEVELOPMENT AND SCIENTIFIC EFFORT PER INHABITANT (1957) (RELATIVE)

Country	Electrical energy	Total energy	Steel	Sulph. acid	Cement	Shoes	Dollars for science
Yugoslavia	1	1	1	1	1	1	1
U.S.S.R.	3·1	4·2	4·4	3·3	1·3	1·4	20·4
United Kingdom	5·2	8·1	7·2	6·7	2·1	2·5	20·1
United States	12·2	14·8	10·3	12·8	2·8	3·1	53·2

Table 5. SCIENTISTS AND ENGINEERS PER INHABITANT (1957) (RELATIVE)

Country	Scientists, engineers in research	Engineers in industry	Graduating Engineers	Graduating Scientists
Yugoslavia	1	1	1	1
U.S.S.R.	5·5	11·1	5·7	1·8
United Kingdom	4·0	3·6	1·9	3·3
United States	7·1	8·3	2·5	5·9

all. For this reason in writing about the undeveloped countries, as one author has said, one is prone to commit the well-known sin of over-generalization and under-documentation. This sin of 'feigning hypotheses' will not be avoided in the comments to the tables.

Whether there is a general 'logic of development' which makes undeveloped countries neglect research, as evidently Yugoslavia has done up to now, is difficult to say. But some of the few economists who have considered the role of research in economic development seem to agree that "There is no doubt that one of the main deficiencies of underdeveloped countries is their failure to spend adequately upon research and upon the development of new processes and materials appropriate to their circumstances"[5]. From Table 3 and the available inadequate, partial evidence from other countries, one could reformulate W. A. Lewis's words as a quantitative 'law': "The higher the economic development of a country, the greater is the percentage of the gross national product invested in research".

This 'law' actually represents a new definition of an undeveloped country in the scientific revolution era. It would be worth while to analyse the causes of this 'law' by all the methods available to social science. Here we shall only point out some of the consequences of such neglect of research.

As Marx would have put it, research lowers the 'exchange value' and increases the 'use value' of the existing goods; it creates completely new 'use values' by creating new products for new needs. Thus, for example, in the United States, "about 41 per cent of the manufacturing industries research money is spent on the improvement of present products, 48 per cent on new products and only 11 per cent on new processes"[6]. Research increases the productivity of labour; according to one source[7] almost 1 per cent of the annual increase of productivity of labour of 2·2 per cent in the United States is due to research. By neglecting research an undeveloped country has to leave it to others to transform its raw or semi-fabricated materials into new or better kinds of products, which it will have to buy. At the same time, it will continue to spend more labour per unit product than the countries which encourage research. Thus it continues to be an object of exploitation in the world market.

To cope with the "dynamically competitive conditions" of the scientific revolution mentioned by Mr. Popovich, a country must start to develop research simultaneously with its economic potential. For although research expenditure constitutes a small percentage of the gross national product, it takes considerable time to translate it into tangible results. To transform a laboratory result into an economically successful commodity takes on the average 5–10 years. It takes at least 10 years to train a talented secondary school graduate for research. The time needed to create 'tradition', that is, the atmosphere necessary for productive scientific work, is much longer. It follows that the results of neglecting research will be felt only when it may prove too late to cope under competitive conditions.

Some of the noticeable characteristic traits of science in undeveloped countries can be attributed to the neglect of research; such as, for example, the neglect of research in the universities. From the official figures on research expenditure in the universities, one can conclude that Yugoslavia spends not much more than 1 per cent of its research funds there. This is several times less than in the United States and the United Kingdom. At the same time that the universities are starving for research funds, the research institutes are thriving. That Yugoslavia is not alone in this is shown by the following resolution of the physics teachers of India[8]: "As the main burden of training future physicists must be borne by the universities, the Universities Grant Commission is requested to ensure that the emoluments, research grants and other facilities available to the universities teachers are adequate and in no ways inferior to those available to people in similar positions in the National laboratories or elsewhere". There is evidence that scientists in Yugoslavia and India are not alone in feeling this way.

In listing a set of decisions constituting a research policy, perhaps the most important was put last. This can be seen from the following words of Prof. Polanyi in *Science* in 1950, illustrating something encountered by anyone who has studied this or that phase of developing science in one or several new countries.

"Those who have been in those parts of the world where the life of science is just beginning, know the tremendous difficulties and the struggle which the lack of scientific tradition imposes upon the pioneers working to found science in these countries. On one hand the research work is stagnating because of lack of encouragement, and on the other it is developing completely chaotically for the lack of any kind of directing influence. Unsound reputations spring up like mushrooms, founded on nothing or on the commonest results, or often on empty boasting. The political and economic interests influence to a large extent the nominations to important positions and in deciding on funds for research. No matter how great is the local talent, such an environment will not make it possible for it to develop" (translated from Yugoslav).

This illustrates only some of the aspects of a lack of transfer of information inside a research community and between it and the other sectors of society, such as industry, Government and others, which must participate in formulating a research policy. Such a lack of information, among other matters, gives rise to the 'nuclear myth', so prevalent in undeveloped countries. There is a fair amount of qualitative evidence that in some of these countries the expenditure on nuclear physics and nuclear energy research is many times greater than in the fields of utmost economic importance. In the case of Yugoslavia there is also quantitative evidence. Thus, for example, from Table 6 presented at the symposium (not published here) one can estimate that in the next five years Yugoslavia now plans to spend about ten times more on research in nuclear energy than in the chemical, metal, petroleum, food, textile, paper and non-metal industries combined, which in 1958 contributed 22·5 per cent of its national income. This should be considered in the light of the statement of a Nuclear Energy Commission spokesman that Yugoslavia will need nuclear power at the earliest 20–25 years from now[9].

"Science is the motor of social progress", said one of the slogans at the fifth Congress of the Socialist League of Yugoslavia, its mass political organization, in May 1960. The logic which neglects the development of a sound research policy results in the development of all parts of the vehicle of social progress except one: its motor. From all that has been said it emerges that the usual economic indicators are necessary but not sufficient as a measure of economic development. Any measurement of economic development to be adequate must include indicators about this motor, that is, about the scientific effort, the scientific potential and its scientific and social productivity.

---

[1] Melentiye Popovich (president of the newly formed Federal Research Council), "The Social Aspects of Scientific Research" (*Socijalizam*, No. 1, 1960).

[2] Annual Report of the Advisory Council on Scientific Policy 1956–57 (H.M.S.O., London).

[3] "La Matière Grise et L'Europe" (Centre de Recherche Européenes, Lausanne, 1960).

[4] "Comparisons of the U.S. and Soviet Economies", Part 2 (G.P.O., Washington, 1959).

[5] Lewis, W. A., "The Theory of Economic Growth", 175 (Allen and Unwin, Ltd., 1955).

[6] "The Scientific Revolution", by Elbers, G., and Duncan, P., 97 (Public Affairs Press, Washington, D.C., 1959).

[7] Ewell, R., *Chem. and Eng. News* (July 18, 1955).

[8] "Physics in Indian Universities", *Nature*, 181, 23 (1958).

[9] *Avdo Humo*, '*Borba*' (Dec. 28, 1959).

Principal Sources used in Tables

(1) Statisticki Godisnjak 1959, Savezni Savet za Statistiku, Beograd.
(2) Jugoslovenski Pregled 1957, 1958.
(3) Izvestaj Savezne Industrijske Komore za 1957, 1958, Beograd.
(4) Statistical Abstract of the United States (G.P.O., Washington, 1959).
(5) Annual Abstract of Statistics, No. 96 (H.M.S.O., London, 1959).
(6) Colonial Research 1958–59 (H.M.S.O., London).
(7) Annual Report of the Advisory Council on Scientific Policy, 1956–57 (H.M.S.O., London).
(8) S.S.S.R. v Cifrah, Statisticeski Zbornik, Centralnoe Statisticeskoe Upravlenie pri Sovete Ministrov S.S.S.R. (Moskva, 1958).
(9) Scientific Research in Great Britain (G.P.O., Washington, 1960).

MEASURING THE SIZE OF ISOLATED CELLS

By DR. SAMUEL S. EPSTEIN and JACQUELINE B. WEISS
Hospital for Sick Children, Great Ormond Street, London, W.C.1

THE accurate sizing of individual cells is a problem which has interested microscopists since the seventeenth century. One of the earliest recorded attempts at measuring the size of cells was made by Leeuwenhoek[1] in 1684. He selected grains of sand of similar size, arranged them along graduated lines and determined the number of grains to the inch. He then attempted to size red blood cells by relating their diameters to a grain of such sand. An equally ingenious approach was that of Jurin[2], who in 1718 twisted hair finely around a pin and measured microscopically the length of a coil and the number of component twists, thus obtaining the diameter of the hair. He then counted the number of red cells which equalled the diameter of a segment of hair.

With the progress of optical science and microscope design, projected cell images were measured by means of an ocular prism attachment (camera lucida). No real degree of precision, however, was reached until 1910 when Price-Jones[3] described his classical method for determining variations in the diameters of red blood corpuscles. He projected the images of microscopic fields of stained blood films directly on to paper in a system of known magnification. Individual cells were outlined in pencil, measured with a millimetre scale and their diameters expressed in μ. The average diameters of successive groups of 100 cells were found to be relatively constant. This procedure was afterwards refined when Price-Jones[4], applying the statistical concept of Yule[5], plotted size distribution curves of groups of 500 red blood corpuscles. He also suggested methods for the measurement of non-circular cells, based on the assumption that the average of their greater and smaller axes approximated to the circular diameter.

In 1924, Pijper[6] demonstrated that red blood cells spread in a monolayer on a glass slide would function as a diffraction grating—the translucent interspaces allowing passage of unaltered light. Diffraction would thus occur at the edge of each cell. This same observation had, in fact, been made a century previously by Young[7], who devised an 'eriometer' to measure size of wool fibres and later adapted this to red blood cells. A source of illumination, viewed through such a slide as Pijper described, appeared surrounded by a series of concentric halo spectra, the size of the halo being inversely proportional to the size of the cell. This method is of limited value when there is much anisocytosis, as it determines the modal rather than the arithmetic mean. Furthermore, it is strictly applicable only to cells which are both circular and translucent.

Measuring the approximate size of bacteria was performed in 1926 by Wilson[8], who related opacities to cell counts of suspensions of organisms. Earlier, Brown[9] had related the dried weight of organisms to their opacity in suspension. At this time bacteriologists on the whole were not interested in determining the size of bacteria—accepting the doctrine of Koch that cell forms are invariably constant. However, in 1928, Henrici[10], in a monograph on problems of morphological variations of bacteria, described in detail several methods for measuring the size of micro-organisms. For rod-shaped organisms he applied the type of projection method described by Price-Jones, and expressed cell size as a function of length. He also made size-distribution studies at different phases of growth, in this respect preceding Price-Jones's concept that determinations of average cell size alone were of limited value. With curved organisms, such as *Vibrio cholera*, he re-photographed the pencilled cell images as composite photographs, arranging the organisms in such a way that the centres and long axis of each separate cell coincided as nearly as possible on the plate. He measured cell area with a planimeter and length with dividers and derived an area/length index distribution curve for each stage of growth. For very small organisms he devised a method designed to overcome the difficulties of projection at high magnifications: projecting the cell images on to panchromatic films at a magnification of 3,000 times and reprojecting these photomicrographs at a magnification of 7–10 times. The projected images were traced on to cards and their area and length measured. Henrici found that by counting a sufficient but unspecified number of cells, the error due to fuzziness at the edge of the projected images could be compensated. He did this by tracing through the centre of the "zone of unsharpness", the chances being as great for "going inside the middle of this zone as outside of it". More recently an original technique, based on comparative weights of paper cut-outs of projected cell images, has been applied to a microbiological system[11].

Ocular Graticules

In recent years measuring the size of particles has attracted the attention of physicists and in the course of the past decade two distinct approaches to this problem have been evolved: the visual and the automatic. Strictly visual methods of measuring the size of particles applicable to cells involve the use of eye-piece graticules. These constitute a modification of the micrometer described more than a century previously by Kater[12], whereby a scale seen with the left eye was superimposed on cell images seen with the right eye. The more recent methods consist essentially of graticules with rectangular grids defining the counting area and a series of reference circles in the grid by which images are visually matched[13,14]. Other methods of reference include graticules with vertical lines of known separation[15], and gauges such as the flocytometer. Statistically designed techniques employing particle profile test strips have been used to assess the accuracy of graticule methods and minimize observer bias[16].

Spot Scanning

In general, automatic devices have depended on the use of television techniques and the photo-electric spot scanning of a specimen, either directly from a microscope preparation or from a photograph which can be taken from living material[17,18]. These methods are capable of providing rapid information and enable the analysis of numerous replicates. Several principles of spot scanning have been applied; these include double scanning, which compares counts obtained by scanning at different track widths, and intercept length scanning, whereby the number and length of intercepts of scanning lines across particles are measured and area and perimeter of the particle deduced. The guard spot method is a refinement of the intercept method and involves the use of two scanning spots, one controlling counting of the other. The absence of the control signal indicates that the lower or upper edge of a scanned particle has been reached. Thus a count of one is registered for each particle. Information from such a scanning analyser can be obtained in three forms: total count, mean area and approximate size distribution of particles or cells.

Certain errors may be introduced in both counting and estimating size by the aggregation of cells and, furthermore, irregularly shaped cells may be counted more than once due to re-entry of the counting spot. Information in the case of these cells may best be derived from their mean area in a given field by the integration of total cell area and count. Size distribution analyses are not easily performed. With circular cells, size is generally expressed in terms of diameter, and measuring size can be performed by counting only cells the diameters of which exceed a selected length. A distribution analysis of the complete field can therefore be obtained by counting at consecutive size increments—the value of the increments being determined by the field size. Where small size increments, such as those for red blood cells, are required, distribution curves cannot be obtained at a useful magnification on conventional machines. In general, the minimum measurable increment is of the order of 1·5–2μ in a field of $300\mu^2$.

The flying-spot particle resolver, which uses an electronic memory-device to simulate the double scanning spot, has been used for the determination of the mean area of *Euglena gracilis* grown at various concentrations of vitamin B_{12} (ref. 19).

Double-Image Microscopy

A semi-automatic visual method of determining the size of a cell—a double-image microscope micrometer—has recently been described[20,21]. This consists essentially of a mirror mounted on the diaphragm of a loudspeaker-type transducer, which is introduced between objective and eye-piece in a simple microscope system. The transducer is fed with alternating current, and the light source is arranged to flash when the vibrating mirror is at extreme positions. As a result of persistence of vision, two stationary images of each particle are seen. Image separation, in a vertical direction, depends on the amplitude of current and can be varied by means of a potentiometer. The diameter of a circular cell can thus be recorded on a calibrated ammeter after image separation has been adjusted so that the two images just touch. With irregular particles the microscope stage is rotated so that any chosen chord of the particle may be measured in the same manner. The reproducibility of this method for measuring circles is better than 1 per cent at 10μ and 3 per cent at 1μ. The instrument can be fitted with an electromagnetic device[22] for size distribution analyses. A more tedious modification involving the same principle in which, however, the image is split by shearing with two prism blocks arranged as an interferometer has also been described[23].

Cell Conductivity

The methods so far described are only capable of evaluating optical cross-sections of cells. A machine has, however, been devised (Coulter Electronics, Chicago) for the automatic measurement of cell volume[24,25]. This method depends on differences in resistance between cells and the fluid medium in which they are suspended. The cell suspension is forced through a small aperture of appropriate width, which has an immersed electrode on either side. Each cell, as it passes through the aperture, causes a change in resistance between the electrodes. A voltage pulse of short duration is thus produced which has a magnitude proportional to the size of the particle and which is essentially proportional to particle volume. The voltage pulses are amplified, fed to a threshold circuit with an adjustable threshold-level and counted. By counting at successive threshold increments, size distribution curves can be easily and accurately obtained. Corrections are automatically made for co-incident passage of more than one particle through the aperture, and the large number of particles counted minimizes error. Calibration is performed by using standard particles of known size. The accuracy of this method as applied to measuring the size of bacteria has been shown to be of the order of 2 per cent of the diameter for 1μ spheres[26]. It will be obvious that information obtained from a machine of this nature is of greater potential value to biologists than more conventional methods merely measuring some planar function.

[1] Leeuwenhoek, A. van, *Phil. Trans. Roy. Soc.*, 1673, 789 (1684).

[2] Jurin, J., *Phil. Trans. Roy. Soc.*, 30, 762 (1718).

[3] Price-Jones, C., *Brit. Med. J.*, ii, 1418 (1910).

[4] Price-Jones, C., "Red Blood Cell Diameters" (Oxford Medical Publications, London, 1933).

[5] Yule, U., "An Introduction to the Theory of Statistics", fifth ed. (London, 1919).

[6] Pijper, A., *Lancet*, ii, 367 (1924).

[7] Young, T., "Introduction to Medical Literature", 578 (1813).

[8] Wilson, G. S., *J. Hyg.* (Lond.), 25 (2), 150 (1926).

[9] Brown, H. C., *Indian J. Med. Res.*, 1, 711 (1914).

[10] Henrici, A. T., "Morphologic Variation and the Rate of Growth of Bacteria", 1 (Baillière, Tindall and Cox, London, 1928).

[11] Epstein, S. S., and Weiss, J. B., *Biochem. J.*, 75, 247 (1960).

[12] Kater, H., *Phil. Trans. Roy. Soc.*, 419 (1814).

[13] Patterson, H. S., and Cawood, W., *Trans. Faraday Soc.*, 32, 1084 (1936).

[14] Fairs, G. L., *Chem. and Indust.*, 62, 374 (1943).

[15] Hamilton, R. J., Holdsworth, J. F., and Walton, W. H., *Brit. J. App. Phys.*, Supp., No. 3 (1954).

[16] Watson H. H., and Mulford, D. F., *Brit. J. App. Phys.*, Supp. No. 3, (1954).

[17] Hawksley, P. G. W., Blackett, J. H., Meyer, E. W., and Fitzsimmons, A. H., *Brit. J. App. Phys.*, Supp. No. 3 (1954).

[18] Causley, D., and Young, J. Z., *Research*, 8, 430 (1955).

[19] Epstein, S. S., Weiss, J. B., Causley, D., and Bush, P. (unpublished work).

[20] Timbrell, V., *Nature*, 170, 318 (1952).

[21] Timbrell, V., Physical Society Exhibition Handbook (London, 1958 and 1959).

[22] Phys. Soc. Exhibition (Abstracts), *Lab. Prac.*, 8 (1), 33 (1959).

[23] Dyson, J., *Nature*, 184, 1561 (1959).

[24] Brecher, G., Schneiderman, M., and Williams, G. Z., *Amer. J. Clin. Path.*, 26 (12), 1439 (1956).

[25] Berg, R. H., Symposium on Particle Size Measurement. American Society for Testing Materials. Special Tech. Pub. No. 234.

[26] Kubitschek, H. E., *Nature*, 182, 234 (1958).

NEWS and VIEWS

Electrical Engineering in the Imperial College of Science and Technology

Sir Willis Jackson, director of research and education with Metropolitan-Vickers Electrical Co., Ltd., now the Associated Electrical Industries, Ltd., and president of the Institution of Electrical Engineers, has been appointed to the chair of electrical engineering at the Imperial College of Science and Technology, London. He will take up this post in October 1961, succeeding Prof. Arnold Tustin, who has been responsible for the central planning of the new building for the Department, and who has for some time wished to relinquish the post of head of the Department. Prof. Tustin will continue to direct the work of the Department in the field of heavy electrical engineering. Other leading members of the Department are Prof. Dennis Gabor (applied electron physics) and Prof. Colin Cherry (telecommunications).

The new appointment exemplifies the very close links which now exist between industry and the Imperial College at the highest level. Sir Willis Jackson resigned his chair at the College some seven years ago to go to Metropolitan-Vickers (see *Nature*, 171, 242; 1953). From this position he has exercised great influence both within the electrical industry and in the field of technological education in general. Now he is to return to his old College and his old Department. It is of the highest significance that one of the most distinguished technologists in Britain should be re-entering the academic ranks in a key post.

Royal Society Visiting Professorship: Prof. A. Schlüter

The Royal Society has instituted a visiting professorship so that overseas scientists of high distinction may be invited to the United Kingdom for a period of an academic year, or at least six months, to enable them to carry out research. The first holder of the appointment will be Prof. Arnulf Schlüter, professor af theoretical physics in the University of Munich, and also of the Max-Planck-Institut fur Physik und Astrophysik, Munich. He will take up the appointment on March 1, 1961, and work in the Department of Applied Mathematics and Theoretical Physics at Cambridge on problems in theoretical astrophysics and plasma physics. Prof. Schlüter, although still a young man, has achieved international distinction for his work. He was among the first to perceive the importance of magnetic fields in interstellar gas clouds, and has made many contributions to cosmical electrodynamics. He has clarified the nature of conductivity in ionized gases, and advanced the knowledge of the conditions for equilibrium and stability of plasmas. More recently he has investigated the conditions for thermonuclear reactions.

Sociological Studies at the University of Sheffield: Prof. R. K. Kelsall

Mr. R. K. Kelsall, at present head of the Department of Social Studies at Sheffield, has been appointed to a newly created chair of sociological studies. Mr. Kelsall was educated in the University of Glasgow and graduated M.A. with honours in political economy and history. He was awarded a Clarke postgraduate scholarship and a Leverhulme research grant, and also the Gladstone Prize. In 1933 he was appointed lecturer in the Economics and Commerce Department of University College, Hull, and was made head of this Department in 1939. In 1944 he took up an appointment as research officer in charge of the Ministry of Town and Country Planning's regional research unit for Birmingham and the West Midlands, and held this appointment until 1950, when he was appointed senior research officer in charge of the Nuffield Sociological Research Unit at the London School of Economics. He was appointed head of the School of Social Studies in the University of Sheffield in 1957, the post he now holds. Mr. Kelsall has had wide experience of many different kinds of social surveys, and has published many articles and several books on the results of his work.

Institution of the Rubber Industry: Awards

DR. ERICH KONRAD, formerly director of the Leverkusen Laboratories, Farbenfabriken Bayer, has been awarded the Colwyn Medal of the Institution of the Rubber Industry, the highest honour of the Institution, for conspicuous services to the rubber industry especially in the field of synthetic rubber development. As an assistant in the Chemical Institute of the University of Freiburg, Dr. Konrad entered the field of high-polymer chemistry. With his appointment in 1927 to Bayer at Leverkusen, his work received a decisive turn towards the chemistry and technology of rubber. His work on rubber synthesis reached the point of practical application in the setting up of synthetic rubber plants as early as 1936, and was recognized by the award of the Gold Medal by the Committee of the International Exhibition in Paris, 1937. The work of Dr. Konrad is one of the foundation stones on which the present-day synthetic rubber industry is built, and his rich experience in this field has given a decisive impetus to the development of new elastomers and new types of foamed materials.

The Hancock Medal of the Institution for 1960 has been awarded to Mr. C. B. Copeman, chairman of Maclaren and Sons, Ltd., publishers, for outstanding services to the Institution and the rubber industry.

Selby Fellowship: 1960 Award

DR. W. DEUCHARS, of the United Kingdom Atomic Energy Authority, has been awarded the Selby Fellowship for 1960. The award was established last year (see *Nature*, 184, 684; 1959) "to recognize that, whereas there are numerous scholarships that enable Australian graduates to proceed overseas for research experience, there is now a need for measures to bring young graduates from British and other overseas universities for postdoctoral work in Australian laboratories". The award, which is being administered by the Australian Academy of Science, Canberra, is normally for one year's work in an Australian university or research institute in any branch of physical or biological science. It carries a stipend of £A.1,500, and up to £A.500 of the holder's travel costs are met. Dr. W. Deuchars will go to Canberra and will work with Prof. E. W. Titterton at the Australian National University, Canberra. Applications for the next award close on August 31.

U.K. Commonwealth Scholarship Commission

FOLLOWING the setting up in the United Kingdom of the Commonwealth Scholarship Commission early this year under an Act of Parliament (see also this issue of *Nature*, p. 441), it has now been decided to award about 220 scholarships tenable in the United Kingdom from October onwards. The majority of these scholarships will be at the postgraduate-level and for two years, covering the cost of fares, tuition fees and living expenses while the holder of the scholarship is in the United Kingdom. The Commonwealth Scholarship Commission has now issued its first list of recipients for the award. This list of successful candidates covers nine Commonwealth countries and includes 66 awards, of which 44 are for scientific subjects. The distribution of these first scholarships is as follows: Canada, 18 (9 scientific); Australia, 16 (10 scientific); New Zealand, 10 (8 scientific); Ceylon, 6 (5 scientific); Hong Kong, 8 (5 scientific); Kenya, 3 (all scientific); Singapore, 3 (2 scientific); Tanganyika, 1 scientific; and Uganda, 1 scientific.

Road Research

DELEGATES from thirteen member and associated countries of the Organization for European Economic Co-operation have recommended that an international body should be set up to foster road-safety research. It is suggested that the international body should be responsible for co-ordinating the research effort of the various countries concerned; to foster the interchange of road-research information; and to recommend new researches on problems the solution of which requires, or would profit from, international co-operation. It was also recommended that each country should set up a national committee for road-safety research which would, in addition, provide a link with the proposed international body.

Integration of the Cape and Royal Greenwich Observatories

THE merging has been announced of the Cape Observatory with the Royal Greenwich Observatory under the Astronomer Royal. The Astronomer Royal and H.M. Astronomer at the Cape of Good Hope have been, and will continue to be, responsible to the Admiralty through the Hydrographer of the Navy. The Cape Observatory fulfils, in the southern hemisphere, much the same functions as those performed in the northern hemisphere by the Royal Greenwich Observatory the work of which it supplements, and there will be many advantages to be gained from the integration of the two Observatories.

Nature Conservation in Wales

THE Nature Conservancy has recently announced developments in its work in Wales, including the establishment of a new Nature Reserve at Cwm Glas, Crafnant, which, lying at the head of an upland valley, runs south-west for a distance of four miles from Trefriw in the Conway Valley. The Reserve covers 38 acres of glacially over-steepened slopes, broken by rock outcrops, and culminating in the summit of Moel Wen. It lies on basic volcanic rock and has a rich flora, including a number of arctic-alpine species, which are here growing at a relatively low altitude. There is a remnant ash-wood with a rich ground flora, and while the predominant tree is ash there are, in addition, many exceptionally large hawthorns. Together with plants typical of lowland woods and fertile soils the wood contains rock stonecrop, orpine and hart's-tongue fern, which are more particularly characteristic of such shaded, rocky places in western Britain.

Further to the establishment by the Nature Conservancy in 1955 of the Newborough Warren Ynys Llanddwyn Nature Reserve, Anglesey, and additions in 1956 and 1959, the Conservancy has now purchased another 78 acres. The Reserve now covers 1,470 acres and has a coast line of 10–11 miles. The area is of great ecological and physiographical interest, as the boundary between mobile and fixed sand and the gradation between open and closed plant communities pass right through it. Extensions are also announced to the Coed Rheidol Nature Reserve, near Devil's Bridge in Cardiganshire, and the Reserve now covers an area of 89 acres. Coed Rheidol is an interesting example of a moist, mossy sessile oak wood with a rich associated flora and fauna which have developed under conditions of high humidity and heavy rainfall.

British Poultry Science

When journals are being born at the rate of about two a day, the need for each new-comer must be scrutinized carefully. *British Poultry Science*, which has just been issued, is intended to be an international journal for the publication of original researches on the fowl, and for review articles (1, No. 1; April 1960. Pp. 72+xvi. Initially two numbers annually, published in April and October. Annual subscription, 30*s.*; U.S.A. and Canada, 5 dollars. Single issues, 17*s.* net; U.S.A. and Canada, 2.75 dollars net. Edinburgh and London: Oliver and Boyd, Ltd., 1960). The contents of the first number give no indication of how it is to differ from, or improve on, the established journals which already cover this field, and, indeed, some of its contents have already been published in part elsewhere. Its further aim of bringing within its covers all kinds of scientific work on the fowl is also open to question, if only because research workers prefer to publish by discipline rather than by organism (and libraries also choose to purchase on this basis). The fowl is perhaps unique among animals in already having journals devoted to it; but it is not clear that they have stimulated fundamental work on the biology of the fowl. It seems more likely that this stimulus will come from the rapidly increasing technical requirements of the poultry industry, which, in many aspects, have already outgrown their scientific base. If this new journal is to prosper, its policy will have to be more clearly defined, particularly with respect to its emphasis on pure and applied science, and towards its anticipated lay readership.

Local Health Service

Six pilot studies into local health carried out under the direction of governments throughout the world are discussed in the first part of a report called "Local Health Service", by the World Health Organization (Report Series, No. 194. Pp. 49. Geneva: World Health Organization; London: H.M. Stationery Office, 1960. 2 Swiss francs; 3*s.* 6*d.*; 0.60 dollars). The Expert Committee on Public Health Administration in this, its third report, reaches the conclusion that the methods used are generally sound, and that, in the development of health services locally, such studies should become a routine procedure, not only as a means of assessing what services exist but also as a preliminary to the setting up of new services. The Committee discusses some of the factors affecting local health services: the need for decentralization of health services and for an efficient local administration; the various methods of organizing community effort in public health work; the importance of a closer alliance between general medical practice and local health service, and the consequent need for inculcating a proper approach to public health in the undergraduate medical curriculum; and the problems of urbanization arising from the great influx of people into the towns in response to industrial demand.

Unesco Fellowships for Electronic Computing Research

The United Nations Educational, Scientific and Cultural Organization is offering six fellowships to be shared among member States to enable highly qualified specialists to undertake research in the use of electronic computers for the purpose of mechanical translation, the theory of switching or the use of computers for the reduction of geophysical data. The fellowships will normally be for six months and will carry a travel grant and a monthly allowance varying according to the country of study. Further information can be obtained from the United Kingdom National Commission for Unesco, Ministry of Education, Curzon Street, London, W.1.

University News:

Belfast

Among recent appointments to lectureships are the following: Dr. N. T. Dunwoody (engineering mathematics) and Mr. R. G. A. Stretch (psychology).

Birmingham

Dr. I. E. Bush has been appointed to the Bowman chair of physiology and to the directorship of the Department of Physiology from October 1. Dr. Bush has been a member of the external staff of the Medical Research Council since 1958, and is also a Senior Research Fellow at New College, Oxford.

The title of professor of physiological chemistry has been conferred on Dr. W. V. Thorpe, who is at present reader in chemical physiology, as from October 1.

The following appointments are also announced. *Lectureships:* Dr. J. D. Dowell, Dr. P. Swinbank and C. P. van Zyl (physics); Dr. J. M. Webber (chemistry); K. Foster (mechanical engineering); Dr. G. W. Rowe (industrial metallurgy); Dr. V. J. Emery (mathematical physics); Dr. E. F. Stack-Forsyth (electrical engineering); R. N. Morris (econometrics and social statistics). *Research Fellowships:* Dr. T. F. Tuan (mathematical physics); Dr. N. Pessall and B. Cockayne (physical metallurgy); D. J. White to be Kenward Memorial Fellow (engineering production); H. R. Shaylor to be Staff Fellow in nuclear physics in the Department of Physics.

Bristol

Prof. T. K. Ewer, at present professor of animal husbandry in the University of Queensland, has been appointed to the chair of animal husbandry. The following appointments are also announced. *Lectureships:* Dr. P. C. Caldwell (biochemistry within the Department of Zoology); A. J. B. Cruickshank (physical chemistry); Dr. I. O. Sutherland (organic chemistry). *Research Fellowship:* Dr. P. H. Fowler (physics).

Edinburgh

The following appointments have been announced: *Readerships*, Dr. J. P. Duguid (bacteriology) and Dr. C. A. Beevers (chemistry); *Lectureships*, J. R. Small (accounting and business methods), Dr. C. G. Thomson (clinical chemistry), Dr. D. J. McAuliffe (ophthalmology), and Dr. F. M. Martin (public health and social medicine).

Leeds

Dr. F. Hepburn has been appointed lecturer in medical physics.

Among the grants in aid of research which have recently been announced are: £5,000 to the Department of Physics from the Department of Scientific and Industrial Research; £2,100 to the

Department of Civil Engineering from the Cement and Concrete Association; 7,000 dollars to the Department of Biomolecular Structure from the Muscular Dystrophy Association of America.

London

DR. C. B. B. DOWNMAN has been appointed to the Sophia Jex-Blake chair of physiology at the Royal Free Hospital School of Medicine; Dr. I. Doniach to the chair of morbid anatomy tenable at the London Hospital Medical School; and Dr. J. Hamilton to the second chair of physics tenable at University College. Among the appointments to readerships are: Mr. A. J. Buller (physiology), tenable at King's College; Mr. J. C. de Courcy Henderson (reinforced concrete structures), tenable at the Imperial College of Science and Technology. Titles of "professor in the University of London" have been conferred on Dr. H. Elliot (physics), in respect of his post at the Imperial College of Science and Technology, and on Dr. W. J. Hickinbottom (organic chemistry), in respect of his post at Queen Mary College. Titles of professor emeritus have been conferred on Prof. T. J. Bosworth (veterinary pathology), Prof. E. S. Pearson (statistics), Prof. Dorothy S. Russell (morbid anatomy), Prof. W. Smith (bacteriology), and Prof. E. E. Turner (chemistry).

Prof. E. T. C. Spooner, University professor of bacteriology and immunology, London School of Hygiene and Tropical Medicine, has been appointed dean of the School in succession to the late Sir James Kilpatrick.

Sheffield

THE following appointments to lectureships have been announced: Mr. F. W. G. Warren (applied mathematics); Dr. D. N. Jones (chemistry); Dr. R. N. Dixon (chemistry); and Dr. J. M. West (metallurgy).

"Roughness of the Moon as a Radar Reflector"

THE portion of this issue of *Nature* including the communication with the above title (p. 490) was printed before the mistake referred to below was noticed. Dr. B. H. Briggs writes: "Owing to an unfortunate error, the dotted curve in the graph is approximately $\exp(-20\,\theta)$ and not $\exp(-10\,\theta)$ as stated. The detailed agreement between the optical observations and the radar results of Hughes is therefore not as close as was originally thought, though it remains true that both methods indicate a mean slope of the order of 3°. I am indebted to Dr. Hughes for pointing out the above error".

Announcements

THE Medical Research Council's Neuropsychiatric Research Unit, under the direction of Dr. D. Richter, has been transferred from the Whitchurch Hospital, Cardiff, to the Council's Laboratories at Carshalton, Surrey.

DR. R. L. SMITH-ROSE, who is retiring from the post of director of the Radio Research Station of the Department of Scientific and Industrial Research (*Nature*, 185, 353; 1960), has been appointed chairman of the Post Office Frequency Advisory Committee in succession to Sir Lawrence Bragg.

PROF. F. D. RICHARDSON, professor of metallurgy in the Imperial College of Science and Technology, London, will deliver the fourth Robert Horne Memorial Lecture of the Society of Chemical Industry in the Chemistry Department, University of Bristol, on September 29, at 6.30 p.m. He will speak on "The Extraction of Metals and the Chemistry of Metals". The Lecture is open to the public.

AN international colloquium is to be held at the University of Grenoble on "The Physics of Electrostatic Forces and Their Applications" during September 27–October 1. The Colloquium is organized by Le Centre National de la Recherche Scientifique. Further information can be obtained from Prof. Noël Felici, Faculté des Sciences, Université de Grenoble, Grenoble.

THE European Association for Potato Research has announced its intention to organize a series of triennial conferences to review the position of potato research. The first of these conferences is to be held at Brunswick during September 12–17. Further information can be obtained from Tagungsbüro der EAPR, Institut für Pflanzenbau und Saatguterzeugung, Bundesallee 50, Brunswick.

THE Plastics and Polymer Group of the Society of Chemical Industry has arranged a three-day symposium on "High-temperature Resistance and Thermal Degradation of Polymers", to be held during September 21–23 at the William Beveridge Hall, Senate House, University of London. Further information can be obtained from the Convenor, Plastics and Polymer Symposium Sub-Committee, 14 Belgrave Square, London, S.W.1.

THE Institution of Gas Engineers and the Corrosion Group (Birmingham and Midlands Section) of the Society of Chemical Industry are organizing a joint symposium on "The Protection of Gas Plant and Equipment from Corrosion", at the College of Advanced Technology, Birmingham, during September 22–23. Further information can be obtained from the Symposium Secretary, Department of Chemistry, College of Advanced Technology, Costa Green, Birmingham, 4.

THE Chemical Society of London has announced that it will consider a number of applications for the assistance of research in any branch of chemistry. About £700 per annum is available for this purpose. Applications should be made to the General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1, not later than November 15.

THE Commonwealth Scientific and Industrial Research Organization (Australia) has issued a List of Publications to December 31, 1959, including both those of the Organization itself and of its predecessors (Pp. 45. Melbourne: Commonwealth Scientific and Industrial Research Organization, 1960). The publications are arranged under handbooks and monographs: journals; bulletins; pamphlets; circulars; land research series; soil publications; leaflets; semi-technical periodicals; divisional publications; and miscellaneous publications. There is also a subject index.

ERRATUM. In the communication entitled "Two Types of Catalase-like Activity in the Lactic Acid Bacteria", by R. Whittenbury, in *Nature* of July 30, p. 433, there is an error in Table 1. The number of catalase-positive organisms recorded for *L. cellobiosus* and *L. viridescens* are 2 and 0, respectively; they should read 0 and 2.

THE JOHN INNES INSTITUTE

THE fiftieth anniversary of the John Innes Horticultural Institution was celebrated on July 8. The occasion served not only to recall the past achievements of the Institution, but also to announce some major new developments. These included a change in the title of the Institution, an extension of the scope of its activities and the opening of a new laboratory building.

Cell Biology and the construction of a large building to house it represent a new departure. The Cell Biology Laboratory (Fig. 1), shown in the photograph, was erected by the Trustees of the John Innes Charity and is being supported by the Agricultural Research Council. When fully equipped and staffed, the new building will provide excellent research facilities for some twenty-five scientists.

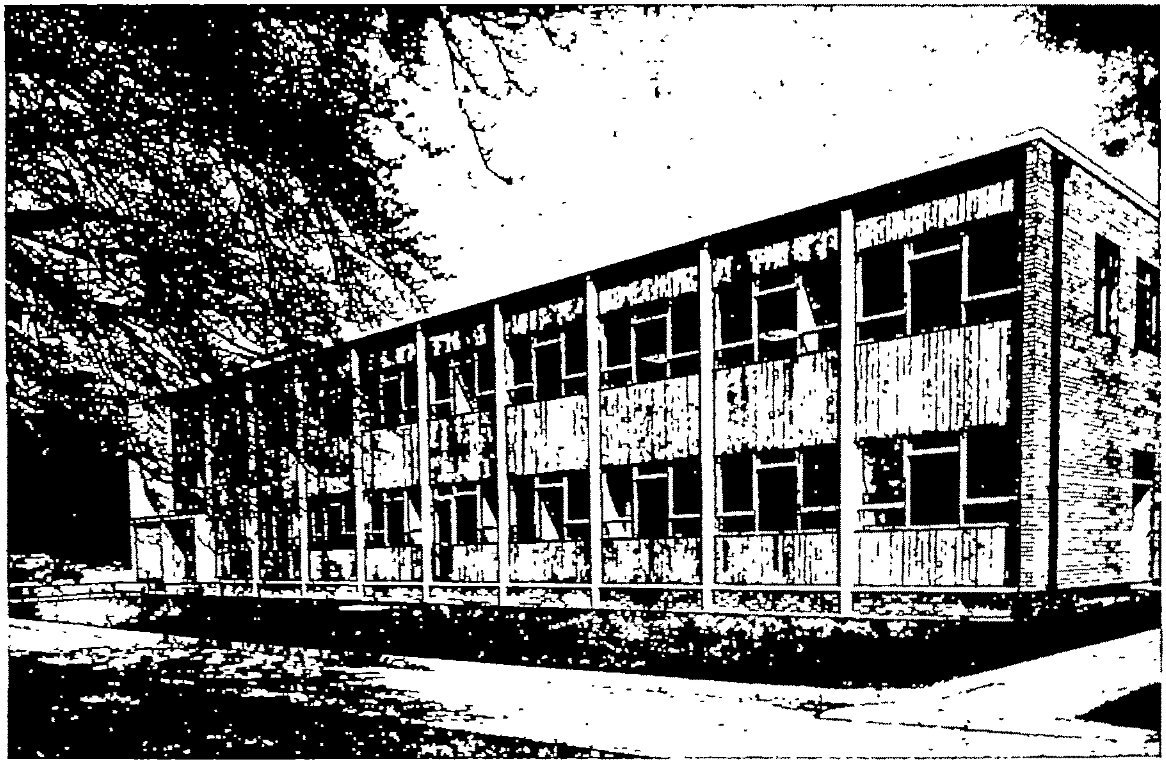


Fig. 1. The Cell Biology Laboratory, John Innes Institute

The John Innes Horticultural Institution was founded under the will of John Innes, of Merton, and began its life in that London suburb in 1910. William Bateson was the first director, and it was he who chose genetics and cytology as subjects for investigation; work which reached its climax just before the Second World War, when C. D. Darlington had published "Recent Advances in Cytology" (1932) and "The Evolution of Genetic Systems" (1939). Some of the other books published by members of the staff during this pre-war period were: "Recent Advances in Plant Genetics" (1932) by F. W. Sansome and J. Philp, "The Genetics of Garden Plants" (1934) by M. B. Crane and W. J. C. Lawrence, and "Practical Plant Breeding" (1937) by W. J. C. Lawrence. With the resumption of full-scale research activities after the War, there came K. Mather's work on quantitative variation and his book "Biometrical Genetics" (1949).

While the tradition in genetical studies is being maintained with the recent appointment of Dr. J. R. S. Fincham to take charge of the Department of Genetics, the establishment of a Department of Cell Biology and the construction of a large building to house it represent a new departure.

The Department of Cell Biology has no categorical commitment, and its members will be free to pursue their own research interests within the very wide framework implied by the term 'cell biology'. One of the features of the Department is the fact that facilities are available for work on both animal and plant material, and a new animal house is being built to meet the demands imposed by the work on animal cells. It is hoped that this fusion of disciplines and the wide variety of techniques which it involves will provide unique opportunities for the intimate exchange of ideas and experimental skills. The new Department thus represents the fulfilment of hopes originally expressed by Bateson himself, who made it a condition of his appointment as the first director that he should be allowed to carry out studies on animals as well as plants. Dr. Henry Harris, of the Sir William Dunn School of Pathology, Oxford, has been appointed head of the new laboratory.

The original name of the Institution was felt to be too restrictive to embrace the activities which are being undertaken, and the title has now been changed to the 'John Innes Institute'.

K. S. DODDS

THE WORLD HEALTH ORGANIZATION

THE annual report of the Director-General of the World Health Organization for 1959 shows the wide range of the assistance given by the Organization to countries throughout the world, both directly in the form of projects adapted to particular needs, and through international technical services of the more traditional type[*].

The 'project list', occupying more than half the volume, gives particulars of the projects, numbering more than 500, in which the World Health Organization has been co-operating with the Governments of some 140 countries, sometimes in conjunction with other organizations. A summary narrative for each project states its aim, the nature of the assistance and progress made during the year, and adds, where possible, an assessment of the results obtained. The list, grouped by country and subject title under each of the six regions of the World Health Organization, includes inter-country and inter-regional projects in which help is given to groups of countries working together on common problems—a type of project that appears to be increasing in importance.

In his introduction, Dr. M. G. Candau, director-general of the Organization, directs attention to the fact that in 1959 the Organization's work was carried on "against a general background of reduced tension in international affairs" and of "substantial improvement of economic conditions throughout the world, particularly in Europe"; and he finds growing evidence of the determination of world leaders to devote more of their countries' resources to help nations still in the early steps of technological and economic development to raise their standards of living.

In discussing some of the changes of emphasis in the Organization's programme, the director-general points out that communicable diseases remain one of the world's most serious health problems. For some, more knowledge is required; for others, such as malaria and smallpox, the methods are broadly known and what is wanted now is organization, trained staff and money.

Among diseases calling for increased vigilance are the treponematoses. More than 100 million people still live in low-prevalence yaws areas, in several countries there has been a disturbing recrudescence of venereal syphilis, and a growing incidence of gonorrhoea has been found in 15 out of 22 countries surveyed. Investigations are being pursued in order to ensure that the most effective assistance can be given to countries combating these problems.

With tuberculosis, recent findings which show that domiciliary chemotherapy may for most cases be as efficacious as treatment in sanatoria are of particular importance to the many countries where there is an acute shortage of sanatoria beds.

Mention is also made of the newer developments against leprosy, bilharziasis, poliomyelitis and the zoonoses, and of preparatory work with the view of eradicating smallpox.

Much preparatory work has been done during the year for the expansion and intensification of the medical research programme. Main targets and priorities, established with the guidance of the Advisory Committee on Medical Research, include the communicable diseases (with emphasis on viruses and diseases prevalent in tropical countries); for the highly industrialized countries, the chronic diseases, particularly cancer and cardiovascular troubles; nutrition, and problems of the increased risk of exposure to ionizing radiations. The 'service to research' will include standardization of nomenclature techniques and equipment, and the expansion of, the Organization's system of international reference centres.

Emphasis is also being given to the vast programme for the improvement of water supplies for communities, which is a primary objective in the attack on the enormous problems of environmental sanitation. The programme will be carried out in collaboration with departments of public works and with public administrations and financial authorities.

Annexes to the report give details of the membership of the Organization, its Executive Board and expert committees; the main heads of the budget for 1959; and particulars of the secretariat structure and composition.

---

[*] Official Records of the World Health Organization, No. 98: The Work of WHO, 1959—Annual Report of the Director-General to the World Health Assembly and to the United Nations. Pp. x+283. (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) 6 Swiss francs; 10s.; 2 dollars.

THE METROPOLITAN WATER BOARD

LONDON is by far the largest town in Britain taking its raw water supplies from wells in or from rivers flowing through, a densely populated and industrialized area, and the reports of the Director of Water Examination of the Metropolitan Water Board[*] are an invaluable guide to the measures which have to be taken, and the research which has to be carried out, to obtain a safe potable water from these sources.

The first necessity is, of course, to control and restrict pollution of the raw water. A good example of what can be done is afforded by the River Lee; in spite of the growth of both population and industry in the catchment area between 1948 and 1958, the quality of the river water improved substantially during that period. This was due in part to the improvement and extension of the sewage works at Luton (including the provision of a final stage of treatment by rapid sand filtration or by micro-straining), and in part to the treatment of the sewage of several towns, including the new towns of Harlow and Stevenage, at a single works, discharging to the Lee below the Board's New Gauge intake.

Within the catchment area of the Thames there are three major establishments, at Harwell, Aldermaston and Amersham, from which radioactive effluents are discharged. These liquors, in which the level of activity permitted is very low, are regularly monitored before being released—the Harwell effluent by the Atomic Energy Authority, the Ministry of Housing and Local Government, and the Metropolitan Water Board. There is no evidence, from the Board's observations, that there has ever been any activity present, at its raw water intakes, which could be attributed to discharges from the three establishments. The concentration of activity in treated water is about half that present (from fall-out) at the intakes, both in the Thames and Lee, the reduction being due to removal of suspended matter, radioactive decay during storage, and sometimes to dilution with relatively inactive well water. A large-scale experiment was made by adding 500 mc. of strontium-90 to 1·5 million gallons of water, standing in a disused filter bed; during a period of nine months the level of activity was reduced by about two-thirds (the water contained abundant algae and much rooted vegetation), but the results suggested that grossly contaminated waters would not be rendered potable in any reasonable time by storage alone.

---

[*] Metropolitan Water Board. Thirty-Eighth Report on the Results of the Bacteriological, Chemical and Biological Examination of the London Waters for the years 1957–1958. By E. Windle Taylor. Pp. 114+4 plates. (London: Metropolitan Water Board, 1960.) 21s.

An examination of waters from a number of wells for the presence of alkylbenzene sulphonates—the anionic surface-active agents which are the basis of powdered synthetic detergents—showed that in some they were absent, but that in others they were present in concentrations similar to those found in the Thames to which sewage effluents are discharged. It is of great interest that in a well water the presence of the surface-active material may be the only surviving evidence that the water has been polluted by sewage or sewage effluent—ammonia, coliform bacteria, and the other usually diagnostic constituents of effluents having been removed during percolation of the water through the ground. These observations were made before the use on a large scale of biologically 'softer' alkylbenzene sulphonates in detergents sold in the south of England.

Continuing its work on the relation between chemical structure and susceptibility to degradation by bacteria, a wide range of organic substances has now been examined in the Board's laboratories; from this the important conclusion is reached that because of the relative immunity of chlorine-substituted organic compounds to bacterial attack, it is unwise to chlorinate effluents containing mainly organic matter; this would include sewage effluents. Chlorination of such effluents has never been widely practised in Great Britain but appears to be common in the United States, and there has been a good deal of discussion recently on the wisdom of adopting this quite expensive method of treatment.

Among the other matters dealt with in the report are the use of automatic instruments for recording concentration of dissolved oxygen (a knowledge of which is important in taking a water supply from a thermally stratified reservoir); the presence of *Salmonella* organisms in bone meal and other fertilizers; and the persistence of fluoride in water during storage in a reservoir. Considerable advances have been made in the use of the membrane filter technique in the counting of coliform bacteria; with this method the count is available after 18 hr. as against 24 hr. with the older multiple-tube technique.

B. A. SOUTHGATE

EAST AFRICAN FISHERIES RESEARCH ORGANIZATION

To the scientist the annual report for 1959 of the East African Fisheries Research Organization can only be a somewhat depressing document*. When the Jinja Laboratory was established in 1947–48 together with the Lake Victoria Fisheries Service, there seemed to be some real prospect of keeping a developing fishery under full observation, and managing it in a scientific manner in the light of both the catch statistics collected by the Fisheries Service and the information on the biology of the fish acquired by the staff of the Laboratory. In the eleven years of its life the Laboratory has not only made good progress with the task assigned to it, but also made notable contributions to our knowledge of tropical waters. On the other hand, those responsible for government at the political level have signally failed to profit by the scientifically based advice tendered by the Research Organization. As a result, the fishery is rapidly declining in productivity owing to overfishing, precisely as it was predicted that it would in the absence of more stringent and effective control. That this small fishery should be following the same downward path as the internationally exploited sea fisheries, where control is so much more difficult to exercise, is a sad reflexion not only on man's cupidity but also on the lack of scientific understanding of so many of those we appoint to govern us. This last point is further emphasized by the fact that in the small staff at Jinja (a director, four research officers and two senior field officers) there is a vacancy for a fifth research officer which cannot at present be filled for lack of finance. Consequently, the work of the Laboratory is now restricted almost entirely to fish, and moreover the Lake Victoria Fisheries Service has been disbanded, though its duties have been, at least nominally, transferred to the Fisheries Departments of the three Territories concerned (Kenya, Tanganyika and Uganda). It is much to be hoped that means will be found to continue the fundamental observations on the hydrography and chemistry, and the algal and invertebrate populations of the Lake, on which the Laboratory has made such an excellent start.

A series of appendixes give in a convenient, concise and readable form the results of some of the work done at the Laboratory during the year. One of these contains important observations on the analysis of data based on gill-net catches, made by a member of the staff of the Fisheries Laboratory at Lowestoft. Another shows how easily and rapidly the very local populations of *Tilapia esculenta* in Lake Victoria can be over-fished down to a level at which the yield ceases to be profitable. A third gives briefly the results of an investigation, made by an entomologist, of the food of several of the species of fish other than Cichlidae which inhabit Lake Victoria. In contrast to the mainly herbivorous species of *Tilapia*, the species of *Alestes*, *Synodontis afro-fischeri* and *Marcusenius grahami* eat mostly insects, whereas *Barbus altianalis* and *Synodontis victoriae* get most of their sustenance from snails. Other appendixes contain shorter notes on a variety of topics, including the growth of *Tilapia zillii* in a dam and some preliminary observations on the control by fish of snails and mosquitoes in dams.

---

* East Africa High Commission. East African Fisheries Research Organization: Annual Report 1959. Pp. ii+46. (Jinja: East African Fisheries Research Organization, 1960.)

The director, Mr. R. S. A. Beauchamp, who has recently relinquished the post he has held with distinction since he opened the Laboratory in 1948, can look back on a considerable achievement. Not only have he and his colleagues laid a firm foundation of knowledge of the hydrography, chemistry and biology of at least the parts of Lake Victoria within the reach of the Laboratory, but they have also made significant contributions, briefly described in the reports of which this is the latest, to our understanding of the factors which control the productivity of tropical waters. Moreover, the Laboratory itself now has a world-wide reputation and attracts visitors from many countries.

H. C. GILSON

U.S. MATERIALS RESEARCH AND DEVELOPMENT FOR NATIONAL SECURITY

A SPECIAL Committee on Scope and Conduct of Materials Research was appointed by Dr. D. W. Bronk, president of the National Academy of Sciences, to review the materials research needs of the United States with regard to national defence and the public welfare generally; to appraise the adequacy of the present research programmes to meet those needs; to consider the resources available; and to make recommendations. A report now issued under the title "More Effective Organization and Administration of Materials Research and Development for National Security" deals with the scope of materials research from the point of view of the overall adequacy of the present effort, but leaves for continuing review by the Materials Advisory Board of the National Academy of Sciences–National Research Council the question of scope in regard to the technical content of the programme[*]. The question of scope in regard to the scientific content will be dealt with in a forthcoming report of the Academy–Research Council's Committee on Perspectives in Materials Research.

The Committee found that important national security programmes, particularly in defence, nuclear energy and space-research are impeded by the inadequacy of the properties of most of the materials now available to withstand the severe temperature, pressure, radiation, corrosion and stress conditions involved and give high performance. The Committee recommends accordingly that the Government accord high priority in national security plans and programmes to the development of new and improved materials and that the relevant programmes of the agencies and departments be strengthened. The Committee recognizes that there is no simple solution, but that every level of activity needs significant strengthening. To this end it recommends greater centralization of responsibility, more support for, and more effective co-ordination of Government-sponsored materials research and development programmes; Government incentives to encourage research and development on new and improved materials; and steps to assure adequate supplies in the United States of every chemical element or material to support full production and use of new and improved materials. It also recommends improvement in the dissemination of research information and strengthening the universities in their dual role of training scientists and engineers and pursuing research. In regard to the last, the Committee endorses a recently announced programme of Government-sponsored interdisciplinary materials laboratories at several institutions of higher learning, while as regards the dissemination of information it envisages the encouragement and acceleration of publication and removal of secrecy restrictions as well as the greater support of research designed to encourage rapid exchange of technical and scientific information, including expansion and acceleration of the Critical Tables project.

---

[*] National Academy of Sciences–National Research Council. Publication No. 718: More Effective Organization and Administration of Materials Research and Development for National Security. (A Report to D. W. Bronk, President, National Academy of Sciences, by the Committee on Scope and Conduct of Materials Research.) Pp. ix+80. (Washington, D.C.: National Academy of Sciences–National Research Council, 1960.) 1 dollar.

EDUCATION AND INDUSTRY

BRITISH industry has traditionally been badly served by the universities and by the majority of schools. Until quite recently, they have encouraged very few of the ablest young people to think in terms of an industrial career.

The prejudice was not all on one side. The typical industrialist of not so long ago, while he was ready enough to concede the importance of craft training, and even of technical education, conceived rather narrowly, held that industry had certainly no responsibility for any but quite specialized courses, and that no useful purpose would be served by recruiting men on a basis of intellectual quality rather than skill.

Prof. D. G. Christopherson, in a recent issue of the *Esso Magazine* (Spring, 1960), suggests that, although these attitudes are changing, it is the attitude of industry which has changed most quickly and most completely in our time. Before the War, most professors of engineering spent their time resisting pressure from industry in the direction of making courses more specifically technical, so that the graduate would be better able to do a particular job immediately on joining the firm. To-day, the influence of industry is in the opposite direction. Professors of engineering are urged to keep courses general, to resist undue specialization, at least until postgraduate-level, and to include as much material as possible of a completely non-technological character. Although employers are still interested in the professional side of what the university does, most place the greatest emphasis on intellectual quality rather than on technical expertise.

There are a number of reasons for this. In the first place, as the rate of scientific and technological progress quickened, the need for people to be adaptable, quick to learn, and capable of covering a wide field has increased. It is no good giving a man a complete specialized training if what he has specialized in is obsolete before he has reached the age of thirty.

Secondly, a large proportion of university graduates do not in fact do the job for which officially they were trained for more than a quite small proportion of their careers. Finally, as industrial concerns get larger and the place of industry in the national life increases in importance, the scope of the decisions to be taken by industry become even wider, reaching far beyond the boundaries of straightforward technical questions.

There is a fruitful field for active collaboration between the universities and industry. Many students already go to industry for vacation courses. It should be possible to relate what is done in industry much more closely to the academic side than had been done in the past. It might be possible for undergraduates and even more for postgraduates to do part of their 'course work' as an investigation of some industrial problem 'in the field'. The 'sandwich courses' in the colleges of advanced technology may prove to be the pioneers in this field.

But, no matter how good an understanding is achieved between education and industry, and no matter how courses are adjusted to meet contemporary needs, education cannot be thought of as a process which finishes in the early twenties. Some sabbatical period is as essential for men in industry as in the universities. Specialized postgraduate courses on technical subjects for people released from industry are becoming commoner and better supported. The universities and particularly the faculties of science and technology must be prepared to organize more of these courses.

Advanced technical work is not the most important purpose for which industry requires its own 'sabbatical years'. There is a stage at which intellectual renewal is particularly valuable, the stage when a man emerges from a relatively specialized department and begins to take managerial responsibility over a wider field; by that time, he has enough experience to be able to appreciate what the problems of management actually are, but usually scarcely any systematic knowledge of how they have been mastered.

Education in management in Great Britain lags a long way behind that in the United States; this is a matter to which the universities must give much more serious attention. By far the greatest difficulty is the recruiting of suitable staff. Management is essentially a practical subject, and the man who is good at it wants to practise and not to instruct.

A managerial or business school recruiting 'students' from a wide variety of industries would be better than one run by one undertaking, no matter how large; this end can perhaps be most directly achieved by co-operation between the great companies in founding their own institutions rather than by working through the existing university structure.

TRAINING IN RADIOLOGICAL HEALTH AND SAFETY

On the night of October 10, 1957, the core of No. 1 reactor at the Atomic Energy Authority works at Windscale became seriously over-heated and as a consequence a fairly large amount of radioactive material escaped through the reactor stack and was deposited thinly over many square miles of north-west England. Once the alarm was given, the Health and Safety Services of the Authority went into action on their first major emergency test. Fortunately no significant harm was done to the populations of the surrounding areas, although the affair naturally received widespread publicity.

By now the 'Windscale incident' has almost passed into history, but it is interesting to find unexpected repercussions almost three years later. Following the accident, the Prime Minister set up a Committee under Sir Alexander Fleck to report, among other things, on the organization for control of health and safety in the United Kingdom Atomic Energy Authority. The report of this Committee directed attention to the serious shortage of trained radiological health and safety specialists and called for comprehensive schemes of instruction in this field as a "matter of urgent national importance". The Fleck Committee firmly placed the onus of leading the build-up of a national supply of specialists on the Atomic Energy Authority. In view of this, the Authority set up a further Committee under Sir Douglas Veale to consider what steps should be taken to provide a staff concerned with health and safety for the Authority, and for the nation as a whole, including the establishment of a national training centre*.

Although now a matter of extensive public concern, radiological health and safety are by no means a new problem. The hazards to man of ionizing radiations have been known since the early years of the century, and the distressing experiences of the early radiological workers have kept the matter well to the fore in the minds of their successors. In 1921 the first concerted effort to deal with the problem came with the publication of the first Recommendations of the British Committee for Radiological Protection. This was quickly followed by other national recommendations and by the Recommendations of the International Commission; the latter, revised from time to time, still form the basis of world-wide radiological protection measures. Until 1945, radiological safety was a matter of concern limited almost entirely to medical radiologists and a handful of physicists attached to hospitals and medical schools. The development of nuclear reactors and weapons changed the whole picture. Production and uses of ionizing radiations have increased enormously, the number of persons occupationally exposed has increased correspondingly, and we are now faced with the position that, to a greater or less degree, whole populations are at some hazard. The number of hospital physicists has increased and the atomic energy industry has recruited considerable staffs for health and safety work, but it is clear that further recruitment and the provision of specialized training are necessary if the inevitable hazards of ionizing radiations are to be kept to a minimum.

---

* Report of the Committee on Training in Health and Safety to the Authority Committee on Health and Safety, United Kingdom Atomic Energy Authority, February 1960. Pp vi+96. (London: H.M. Stationery Office, 1960.) 5s. 6d. net.

The Veale Committee estimates that in the present decade, Britain's needs will be met by recruiting and training some 500 staff at graduate level and 600 at technical level. These are modest enough figures, but they nevertheless represent a further demand on the country's already strained resources of scientific man-power. Of the graduate group, 200 are placed in Category *A*, with a requirement of good degrees in science, medicine or engineering and capacity to assume higher managerial responsibilities and play a leading part in scientific development. The recruitment of this category is likely to prove the most difficult. Establishment of a national training centre is rightly rejected by the Veale Committee and it is proposed the postgraduate training should be limited to a small number of university centres, using the normal advanced course and research studentships of the Department of Scientific and Industrial Research to support the trainees. This is probably a wise recommendation. Nevertheless, as a balanced radiological health and safety force requires primary qualifications in physics, chemistry, engineering, biology or medicine, considerable pressure will be required to overcome the blandishments of lucrative industry and professions and the temptations to do postgraduate research in the appropriate department of the young graduate's *alma mater*. A high level of altruism may be necessary if a well-qualified medical graduate is to accept the rigours of a Department of Scientific and Industrial Research studentship in an almost alien subject, in order to qualify in radiological health and safety.

The recruitment problem in the rather lower graduate category and in the technical grade, though not easy, should not prove insuperable. The Committee goes well beyond the question of recruitment and training of full-time health and safety staff. Recommendations are made on background training for groups of administrators, managers and professional workers whose duties may bring them into contact with radiations and radiation workers. Many other groups, varying from medical officers of health and general practitioners to public health inspectors, police and fire services and nurses, are likely to be increasingly involved in radiation problems, and wide dissemination of knowledge of radiation hazards and protection at a fairly elementary level becomes essential.

In some of the appendixes to the report, outlines are given of existing or proposed training curricula at levels ranging from a Ph.D. course to simple background courses. It is clear that if recruitment is satisfactory, adequate training can be made available. Eyebrows may, however, be raised in some university boards of studies at the proposal that some Ph.D. courses should be converted from the traditional British research pattern to the American form, including a high proportion of formal teaching and examinations.

Ionizing radiations have become a major and ubiquitous factor in modern life, and, as with other developments, they bring their own hazards. The vigorous implementation of the report could go a long way towards establishing public confidence that the hazards, which to many are strange and unseen, are kept within the limits which might reasonably be accepted in a rapidly developing civilized community.

J. E. ROBERTS

LOCALIZATION BY AUTORADIOGRAPHY AT −195° C. OF RADIOACTIVE AREAS IN RATS EXPOSED TO A HIGH FLUX OF THERMAL NEUTRONS: IMPORTANCE OF PHOSPHORUS-32 IN CONSECUTIVE INTERNAL IRRADIATION

By JEAN CHANTEUR and PIERRE PELLERIN

Institut National d'Hygiène, Service Central de Protection contre les Rayonnements, B.P. 30, Chatillon-sous-Bagneux, Seine

THE purpose of this present work was to localize the organs or areas of the body of a mammal capable of becoming the seat of a radioactivity induced by exposure to a flux of thermal neutrons. Autoradiography at the temperature of liquid nitrogen[1] seemed to us to be the simplest and speediest method of carrying out this localization by applying it to a young rat.

A preliminary calculation has enabled us to fix in 5 min. the duration during which such rats should be subjected to a flux of thermal neutrons (6×10^{12} n./cm.^{2}/sec.) which we had available in a large nuclear reactor so that we could both make an autoradiographic exposure in an acceptable time, and not reach an activity of the block that might be dangerous for the operators. (We thank the Service of Biology and the Exploitation Service *EL3* at Saclay which placed suitable irradiation means at our disposal for bringing this experiment to a successful conclusion.)

Rats weighing 25 gm. were placed alive, in pairs, in plastic irradiation cartridges, and the latter were conveyed by pneumatic tube to the irradiation holes of the reactor.

After 5-min. irradiation, the cartridges were removed from the reactor. We ascertained that the rats had been killed by the flux of neutrons, and that in the exposure conditions just described the dose-rate at 10 cm. from the cartridge containing the two rats was about 1 roentgen/hr. at the exit from the pneumatic tube.

With the usual precautions required by this dose-rate (screens, lead containers, remote control, etc.) we immediately proceeded to freeze the rats in liquid nitrogen (−195° C.), including them in the frozen mixture of water and alcohol, then counter-sinking the autoradiography plan according to the technique previously described by one of us[1].

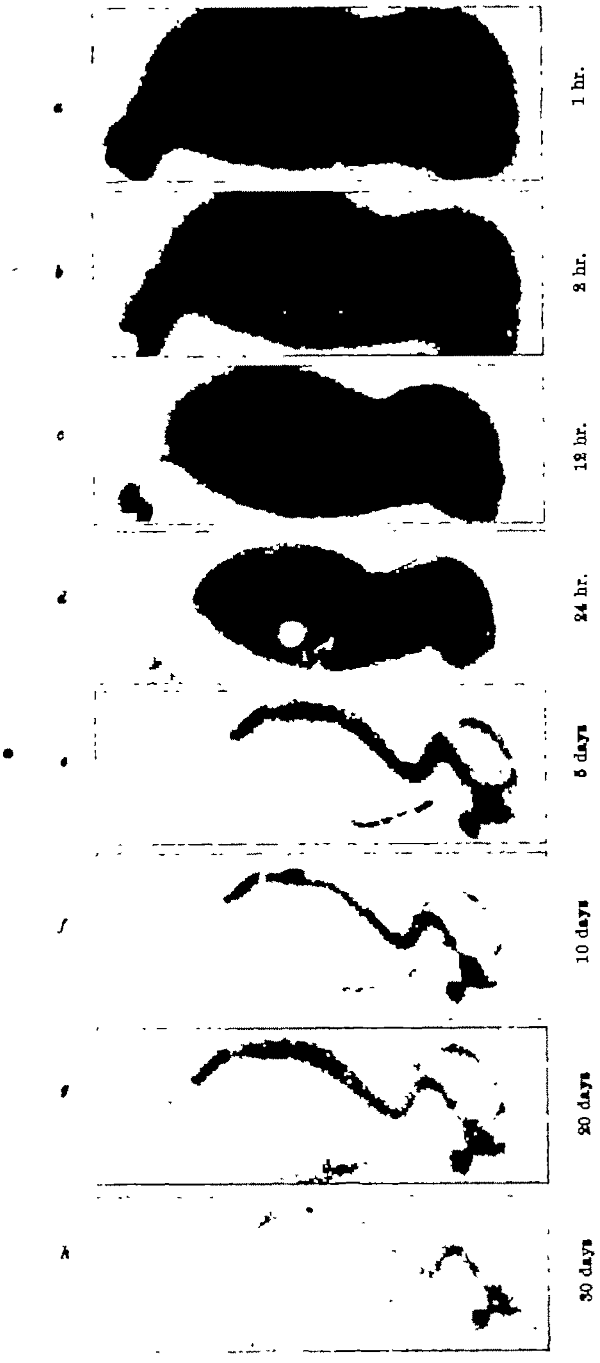


Fig 1

In order to be able to watch the relative decreases of radioactivities induced in the various anatomical areas, we have, by a series of preliminary tests, fixed the duration of the reference autoradiograph exposure at 8 min. This reference autoradiograph was then systematically carried out after increasing times from withdrawing the rats from the reactor (successively, 1, 2, 12 and 24 hr., 5, 10, 20 and 30 days after being exposed to the flux of neutrons). We have ascertained, by interposing opaque filters, that there was no low-temperature luminescence effect[3].

Fig. 1 shows the series of reference autoradiographs, on which will be noticed that immediately after withdrawal the radioactivity induced is intense over the whole of the section surface, then progressively decreases in the course of time, at the same time that considerable localizations exist in the region of the bones and teeth.

As it was probable that saturation phenomena of the photographic emulsion could explain the general blackening of the first moments, we have, for each duration following withdrawal, systematically made other exposures, shorter, on one hand, in order to distinguish possible localizations hidden by the saturation, and on the other, longer ones to emphasize localizations tending to disappear in the course of time.

We were thus able to ascertain important bony and dental radioactive localizations from the very first moments following irradiation (Fig. 2), with an autoradiographic exposure time of 1 min. which only, however, left a general fog. After six days, this fog is much reduced on the corresponding autoradiographs (Fig. 3), which nevertheless were taken with an autoradiographic exposure time of 45 min.

As could be expected, the interpretation of activation autoradiographs thus appears to be complex, and we have been led to calculate, for the chief elements forming the system, the activities induced by exposure to the thermal neutrons previously defined, by applying the formula :

$$A = \frac{0\cdot6.\Phi.\sigma}{3\cdot7 \times 10^{10} M} \left\{1 - \exp(-0\cdot69)\frac{t}{T}\right\}$$

in which Φ is the flux of neutrons per cm.^{2} and per sec., σ the cross-section in barns, M the atomic weight of the irradiated element, t the duration of irradiation, T the half-life of the isotope formed, and A the specific activity in curies per gm. The total activity of each element was then deduced from the tables, giving the detailed chemical composition of the system.

Fig. 4 shows the decrease of some of these elements in relation to time. Autoradiographic detection can only be applied to elements possessing at the same

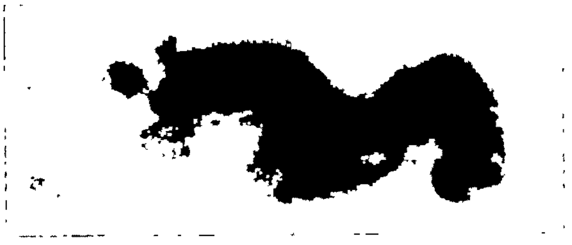


Fig 2

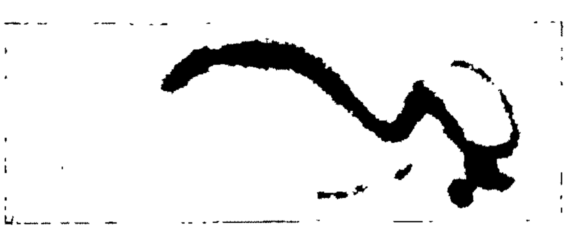


Fig. 3

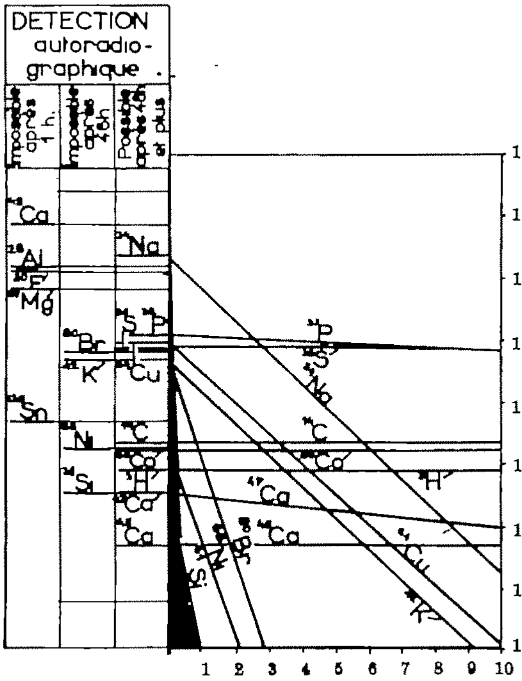


Fig. 4

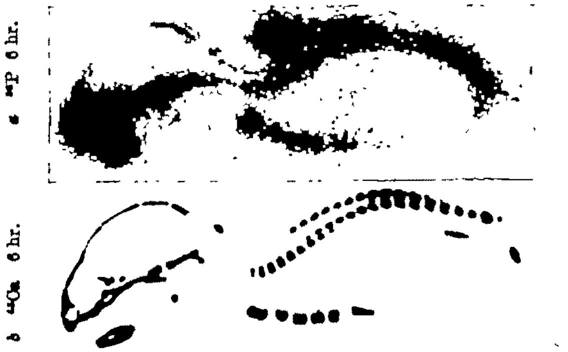


Fig. 5

time a high initial activity, a somewhat lengthy period and sufficient energy to allow of acceptable exposure conditions. The diagram shows that after some minutes, the sodium-24, sulphur-35, phosphorus-32, calcium-47 and -45, copper-64 and potassium-42 are practically alone in combining the three conditions, which confirms the comparison with the results of previous work with certain of these elements injected alone[2-4].

We may thus partly attribute the initial general fog to the even distribution of sodium-24, but its short period must appreciably reduce its autoradiographic efficiency in a few days. Sulphur-35 coming from chlorine-35, of even distribution, must also participate in the general fog.

On the other hand, it is permissible to anticipate bony localizations by activation of calcium and phosphorus in which the skeleton is particularly rich (tricalcium phosphates and apatites). Throughout the first minutes, fluorine-20 (teeth) and calcium-49 probably play an important part. Then phosphorus-32 and calcium-45 and -47 must take up the relay with slighter activity, but with a longer half-life. It should finally be possible to notice a thyroidal localization of iodine-128 during the first hour.

A systematic examination of the autoradiographs confirms these expectations on the whole: by comparing the various reference autoradiographs during a space of time (8-min. exposure), we notice that the intense fog of the first hours (Fig. 1*a*) has practically disappeared in five days (Fig. 1*e*), which enables it to be attributed to elements evenly distributed over periods of less than 24 hr. (sodium-24 and potassium-42). The bony and dental localizations that are perceived from the first hours for exposure times of 1 min. (Fig. 2) remain detectable; on the other hand, up to four weeks for the reference exposure of 8 min. (Fig. 1*h*). The decrease in blackening corresponding to these localizations is attributable to a radioelement of a period of about two weeks, and it thus seems that it is essentially phosphorus-32 which is the cause in this case, much more so than a long-period radioactive calcium, which is, moreover, in a thousand times lesser proportion as shown by the diagram. The comparison with the autoradiographs obtained by the same technique after injecting phosphorus-32 (Fig. 5*a*) and calcium-45 (Fig. 5*b*) confirms this interpretation, for the autoradiograph of the activated rat (Fig. 2) has a striking resemblance to that of the rat that has received the injection of phosphorus-32 (Fig. 5*a*) both by its localizations as well as the absence of sharpness due

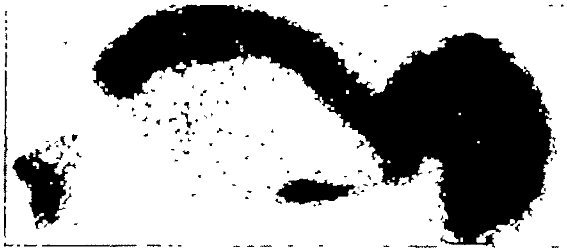


Fig. 6

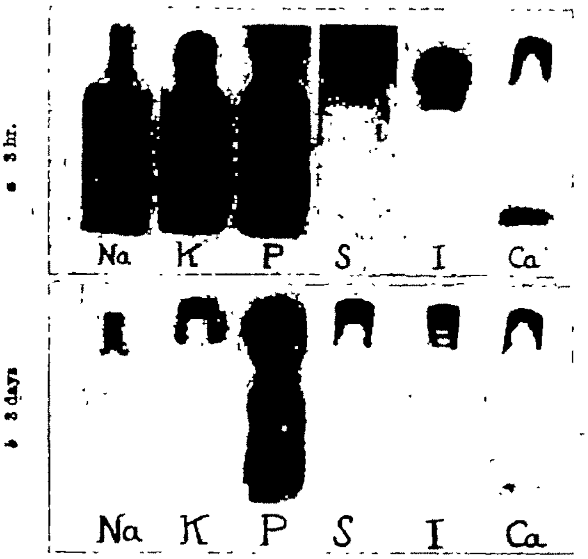


Fig. 7

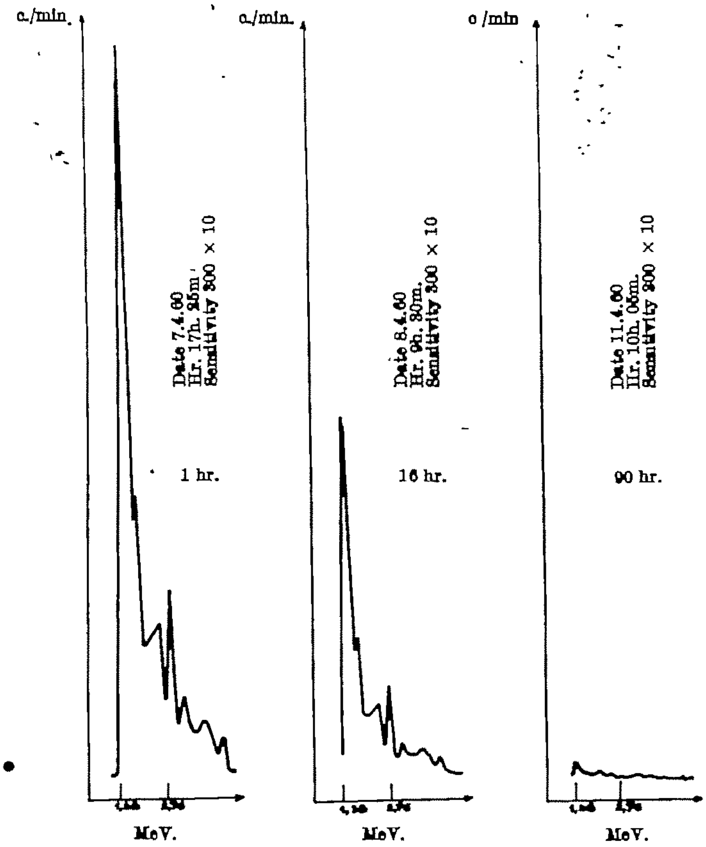


Fig. 8

to the very penetrating beta-ray emission of phosphorus-32. It should be noticed that after several days (Fig. 6) it is possible to find an appreciable background fog with an exposure distinctly greater than the reference exposure (1 hr. 30 min.); the appearance then becomes rigorously identical with that of the autoradiographs following injections of phosphorus-32, which leads one to think that this background fog is due to the activation of cellular phosphorus and more particularly nucleic acids.

As for iodine-128, which should be found in the region of the thyroid, it was not possible to show this in the conditions of these experiments, undoubtedly on account of its very short period.

In order to check these interpretations, we exposed to the neutrons flux plastic flasks of solutions titrated with soda, potash, phosphoric acid, sulphuric acid, iodine and lime, at the same concentration as in the rat's system. The flasks were autoradiographed following the same technique, and we ascertained (Fig. 7*a*) that after equal exposures on the first day, sodium-24, potassium-42 and phosphorus-32 give an intense blackening, sulphur-35, iodine-131, calcium-47 and -45 a slight or zero blackening. On the third day (Fig. 7*b*), with the same exposure time, all the blackenings are practically nil, except for phosphorus-32.

Finally, we carried out the gamma spectrometry of a rat on emerging from the pile and on the following days (Fig. 8). The appearance of the spectrum and its decrease in relation to time in identical spectrographic conditions confirm the relative importance of sodium-24 among the gamma emitters brought into play during the first days[6].

In conclusion, it appears that an exposure to a flux of thermal neutrons must secondarily involve, by the radioactivity induced in the body, a general irradiation of relatively short duration by gamma-rays of sodium-24 and potassium-42, and a much longer irradiation by the beta-rays of phosphorus-32 and, to a certain extent, of calcium-45, essentially localized in the skeleton. This latter conclusion must lead to considering the bone marrow as a critical organ with regard to irradiation by thermal neutrons. At the same time it is advisable to emphasize the preponderating part played by phosphorus-32 in this irradiation, which is both dangerous somatically by the elective irradiation of the bone marrow by beta-rays and genetically by the activation of nucleic acids.

[1] Pellerin, P., *C.R. Acad. Sci.*, 244, 1555 (1958). Proc. First Unesco Int. Conf., Paris, 2, 684 (1957).

[2] Pellerin, P., Fallot, P., *et al.*, *Nature*, 184, 1385 (1959).

[3] Pellerin, P., and Stroux, M. R., *C.R. Acad. Sci.*, 249, 2125 (1959).

[4] Tubiana, M., Pellerin, P., and Stroux, M. R., *C.R. Acad. Sci.*, 249, 2875 (1959).

[5] Kellershohn, C., and Pellerin, P., "Strahlentherapie" (Bad Gastein IV, 1960).

[6] Operation "Teapot", Nevada Test Site. Report of the Test Director Atomic Energy Comm. (1957).

EFFECTS OF LINEAR ENERGY TRANSFER ON THE RADIOLYSIS OF WATER AND HEAVY WATER

By Dr. E. COLLINSON, Prof. F. S. DAINTON, F.R.S., and J. KROH

Department of Physical Chemistry, University, Leeds, 2

THE primary act in the decomposition induced by X- or γ-rays of water may be represented by the equation (1), and earlier work both in these laboratories[1] and elsewhere[2] has established:

$$G_{-\mathrm{H_2O}}\mathrm{H_2O} \xrightarrow{X,\gamma} G_{\mathrm{H}}\mathrm{H} + G_{\mathrm{OH}}\mathrm{OH} + G_{\mathrm{H_2}}\mathrm{H_2} + G_{\mathrm{H_2O_2}}\mathrm{H_2O_2} \qquad (1)$$

and that when heavy water is used instead of ordinary water, $G_{\mathrm{H_2}}/G_{\mathrm{D_2}} > G_{\mathrm{D}}/G_{\mathrm{H}} > G_{\mathrm{OD}}/G_{\mathrm{OH}} > G_{-\mathrm{D_2O}}/G_{-\mathrm{H_2O}} > 1$. When radiations of very high linear energy transfer are used, the observed yields of hydrogen ($G(\mathrm{H_2})$) and hydrogen peroxide ($G(\mathrm{H_2O_2})$) are much larger, and there is evidence that a significant fraction of the hydroxyl radicals reacts with the hydrogen peroxide to form

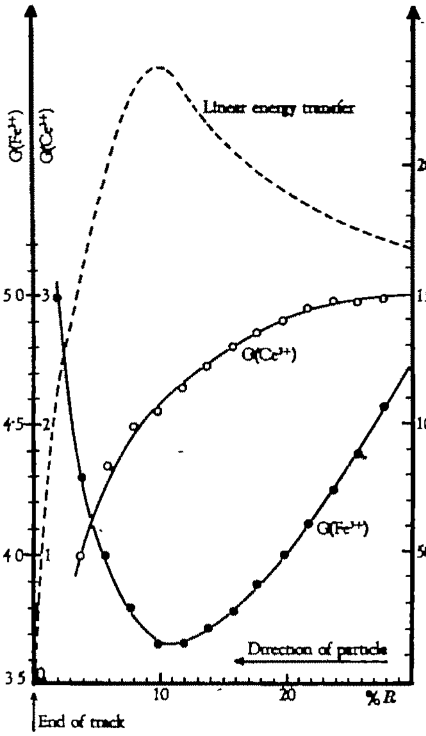


Fig. 1. $G(Fe^{3+})$ and $G(Ce^{3+})$ as a function of the percentage of the α-particle track entering the solution. Broken line is $-dE/dx$ = linear energy transfer at distances from the end of the track obtained by multiplying the abscissa by the range (40µ) of polonium α-particles in water (ref. 4)

$HO_2\cdot$ radicals and water as the track expands and before solutes can 'scavenge' them[3]. Most solutes, therefore, 'see' the primary act in, for example, the α-radiolysis of water as given by equation (2).

$$G_{-H_2O}H_2O \xrightarrow{\alpha} G_{H}H + G_{OH}OH + G_{HO_2}HO_2 + G_{H_2}H_2 + G_{H_2O_2}H_2O_2 \quad (2)$$

The aim of the work, which is briefly reported here, was to determine (*a*) whether equation (2) is valid and (*b*) the values of $G(H)$, $G(OH)$, $G(HO_2)$, $G(H_2)$ and $G(H_2O_2)$, and the effect on them of changing linear energy transfer and changing the irradiated solvent from ordinary water (H_2O) to heavy water (D_2O).

(1) *Effects of linear energy transfer.* In order to investigate the effect of the changing linear energy transfer along the α-particle track, aqueous solutions of 0·1 *N* sulphuric acid containing either (*a*) ferrous ions or (*b*) ceric ions or (*c*) ceric and thallous ions were irradiated by a flat, external α-particle source (polonium-210), the energy of the α-particles entering the solution being controlled by the use of interposed layers of mica and/or variation in the distance between the sources and the surface of the irradiated solution. An ionization chamber, similar to that described by Miller and Wilkinson[4], was employed for physical dosimetry.

Perhaps the most striking results are those shown in Fig. 1, where $G(Fe^{3+})$ for aerated ferrous sulphate solutions and $G(Ce^{3+})$ for ceric sulphate solutions are plotted against the length of an α-particle track in the solution expressed as a percentage of the length of a 5·3-MeV. α-particle track in the same solution (R).

For comparison we have also plotted the linear energy transfer in keV./µ at various distances from the end of the track, and it is most striking that $G(Fe^{3+})$ passes through a minimum when the initial linear energy transfer of the α-particle track in the solution is close to the maximum possible value for an α-particle in this medium.

The difference in position of the maximum and minimum is not unexpected, since the ordinate G corresponds to:

$$\int_0^{\%R} (dG_x/dx)\, dx$$

where G_x is the value of G for that particular linear energy transfer $(-dE/dx)$ at the point on the α-particle track a distance x from the end of the track. The minimum value of $G(Fe^{3+}) = 3·65$ is in very good agreement with the value expected from the empirical formulæ of Schuler and Allen[5], which is based on experiments with mono-energetic beams of He^{2+} ions.

The presence of thallous ions in solutions of ceric sulphate does not influence $G(Ce^{3+})$ for α-particles of energy $\lessdot$ 3 MeV., and hence *no* hydroxyl radicals are available to this solute, presumably because they are removed by reaction with one another or with molecular products. Since $G(Ce^{3+})$ increases with x (see Fig. 1) we conclude that intra-track reactions removing reducing species are occurring to a decreasing extent and that the back-reaction concerned may well be (3):

$$H + H_2O_2 \rightarrow H_2O + OH \quad (3)$$

When tritium β-particle radiation was used, both the deaerated ferrous system and the ferrous-cupric system were also studied. The value of $G(Ce^{3+})$ was found to be 2·84, which is much lower than Hardwick's value[6] of 4·54, and this and other data lead to values of molecular and radical yields (G_H = 2·9, G_{OH} = 2·1, $G_{H_2O_2}$ = 1·0 and G_{H_2} = 0·6) for acidified water, which are much closer to those for cobalt-60 γ-rays than the values hitherto accepted[7]. Consideration of this result, the data given in Fig. 1 and the value of $G(Ce^{3+})$ for γ-rays, indicates that $G(Ce^{3+})$ has a maximum value at a linear energy transfer intermediate between the mean values for polonium-210 α- and tritium β-particles. This maximum has been predicted by Burch[8], though at lower values of the linear energy transfer.

(2) *Isotope effects.* An isotope effect, similar in magnitude and sign to that observed for γ- and X-rays, was found for tritium β- and polonium α-particles. This effect at first increases with increasing mean linear energy transfer, then passes through a maximum and decreases in the region of mean linear energy transfer corresponding to low-energy α-particles. This is illustrated by the values of the ratio G_D/G_H which are given in parenthesis after the type of radiation: 220-kVp. X-rays (1·11), tritium β-particles (1·14), 3-MeV. α-particles (1·17) and 1·6-MeV. α-particles (1·04).

Associated with this effect are differences in the initial rates of formation of deuterium and hydrogen peroxides, and the steady-state concentrations of these two compounds in aerated heavy and ordinary water irradiated with tritium β-particles. Although deuterium peroxide is initially formed at about the same rate, the steady-state concentration ultimately reached is higher, and measurements of the decomposition induced by irradiation of ~ 10^{-3} *M* deuterium peroxide solution in heavy water, and hydrogen peroxide solution in ordinary water, showed that this effect is due to a more rapid decomposition of the latter.

Full experimental details and further discussion of these experiments will be published elsewhere.

We are indebted to the Polish Government and the Rockefeller Foundation for financial aid which made this work possible.

[1] Armstrong, Collinson, and Dainton, *Trans. Farad. Soc.*, **55**, 1375 (1959). Coatsworth, Collinson and Dainton, *ibid.*, **56**, 1008 (1960).

[2] Mahlman and Boyle, *J. Amer. Chem. Soc.*, **80**, 773 (1958).

[3] Miller and Wilkinson, *Trans. Farad. Soc.*, **50**, 690 (1954).

[4] Holloway and Livingston, *Phys. Rev.*, **54**, 18 (1938).

[5] Schuler and Allen, *J. Amer. Chem. Soc.*, **79**, 1565 (1957).

[6] Hardwick, *J. Chem. Phys.*, **31**, 226 (1959).

[7] Allen, *Radiation Res.*, 1, 85 (1954).

[8] Burch, *Radiation Res.*, 11, 481 (1959).

ORIENTING EFFECTS IN OCTAHEDRAL AQUATION

By SIR CHRISTOPHER INGOLD, F.R.S., PROF. R. S. NYHOLM, F.R.S., and DR. M. L. TOBE

Department of Chemistry, University College, London

IN three recent reviews of octahedral substitution[1], the subjects considered include aquation, which subsequent work[2] seems now to have appreciably clarified. This article is written because it appears possible to discuss the mechanism of aquation with more assurance than before, to interpret more fully an extended pattern of rate data, and to offer the first stereokinetic rule applicable to octahedral substitutions.

(1) Experimental Data

The experimental data are of two kinds, namely, rates of aquation, and the proportions of isomeric products formed by aquation. As to the latter, it has not always been appreciated that the products formed may be different from the products found, because the initial products undergo isomeric changes at rates often comparable to those of their formation.

In attempting to interpret these phenomena, our starting point is still the observation[3] concerning cobalt (III) aquations of the form:

$$[\mathrm{Co\ en_2}\,A\,X]^+ + \mathrm{H_2O} \rightarrow [\mathrm{Co\ en_2}\,A\,\mathrm{OH_2}]^{++} + X^-$$

that, with a constant replaced ligand *X*, a constant stereochemical relation, *cis* or *trans*, between *X* and the 'orienting' ligand *A*, and a succession of ligands *A*, taken in a presumable order of decreasing electron supply to, or increasing electron withdrawal from, the metal, the rate of aquation at first falls sharply and then rises sharply along the series. This can be illustrated more fully than before, as it is in the third column of Table 1 (en = ethylenediamine).

(2) Duality of Mechanism

Following the lines of an early theoretical treatment of similar patterns of kinetic phenomena in organic chemistry, rates such as those shown in Table 1 have been schematically plotted[3,1a,b,c] on two curves which intersect at a rate minimum; and the falling and rising curves have been interpreted as indicating different mechanisms, having different, indeed qualitatively opposite, polar requirements. Along the falling curve, an excess of electron export from the reaction site, over any electron import there may be to it, must be required in order to bring the system to the transition state: obviously, ligand loss is in the lead, as is consistent with the presumed mechanism, S_N1. Along the rising curve, an excess of electron import to the reaction site is needed in order to produce the transition state: here the binding of water must be in the lead, and the mechanism bimolecular, as is the assigned mechanism, S_N2.

In order to develop this general approach in more detail, not only with respect to the rate pattern but also in regard to the stereochemical orientation of aquation, for which the data are in the fifth column of Table 1, it is necessary to consider the electronic constitutions of the orienting ligands, and so to deduce the types of polar properties they should possess, and the effects of such properties on rate and orientation in the two mechanisms of aquation. We shall have to consider three different types of polar properties.

Table 1. RATES OF (k_1 IN SEC.$^{-1}$ AT 25°), AND ISOMER RATIOS (PER CENT CONFIGURATIONAL CHANGE) OF FIRST-FORMED PRODUCTS IN THE AQUEOUS REACTIONS

$$[\mathrm{Co\ en_2}\,A\,X]^+ + \mathrm{H_2O} \rightarrow [\mathrm{Co\ en_2}\,A\,\mathrm{OH_2}]^{++} + X^-$$

X	*A*	$10^7 k_1$	Note.	Ref.	Per cent *trans*	Note.	Ref.	Mech.
cis-Cl	OH	130,000		9	0 ?	*a*	6	S_N1
,,	N_3	2,400		12	0		12	
,,	Cl	1,250	*b*	9	0	*c*	6	
,,	NCS	114		11	0	*d*	11	
,,	NH_3^+	~5	*e*	8	0		14	S_N2
,,	OH_2^+	~150	*f*	4, 9	—		—	
,,	NO_2	1,120		3	0		3	
cis-Br	NCS	240		11	0		11	S_N1
,,	NH_3^+	15		8	0		14	S_N2
cis-NO_2	NH_3^+	180		8	0		14	S_N2
					Per cent *cis*			
trans-Cl	OH	14,000		9	some		13	S_N1^h
,,	N_3	2,500		12	20		12	
,,	Cl	160	*b*	9	some		5	
,,	NCS	0 5		7	≮50	*g*	11	
,,	NH_3^+	4		10	0		10	S_N2
,,	NO_2	9,800		3	0		3	
trans-Br	NCS	1 7		7	43		7	S_N1
,,	NH_3^+	9		10	0		10	S_N2
,,	NO_2	46,000		14	0		14	
trans-NO_2	NH_3^+	63		10	0		10	S_N2

(*a*) It is shown, though without a quantitative determination, that the initial product is at least largely *cis*.

(*b*) Half the observed rate, that is, the rate of replacement of one 'marked' chlorine atom.

(*c*) With the optically active substrate, there is complete retention of optical activity, and almost certainly of optical configuration.

(*d*) With the optically active substrate, there is a large, perhaps complete, retention of optical activity and configuration.

(*e*) Observed rate at 62·6° calculated for 25° with $E = 23$ kcal./mole.

(*f*) Half the observed rate as given for 30°.

(*g*) Probably not more than 70 per cent of *cis*-product.

(*h*) Possibly not exclusively S_N1 for *trans*-N_3 (text, section 6).

(3) Inductive Effects ($\pm I$) of Ligands

Under the term 'inductive' effects, we include all electrostatically induced deformation of electron shells within the atoms, but exclude all electron-transfer, or 'conjugative', processes.

On grounds well worked over in organic chemistry, we can at once make relative assessments of inductive polarity among some of the orienting groups of concern to us. Thus we can write the following order of increasing inductive electro-negativity (electron attraction), or, what is synonymous (for in these considerations, which are wholly relative, it is convenient to retain the alternative modes of expression), diminishing electro-positivity (electron repulsion): OH, Cl, NO_2, NH_3^+, OH_2^+. The groups N_3 and NCS need further consideration. It seems plausible to assume that the fractional charge, negative in N_3 and positive in NCS, conferred on the first atoms of the groups by the second-written and (as we think) less weighty structures of the canonical pairs:

$$.N{=}\overset{+}{N}{=}\overset{-}{N},\ .\overset{-}{N}{-}\overset{+}{N}{\equiv}N,\ \text{and}\ .N{=}C{=}S,\ .\overset{+}{N}{\equiv}C{-}\overset{-}{S},$$

will be more important for induction than the more distant, formally integral charges. We can then set down the electro-positivity differences $N_3 > NCS > NO_2$ and $N_3 > Cl$, and so build up the following more extensive series, in which some theoretically unresolved dubieties still remain:

$$\text{OH, N}_3 > \text{Cl, NCS} > \text{NO}_2 > \underbrace{\text{NH}_3^+,\ \text{en}_{1/2}^+}_{\text{standard}} > \text{OH}_2^+$$

$$\longleftarrow\!\!-\!\!-\!\!-\!\!-\ +I\ -\!\!-\!\!-\!\!-\!\!\longrightarrow \qquad\qquad -I$$

Electropositivity sequence

There is no convenient natural zero of electropositivity or electronegativity within our range of relative structural effects. We therefore choose a working zero. Among the complexes to which Table 1 refers, most of the octahedral positions are occupied by $en_{1/2}^+$ groups, and in another, less fully investigated but probably similar series, most are occupied by NH_3^+ groups. Electrostatically, these ligands must be much alike, and we could quite well adopt either as our inductive zero, as indicated in the sequence written above. Most of our orienting ligands thus become classified as inductively electropositive. The exceptions are NH_3^+, which we take as inductively neutral, and OH_2^+, which on this scale is electronegative.

An inductive effect acts, not on stereospecifically selected orbitals but on the general electrostatic situation, and most strongly on the most polarizable electrons of the nearest atom. We may plausibly take these to be the unshared electrons of the quantum groups contributing to the valency shell of cobalt; in particular, the $3d_\varepsilon$ sub-shell of six unshared electrons, which surrounds the atom, filling up the spaces between the ligands. An inductively electropositive orienting ligand will press this electron sub-shell in all directions away from itself, between the other ligands, so causing it to encroach the more on all of them, and more especially on the *trans*-ligand. (This would be a so-called '*trans*-effect'.)

Such electropositive electron displacement will evidently affect substitution mechanism by promoting a loosening of the replaced ligand, and by retarding the entry of water. It follows that it will promote S_N1, and retard S_N2 aquation.

The summary of these conclusions is that the $+I$ effect of orienting ligands will, in the order of the electropositivity sequence given above, promote S_N1 and retard S_N2 aquation, and will do all this more strongly in *trans* than in *cis*-positions.

(4) Electromeric Effect ($+E$) of Ligands

Two conjugative, or electron-migratory, processes are factors in the overall polarity of our ligands. In this section we shall consider an electropositive conjugative effect[8,15], that is, one which transfers electrons from the ligand to the metal. It is permitted to ligands which have an unshared pair of electrons on the atom adjoining the metal. In the initial state of the reacting system, the metal has no empty orbital with which it could accept a share of such an electron pair. But in the transition state, provided that the incoming water does not become bound too early, the metal will have the emptying orbital of the outgoing ligand. Thus, if we disregard hyperconjugation, the conjugative effect under consideration is necessarily absent from the initial state, but possibly present in the transition state. That is why we sub-classify it as an electromeric effect ($+E$), rather than as a mesomeric effect ($+M$).

Among the orienting ligands we have examined, four, namely, OH, N_3, Cl and NCS, possess unshared electrons in a location in which they could conjugate as described. Theory is equivocal about the relative conjugative powers of these groups. We might expect that their property of electropositive conjugation would be ordered with some reflexion of the inductive electropositivity sequence, OH, $N_3 > Cl$, NCS. However, N_3 might have to be moved down, and NCS up, in the conjugative sequence, because the adjacent-charge rule restricts conjugation by N_3 except in its minor canonical structure, whereas NCS conjugates through its major structure in which the atoms are uncharged. Formally, the group OH_2^+ should bring up the rear of this series; but we regard the unshared electrons of that group, like those of SMe_2^+ in organic chemistry, as incapable of conjugation, so that OH_2^+ is not an effective member of the class.

Since electromeric conjugation $+E$ requires an emptying bond-orbital, it will enter into, and facilitate, only S_N1 aquations, which are initiated by ligand loss. It will take no part in S_N2 aquations, neither hindering nor helping them.

A stereochemical condition is involved in the $+E$-effect; for conjugating orbitals must be non-orthogonal. In the tetrahedral binding situations of organic chemistry, this condition is commonly fulfilled; but the prohibition of orthogonality is known, for example, in the cases summarized under 'Bredt's rule'. In octahedral situations, the rectangular bonding introduces frequent orthogonality restrictions, and we have one here. For the orbital of the ligand electrons which might conjugate with an emptying octahedral bond-orbital is orthogonal to the *trans* octahedral orbital and non-orthogonal only to the *cis*-orbitals. Thus, electromeric conjugation $+E$ is restricted to *cis*-related ligands (a '*cis*-effect').

This stereospecificity has a further possible consequence. For, if the group, which is normally the most easily replaced of the groups present, is *trans*-related to the orienting ligand, the latter may cause, in a normally less easily loosened *cis*-group, a degree of prior loosening, insufficient for its own replacement, but sufficient to allow it to engage in a tentative or complete edge-displacement involving loss of the labile *trans*-group. Thus, the substitution could involve some rearrangement, a *trans*-factor giving a *cis*-aquo-product. Such rearrangements are evidently confined to substrates with a replaced group X *trans*-situated with respect to a $+E$-type orienting group A. For a fixed orienting group, the greater the normal ease of loosening of the replaced group, the less extensive should be the rearrangement. Among our replaced groups, provided that they are compared in the same structural environment, the order of extent of rearrangement on aquation should be $Cl > Br > NO_2$.

In summary, we may say that the $+E$ effect of the orienting ligands, OH, N_3, Cl and NCS, will leave untouched S_N2 aquations, but will promote S_N1 aquations, chiefly of substrates having *cis*-related orienting and replaced groups; but in the isomeric *trans*-substrates it will induce a tendency to substitution with rearrangement, in the order $Cl > Br > NO_2$ of replaced groups.

(5) Conjugative Effect ($-T$) of Ligands

This electronegative form of electron-transfer involves conjugation the other way round, that is, between unshared electrons of the metal, and an orbital which can be emptied sufficiently in the orienting ligand to allow the latter to share them[3]. The unshared $3d_\varepsilon$ sub-shell of cobalt is the source of the electrons. Any ligand having a double bond transformable to a dipolar bond the positive end of which adjoins the metal will be able to share one pair of such electrons. At least one of the three $3d_\varepsilon$ orbitals of the metal is always non-orthogonal to the receiving ligand orbital, so that at least one pair of electrons is always available for sharing. Hence this form of conjugation belongs to the ground-state of the complex, that is, to the initial state of the reaction: in this aspect, we would sub-classify it as a mesomeric effect ($-M$). Depending on the polar needs of the reaction mechanism, it will make the transition state either easier or harder to reach, and so it will either facilitate or retard reaction. In the former case only, the possibility arises that an intensification of the conjugation will stabilize, and therefore occur in, the transition state, so making it still more accessible, and providing a further facilitation that we would sub-classify as an electromeric effect ($-E$). The conjugative effect ($-T$) includes both its mesomeric and electromeric aspects.

The only orienting ligands of those used in the present work, which have the electronic structures permitting electronegative conjugation, are N_3 and NO_2. Considerations familiar in organic chemistry lead us to place their conjugative electronegativities in the order, $N_3 < NO_2$.

By retracting part of the cobalt $3d_\varepsilon$ shell, these groups will facilitate the water uptake which initiates S_N2 aquations, and will resist the ligand loss with which S_N1 aquations must commence.

Because this conjugation of the orienting ligand is with the unshared-electron sub-shell, rather than with an orbital binding another ligand, it is not sharply stereospecific. But by withdrawing the $3d_\varepsilon$ sub-shell largely from the spaces between the *trans*-ligand and the four *cis*-ligands, it should exert its strongest influence in the *trans*-position (another '*trans*-effect').

In summary, the electronegative conjugative effect of orienting ligands, in the order $N_3 < NO_2$, will inhibit S_N1 and promote S_N2 aquations, acting thus more strongly at *trans*- than at *cis*-positions.

(6) Polar Effects on Rate

In trying to anticipate the results that might follow from the joint action of the three polar factors (sections 3–5), our main guide is organic chemical experience to the effect that, leaving hyperconjugation out of account, conjugation is nearly always more powerful than induction in the control of reactions. Thus, in arranging the sequence of orienting groups used in Table 1, we begin with the $+E$ and end with the $-T$ groups, otherwise using the order of decreasing electropositivity throughout. The major uncertainty which then remains is in the placing of the N_3 group, which belongs to both conjugative types, and possibly ought to have been entered twice in the series.

The fall of rate with decreasing electropositivity, and the succeeding rise with increasing electronegativity, have been noted before, and are the basis of the assignments of mechanism suggested in the last column of Table 1. We can now see further that, over the falling part of the rate series, rates for *cis*-isomers exceed those for *trans*, while over the rising part, the rates of *trans*-isomers are the greater, with the result that the rate minimum shifts one place on passing from the *cis*-series to the *trans*. This accords with our anticipation of stereospecific $+E$ *cis*-activations in S_N1 aquations, and of favoured $-T$ *trans*-activations in S_N2 aquations. The group N_3 remains observationally marginal; but it is theoretically ambiguous, and part of the rate for the *trans*-complex may, despite the assignment of mechanism entered in the last column of Table 1 (but see note *h*), be that of an S_N2 aquation.

(7) Polar Effects on Orientation

In aquation, the predominating tendency is to retention of configuration. For *cis*-substrates, such retention, including that of optical configuration where investigated, is total so far as is known. We can understand the general tendency on the ground that the aqueous solvation shell of the complex ion will contain an inner layer of water more or less embedded among the ligands in the structure, and that such a layer is likely to include at least one water molecule in such close juxtaposition to the replaced group that substitution, whether with loosening or binding in the lead, can be effected simply by a local exchange of these interactions, and thus without the necessity for any more widespread stereochemical disturbance.

The exceptions to total retention of configuration occur among the *trans*-substrates; and there, they are confined to those in which the orienting group belongs to the $+E$ class; but they do include all examples of this class. It can also be said that the configurational changes arise only in, but in all, those aquations of *trans*-substrates to which, on account of the rate trend, an S_N1 mechanism has been assigned. This is so much in line with what would be expected from the theory of *cis*-specificity in the $+E$-activation of S_N1 aquations[1] that it does not seem unreasonable to apply theoretically guided 'induction' to rather few experimental results in proposing the following statement of requirements for aquation with rearrangement: In octahedral aquations which replace X in filled-sub-shell complexes MR_4AX of a transition metal, M, configuration will be totally preserved, unless A and X are *trans*, and A but not R has unshared electrons adjoining M.

It is implied in the theoretical basis of this rule that the conditions for rearrangement which it gives are necessary but not sufficient. Other requirements can be foreseen, as that R must be labile enough to be loosened by the available *cis*-activation, and X not so labile as to be lost altogether independently of R loosening. However, such conditions are not sufficiently definable in terms of constitution to be incorporated in a rule, and hence we leave ours as a permissive rule.

[1] (*a*) Basolo, F., and Pearson, R. G., "Mechanism of Inorganic Reactions", Chap. 3 (John Wiley and Sons, New York, 1958). (*b*) Ingold, C. K., "Substitution at Elements other than Carbon", Chap. 1 (Weizmann Science Press, Jerusalem, 1959). (*c*) "Theoretical Organic Chemistry", 84 (Butterworths Scientific Publications, London, 1959).

[2] Tobe, M. L., *J. Chem. Soc.*, 3776 (1959); and forthcoming papers, some jointly with Baldwin, M. E., and Staples, P. J.

[3] Asperger, S., and Ingold, C. K., *J. Chem. Soc.*, 2862 (1956).

[4] Mathieu, J.-P., *Bull. Soc. Chim., France*, V, 3, 2121 (1936).

[5] Mathieu, J.-P., *Bull. Soc. Chim., France*, V, 3, 2152 (1936).

[6] Mathieu, J.-P., *Bull. Soc. Chim., France*, V, 3, 687 (1937).

[7] Ingold, C. K., Nyholm, R. S., and Tobe, M. L., *J. Chem. Soc.*, 1691 (1956).

[8] Nyholm, R. S., and Tobe, M. L., *J. Chem. Soc.*, 1707 (1956).

[9] Pearson, R. G., Meeker, R. E., and Basolo, F., *J. Amer. Chem. Soc.*, 78, 2673 (1956).

[10] Tobe, M. L., *J. Chem. Soc.*, 3776 (1959).

[11] Baldwin, M. E., and Tobe, M. L., *J. Chem. Soc.* (in the press).

[12] Staples, P. J., and Tobe, M. L., *J. Chem. Soc.* (in the press).

[13] Baldwin, M. E., and Tobe, M. L. (unpublished observations).

[14] Tobe, M. L. (unpublished observations).

[15] Pearson, R. G., and Basolo, F., *J. Amer. Chem. Soc.*, 78, 4878 (1956).

FALL-OUT CÆSIUM IN SURFACE SEA WATER OFF THE CALIFORNIA COAST (1959–60) BY GAMMA-RAY MEASUREMENTS

By Dr. THEODORE R. FOLSOM, Dr. G. J. MOHANRAO and PERRIN WINCHELL

Scripps Institution of Oceanography, University of California, La Jolla, California

STRONTIUM-90 and cæsium-137 decay at very similar rates and relatively slowly, half in about thirty years, or less than 2 per cent a year. The rate at which fall-out is reaching the land surface has been followed by extensive measurement[1] of these nuclides in soil specimens and in various rain samples. On the other hand, the collection of similar data concerning fall-out entering the sea has been seriously limited by measurement difficulties, arising mainly from the excessive dilution and from the presence in sea water of relatively larger amounts of natural radioactivities and relatively enormous amounts of stable nuclides that interfere with chemical concentration and purification.

Fortunately for study of fall-out phenomena, the dispersal of these long-lived fission products after they have entered the sea is also of great interest in the study of food-chains, especially those directly influencing fisheries, and also in the oceanographic study of water movements and mixing. Yamagata has developed a successful technique for measuring cæsium-137 in sea water through its beta-ray after numerous steps of chemical purification; recently he has reported[2] his measurements of the recent distribution of cæsium-137 in waters close to the coast of Japan. Bowen and Sugihara, of Woods Hole Oceanographic Institution, have studied fall-out constituents in the sea for several years and have reported[3] recently on the horizontal and vertical distribution of strontium-90 in the Atlantic Ocean. They point out that their vertical profiles indicate downward mixing to depths of 300–700 metres at a rate much more rapid than might be predicted from existing radiocarbon measurements. They show that a significant amount of strontium-90 has penetrated even to a depth of 1,000 metres.

The oceans are very large, and many more of this sort of data must be collected before generalizations regarding either the arrival or dispersal of fall-out become convincing. Efforts at the Scripps Institution, therefore, have centred around simplifying the chemical assay required, adapting it to shipboard use, and the application of electronic aids wherever possible. Whereas strontium-90 emits only beta-rays and its assay in sea water is tedious, cæsium-137 (which falls into the sea at about the same rate) has both beta- and gamma-emission. To utilize the beta-ray as Yamagata and others have done, the trace of radiocæsium must be chemically separated from the large amount of potassium present in sea water, including the natural beta-emitter potassium-40. On the other hand, the modern scintillation spectrometer has no trouble resolving the gamma-ray of cæsium-137 (0·66 MeV.) in the presence of much larger amounts of potassium-40 (1·46 MeV.). The assay problem, therefore, reduces to one of concentrating sea water cæsium in a way convenient for gamma-ray spectrometry. Gustafson, Marinelli and Brar[4] at the Argonne National Laboratory have shown how low-level gamma-ray assays can be made from bulky specimens by use of large scintillation detectors. It was found at Scripps that the radiocæsium in a barrel of sea water, brought down together with roughly 30 per cent of the potassium by the mere addition of sodium cobaltinitrite, could be collected as a precipitate having a volume of about 250 ml. This wet material, placed near a 3-in. diameter sodium iodide scintillation crystal, gave accurate and reproducible measure of the cæsium content as could be established by adding known amounts of radiocæsium to controls. For this sort of work, a 256-channel gamma-ray spectrometer is now available at Scripps; a digital computer accessory developed at Scripps now permits storage of information on short magnetic tape loops and gives means for the rapid comparison between gamma spectra and the elimination of background effects. At present the precipitate is allowed to settle overnight, collected after decantation and then exposed to a 3-in. crystal, generally overnight. It is expected that gamma spectrographs will be made in less than 2 hr. by the use of larger crystals; and it is planned to have the initial precipitation carried out on board the research ship so that only the concentrated precipitate need be brought back from the longer expeditions.

Details of the procedure will appear elsewhere. Satisfactory reproduction of results has been demonstrated; the difference between the assays of five 200-litre replicate controls was less than 11 per cent. It now appears unnecessary to resort to the use of such large samples; nevertheless, several uncertainties in the early work were avoided by this means. For example, storage in full-sized steel oil drums for one month was found to cause a loss of about 20 per cent of the radiocaesium to the walls; and storage for one week in a rubber barrel caused a loss of about 13 per cent. Losses of this sort may be serious when small samples are stored for a long period, but, of course, are eliminated by immediate chemical precipitation.

Table 1 gives the results of twenty preliminary assays made on 200-litre sea water samples taken just beyond the surf zone (300 metres from shore) at Scripps pier. Serial 10 was deliberately taken when the water was brown with terrestrial mud from a heavy local rain; it is not significantly exceptional in caesium content.

The average caesium-137 is 97 micromicrocuries per kilo litre (97 $\mu\mu$c./kl.).

Table 2 shows the results for water carefully collected in 200-litre aliquots in the open sea many miles from shore. The average concentration is 138 $\mu\mu$c./kl.

For comparison there are two groups of measurements made by Yamagata[1] concerning Japanese waters. He deduced from industrial salt concentrates that coastal waters early in 1958 contained caesium-137 in the amounts 70–150 $\mu\mu$c./kl. Later, by direct low-level beta technique, he measured the concentration in 1959 surface sea water taken from salt works, reporting the average caesium-137 from fifteen samples as 380 $\mu\mu$c./kl.

Of course, too much should not be expected from cursory comparisons between these preliminary sets of measurements. It is believed that the oceanographic phenomenon called 'upwelling' does not occur in the region where the samples of Table 2 were taken; nevertheless, these waters may have been influenced by local vertical mixing of some sort, perhaps at a place thousands of miles to the north of the sampling position. The range of variation in concentrations which appear in these tables as well as in Yamagata's 1959 measurements (240–650 $\mu\mu$c./kl.) should be a warning to those who might hope to establish for specific oceanic areas the average vertical profile of radiocaesium (or radiostrontium or any other water tag) with only a few measurements.

Table 1. CONCENTRATION OF CAESIUM-137 IN SEA WATER FROM SCRIPPS PIER

No.	Date collected	CsCl carrier mgm./l.	Cs-137 $\mu\mu$c./kl.
1	11/30/59	0	76
2	12/ 2/59	0	123
3	12/ 3/59	0	104
4	12/11/59	100	163
5	1/ 2/60	0	67
6	1/16/60	0	90
7	1/22/60	20	135
8	2/ 3/60	30	145
9	2/ 4/60	0	108
10	2/12/60	25	108
11	2/15/60	0	108
12	3/ 4/60	0	99
13	3/12/60	0	45
14	3/17/60	0	46
15	3/18/60	0	67
16	3/25/60	0	79
17	4/ 9/60	0	76
18	4/15/60	0	71
19	4/22/60	0	86
20	4/27/60	0	138
		Average	97

Table 2. CONCENTRATION OF CAESIUM-137 IN SAMPLES FROM THE OPEN SEA

Serial No.	Date collected	Position Lat. N.	Position Long. W.	Distance from coast, miles	Cs-137 $\mu\mu$c./kl.
1	12/10/59	33° 55′	121° 49′	75	81
2	12/17/59	31° 08′	120° 55′	215	163
3	12/17/59	31° 07′	122° 26′	300	161
4	1/31/60	28° 02′	127° 50′	200	152
5	1/31/60	28° 02′	127° 50′	200	124
6	3/8/60	30° 53′	116° 59′	85	87
7	3/15/60	24° 40′	114° 02′	100	144
8	3/18/60	31° 05′	122° 39′	300	150
9	3/19/60	30° 32′	122° 13′	300	141
10	3/21/60	26° 13′	118° 27′	200	230
11	3/22/60	29° 42′	120° 44′	250	120
12	3/25/60	28° 14′	119° 28′	220	100
				Average	138

Sample No. 5 was collected in a neoprene drum. The rest in steel drums.

The increase reported in caesium in Japanese waters between 1958 and 1959 corresponds to an increase in weapon-testing activity and to a world-wide increase in fall-out. However, the difference between the California and the Japanese surface concentrations might be due to several factors; certainly to be considered are the reports of consistently higher local fall-out in Japan, and also are the differences of positions of Japan and California in the general circulation of the Pacific relative to the weapons proving-grounds. Certainly, the behaviour of a water tag in surface-water must be explored first, but these waters move faster horizontally; much more information concerning transport and mixing can be obtained when samples from several depths can be examined. Plans therefore have been made to sample Pacific waters to depths where there is little motion.

Arrival of fall-out, being associated with rainfall, is at best spotty. However, during the past eighteen months there has been a moratorium in weapons tests; and over this period there have not appeared the large peak values witnessed during the previous years. Advantage, of course, should be taken of this simplifying circumstance to establish background values related to the ocean. Another factor arising from the moratorium should be mentioned as it concerns the measurement of radiocaesium in sea water. During the past year the shorter-lived fission products have become so attenuated that essentially nothing needs to be done now to eliminate their interference with caesium-137 in a gamma-ray spectral analysis. Prior to this recent, happy period, the obscuring effects of fresh fall-out constituents were combated at Scripps either by additional chemical treatment, or by fullest use of the digital computer already mentioned and developed for just this purpose.

The matter of vertical biological transport cannot be overlooked. However, one can present an argument for neglecting the biological transport of radiocaesium perhaps as strong as that offered by Bowen and Sugihara for ignoring this contribution in the case of radiostrontium. They argued that biological transport cannot be important because of the presence of large amounts of stable strontium and calcium in sea water. Cæsium, too, is notably soluble; only traces of the radionuclide enter as fall-out and these must share with large amounts (about 0·002 mgm./litre) of stable cæsium; and also there is present in sea water much larger amounts of potassium (about 380 mgm./litre). It is common experience that potassium and cæsium are found together in many reactions—organic and inorganic. Still, a considerable loss of radiocæsium to surfaces has been observed in the actual handling of sea water specimens, and too little is now known about the behaviour of stable cæsium in the actual seas. Fortunately, the chemical behaviour of cæsium is quite different from that of strontium; exploration based upon the progress of fall-out in the ocean should exploit this. At the outset, sampling of radiostrontium should go along with that for radiocæsium.

Various aspects of this work have been supported by the United States Atomic Energy Commission (Contract No. AT(11-1)-34, Project Agreement No. 56), and by the United States Office of Naval Research (Contract 233(34), Amendments No. 7,8,9). We are grateful for suggestions that have come personally from Drs. V. T. Bowen, T. T. Sugihara and N. Yamagata. We wish to thank D. C. Martin for related preliminary studies, and also Barbara Edwards, William Hartin and Richard Schwartzlose for skilful technical assistance.

---

[1] Gustafson, P. F., *Science*, 130, 1404 (1959).
[2] Yamagata, N., *Nature*, 184, 1813 (1959).
[3] Bowen, V. T., and Sugihara, T. T., *Nature*, 186, 71 (1960).
[4] Gustafson, P. F., Marinelli, L. D., and Brar, S. S., *Science*, 127, 1240 (1958).

VISCOSITY INCREMENTS OF NON-IONIZED MOLECULES

By ALFRED POLSON

Council for Scientific and Industrial Research and University of Cape Town Virus Research Unit, Medical School, Cape Town

A DISTINCTIVE property of colloidally dispersed substances as opposed to crystalloids is their relatively higher intrinsic viscosity or viscosity increment. The reason for this is that the medium in which the macromolecular particles are dispersed may be regarded as continuous on account of the great difference in size between the suspended particles and those of the medium. For such systems the frictional forces encountered by a particle moving through such a medium may be calculated from the well-known Stokes's equation. Low molecular substances (so-called crystalloids) do not obey Stokes's equation since the medium in which the molecules are dispersed may no longer be regarded as continuous. When these low molecular substances move through a medium composed of molecules of similar size they will encounter less friction than colloid particles, by slipping into empty spaces in the dispersion medium.

In viscosity and diffusion measurements with crystalloids, the slipping effect will show itself as a low-viscosity increment $[\eta]$ or as an abnormally high diffusion-rate.

Viscosity Increments of Low Molecular Substances

As might be expected, the departure from the ideal or macroscopic friction law of Stokes becomes more pronounced the more closely the molecular diameters of the dispersed particles approach those of the dispersion medium. In Table 1 and Fig. 1 are shown the viscosity increments of low and high molecular substances in water at 20° C. as a function of their molecular volumes expressed as log (MV).

The $[\eta]$ for the low molecular substances are greatly dependent on the molecular volumes, being almost zero for urea and rising to 0·024 for sucrose, and 0·035 for norleucine. An interesting conclusion may be drawn regarding the molecular state of water from the $[\eta]$ log (MV) curves. Let (MV) be the molecular volume of the dissolved substance and (mv) that of the dispersion medium. We may then write:

$$[\eta] = F[(MV) - (mv)]$$

where F is an unknown factor. Whatever F may be, $[\eta]$ will approach zero when (MV) approaches (mv). Knowing (MV) when $[\eta] = 0$ we may estimate (mv).

From Fig. 1 it is obvious that the $[\eta]$, log (MV) relationship for low molecular compounds is presented by a curved wedge which pinpoints on the ordinate at log $(MV) = 1·58$, indicating that the $[\eta]$ will equal zero when the substance under investigation

Table 1. VISCOSITY INCREMENTS AND MOLAR VOLUMES OF A NUMBER OF CRYSTALLOIDAL AND COLLOIDAL SUBSTANCES MEASURED IN WATER AND ELECTROLYTE SOLUTIONS, RESPECTIVELY

Substance	Mol. wt.	Mol. vol.	Viscosity increment
Urea	60	45·1	0·002
Glycine	75	43·5	0·0104
α-Alanine	89	60·6	0·024
β-Alanine	89	58·9	0·030
Glycerol	92	73·8	0·023
Oxalic acid	126	76·4	0·012
α-Amino-butyric acid	103	76·5	0·028
Valine	117	91·3	0·032
Norvaline	117	92·7	0·035
Norleucine	131	108·4	0·035
Glucose	180	111·9	0·036
Citric acid	210	136·3	0·0174
Sucrose	342	209·9	0·0243
Gliadin fraction	27,500	19,525	0·105
β-Lactoglobulin	41,800	30,514	0·045
Ovalbumin	43,800	31,600	0·0427
Hæmoglobin	64,000	46,720	0·0403
Serum albumin	70,000	51,100	0·0488
Amandin	329,000	240,170	0·0525
Thyroglobulin	640,000	467,200	0·071
Jasus lalandi hæmoc.	490,000	357,700	0·0408
H. pomatia hæmoc.*	8,900,000	6,497,000	0·052

The molar volumes of the crystalloids were obtained from the publication by Longsworth (ref. 1) and from "Handbook of Chemistry and Physics" (1958–59), the molecular weights of the proteins from Svedberg and Pedersen (ref. 2), the viscosity increments from papers of Polson (refs. 3 and 4) and unpublished measurements.

* Brohult (ref. 5).

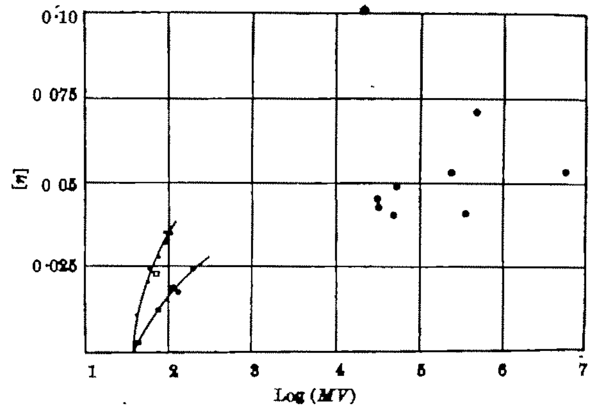


Fig. 1. Variation of [η] with log (*MV*)

The large solid circular spots are the [η]'s of the protein molecules, the small full stops those of the aliphatic amino-acids, and the open circles those of the compact molecules. The open square is the [η] of glycerol

has a molar volume of approximately 38. As the viscosity measurements were all made in distilled water at 20° C., it indicates that water has a molar volume of 38 at 20° C., therefore a molecular weight of 38 or a chemical-structure of $(H_2O)_2$. This is confirmatory evidence of the well-established fact that water molecules form aggregates of the type $(H_2O)_n$ where $n = 1, 2, 3$, etc. At low temperatures the higher polymers predominate, and at elevated thermal levels the monomers are in excess.

It is interesting to note that the top of the wedge shows the variation of $[\eta]$ with log (MV) for the aliphatic amino-acids which may be regarded as composed of rod-shaped particles, while the lower curve presents the $[\eta]$ of the molecules with more compact structures.

Viscosity Increments of Colloidal Particles

From Fig. 1 it is apparent that the $[\eta]$'s of the macromolecules are independent of molecular volume. The scattering around the mean value may be ascribed to variation in states of hydration or in particle shape.

It has been shown in a previous communication[4] that $[\eta]$, the molecular weight M, and the diffusion constant D are interrelated by the following equation:

$$[\eta] = \frac{k}{MD^3}$$

where k is an empirical constant and equal to $8{\cdot}06 \times 10^{-14}$. This equation was derived from the Stokes–Einstein diffusion equation and from Einstein's viscosity law. The empirical constant was based on a knowledge of the molecular weights of a variety of proteins as determined by the oil turbine ultracentrifuge. The value of k at 20° C. calculated from theory was $6{\cdot}16 \times 10^{-14}$. It was further pointed out that the discrepancy between the theoretical and empirical values disappears when the numerical in Einstein's equation was increased from 2·5 to 3·24. It is now generally accepted that the molecular weights of the proteins as determined with the oil turbine ultracentrifuge are approximately 10 per cent higher than the true values on account of faulty registration of the rotor temperature during operation of the oil turbine centrifuge[6]. This implies that the figure 3·24 must be reduced to approximately 2·92 for equation (1) to fit the new values of the molecular weights.

Recently Broersma[7] has re-examined the Einstein viscosity equation theoretically and found that the numerical 2·5 must be multiplied by a factor of 1·2 when applied to colloidal suspensions. The new numerical in Einstein's viscosity equation therefore becomes 3 0, which is in close agreement with the empirical value of 2·92. On introducing this new value into the equation, the viscosity increment of a protein at 20° C. should be truly presented by the equation:

$$[\eta] = \frac{7{\cdot}39 \times 10^{-14}}{MD^3}$$

This equation is free from empirical factors, and it offers a means of molecular weight determination without a knowledge of the partial specific volume of the substance under investigation, as is essential in the ultracentrifugation method.

[1] Longsworth, G. L., *J. Amer. Chem. Soc.*, **75**, 5705 (1953).
[2] Svedberg, T., and Pedersen, K. O., "Die Ultracentrifuge" (Theodor Steinkopf, Dresden, 1940).
[3] Polson, A., *Kolloid Z.*, **88**, 51 (1939).
[4] Polson, A., *Biochim. Biophys. Acta*, **21**, 185 (1956).
[5] Brohult, S., Dissertation Uppsala (1940).
[6] Shulman, S., *Arch. Biochem. Biophys.*, **44**, 230 (1953).
[7] Broersma, S., *J. Chem. Phys.*, **28**, 1158 (1958).

AMINO-ACID SEQUENCE OF HUMAN INSULIN

By Dr. D. S. H. W. NICOL* and Dr. L. F. SMITH†
Department of Biochemistry, University of Cambridge

THE amino-acid sequences of insulins obtained from six species have previously been reported[1–4]. The only differences found were in the sequence of three amino-acids in the *A* chain at positions 8, 9 and 10, as shown in Table 1.

Insulin from several of these species has been used in the treatment of diabetes in man, and it was of interest to know what differences, if any, there were between these proteins and human insulin for which they were acting as a substitute.

Crystalline human insulin was prepared from pancreases obtained at post-mortem. Insulin from

Table 1. The Amino-acid Sequence at Positions 8, 9, 10 of the *A* Chain of Different Species of Insulin

	8	9	10
Cattle	Ala	Ser	Val
Pig, Sperm whale	Thr	Ser	Ileu
Sei whale	Ala	Ser	Thr
Sheep	Ala	Gly	Val
Horse	Thr	Gly	Ileu

---

* Beit Memorial Fellow. Fellow of Christ's College, Cambridge. Present address: Medical Department, Freetown, Sierra Leone.
† External Staff, Medical Research Council.

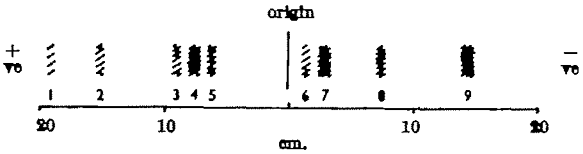


Fig. 1. Electrophoresis of pepsin digest of human faction *B*. Pyridine-acetate buffer *p*H 6·5, 30 V./cm. 1½ hr.

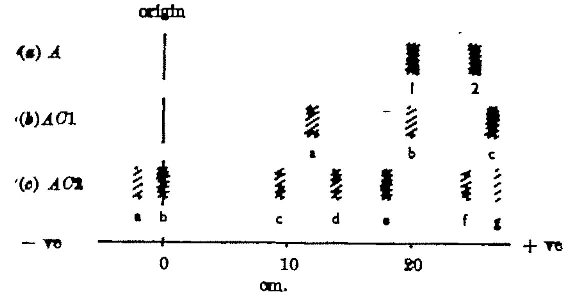


Fig. 2. Electrophoresis of enzymic digests obtained from human fraction *A*. *a*, 15 min. chymotrypsin digest of fraction *A*. *p*H 6·5, 30 V./cm. 1½ hr.; *b*, 18 hr. chymotrypsin digest of *AC*1. *p*H 6·5, 30 V./cm. 1½ hr.; *c*, 18 hr. elastase digest of *AC*2. *p*H 3·5, 30 V./cm. 1½ hr.

individual human pancreases was purified by a method to be published at a later date. Insulin was oxidized with performic acid[5] and fractionated by electrophoresis on paper at *p*H 8·9 in a 1 per cent ammonium carbonate solution.

The amino-acid sequence of fraction *B* was determined as for previous species[2,3] by digestion with pepsin at *p*H 2 and electrophoresing the digest at *p*H 6·5, giving the peptides shown in Fig. 1. An identical pattern was obtained using cattle fraction *B* as a control. Peptides 1–8 gave identical amino-acids on hydrolysis as those obtained from cattle (Table 2). Peptide 9 was different in that it contained no alanine. On treatment of this peptide with trypsin (1 per cent in 1 per cent ammonium bicarbonate, 15 min., 37° C.) followed by electrophoresis at *p*H 6·5, two bands were obtained, one of which on hydrolysis gave the same amino-acids as the parent peptide, but moved faster; the other band was free threonine. This suggested that the C terminal peptide was Tyr.Thr.Pro.Lys.Thr. This was confirmed by treatment of fraction *B* with trypsin, when the peptide Gly.Phe.Phe.Tyr.Thr.Pro.Lys, and free threonine were obtained.

Table 2. Peptides from a Pepsin Digest of Human Fraction *B*

Band (Fig. 1)	Peptide
1	Val.Glu.Ala.
2	Val.Glu.Ala.Leu.
3	Leu.Val.CySO$_3$H.Gly.Glu.Arg.Gly.Phe.
4	Tyr.Leu.Val.CySO$_3$H.Gly.Glu.Arg.Gly.Phe.
5	Tyr.Leu.Val.CySO$_3$H.Gly.Glu.Arg.Gly.Phe.Phe.
6	Phe.Val.Asp(NH$_2$).Glu(NH$_2$).His.Leu.CySO$_3$H.Gly.Ser.
7	Mixture of neutral peptides and amino-acids.
8	Phe.Val.Asp(NH$_2$).Glu(NH$_2$).His.Leu.CySO$_3$H.Gly.Ser.His.Leu.
9	Tyr.Thr.Pro.Lys.Thr.

Fraction *A* was digested with chymotrypsin (1 per cent in 1 per cent ammonium bicarbonate, 20 min., 37° C.) and after drying and electrophoresis at *p*H 3·5 gave the bands as shown in Fig. 2*a*. *AC*1 was eluted and hydrolysed with more chymotrypsin for 18 hr. *AC*2 was hydrolysed with elastase (1 per cent in 1 per cent ammonium carbonate 18 hr. 37° C.) and both electrophoresed at *p*H 3·5 (Fig. 2*b*, *c*). As shown in Table 3, *AC*1 *a*, *b*, *c* were identical with peptides previously obtained from all other species. The peptides obtained from *AC*2 together show that the sequence of amino-acids from A_1 to A_7 and A_{11} to A_{14} is the same as for all other species, and that in positions *A* 8, 9, 10 the sequence is Thr.Ser.Ileu. as had been found for pig and sperm whale insulin.

Table 3. Peptides from Human Fraction *A*

Band	Peptide
(Fig. 2*b*)	
*AC*1*a*	Glu(NH$_2$).Leu.Glu.Asp(NH$_2$).Tyr.
*AC*1*b*	Glu(NH$_2$).Leu.Glu.Asp(NH$_2$).Tyr.CySO$_3$H.Asp(NH$_2$).
*AC*1*c*	CySO$_3$H.Asp(NH$_2$).
(Fig. 2*c*)	
*AC*2*a*	Gly.Ileu.Val.Glu.Glu(NH$_2$).
*AC*2*b*	Tyr + Leu.
*AC*2*c*	Ser.Ileu.CySO$_3$H.Ser.
*AC*2*d*	Gly.Ileu.Val.Glu.Glu(NH$_2$).CySO$_3$H.CySO$_3$H.Thr. + Gly.Ileu.Val.Glu.Glu(NH$_2$).CySO$_3$H.CySO$_3$H.Thr.Ser.
*AC*2*e*	Gly.Ileu.Val.Glu.Glu(NH$_2$).CySO$_3$H.CySO$_3$H.Thr.Ser.Ileu.CySO$_3$H.Ser.
*AC*2*f*	CySO$_3$H.CySO$_3$H.Thr.Ser.Ileu.CySO$_3$H.Ser.
*AC*2*g*	Glu(NH$_2$).CySO$_3$H.CySO$_3$H.Thr.

When some confirmatory experiments were performed using a second batch of insulin extracted from ten pancreases, large amounts of the peptide Ser.Val.CySO$_3$H.Ser. were obtained from fraction *A* in addition to the sequences previously noted. It was also possible to isolate the peptide Tyr.Thr.Pro.Lys.Ala. from a pepsin digest of fraction *B* from this batch. These sequences are identical to those obtained from cattle insulin. Total hydrolysis of a sample of fraction *A* showed the presence of both threonine and alanine approximately in the ratio 1 : 2. This suggested that both cattle and pig sequences occurred in human insulin, and it was decided to determine if some individuals had the pig sequence and others the cattle sequence.

It has been found that fraction *A* can be isolated in a pure state from crude pancreatic extracts after oxidation, by electrophoresis in 20 per cent formic acid in which fraction *A* moves to the anode, all other material remaining at the origin or moving to the cathode. Using this method, fraction *A* was prepared from several individual pancreatic extracts. In later experiments the intact insulin was isolated in pure form, and the amino-acid sequence of both fractions *A* and *B* could be determined. Depending on the amount of material obtained (the pancreases varied from 80 to 150 gm. and the maximum quantity of insulin obtained was less than 10 mgm.) either the sequence or the amino-acid composition of fraction *A* was determined. The latter is sufficient to distinguish between pig and cattle insulin as the only residue of threonine in pig fraction *A* is replaced by alanine, which also occurs only once in cattle fraction *A*.

Twelve specimens were examined in this way, and only the Thr. Ser.Ileu. sequence was found in fraction *A*. While this does not prove that only the sequence Thr.Ser.Ileu. occurs in positions *A* 8, 9, 10 in the human population, to have obtained a sample containing about 60 per cent cattle sequence as in the second batch would suggest a high frequency of occurrence and might be expected to show up at least once in a sample of twelve individuals. The five samples of fraction *B* examined had only threonine as the C terminal amino-acid. It is suggested that this second batch was contaminated with cattle insulin, and that the amino-acid sequence of human insulin is that shown in Fig. 3.

The substitution of threonine for alanine as the C terminal amino-acid of the *B* chain occurs in a part of the molecule which has been shown to be un-

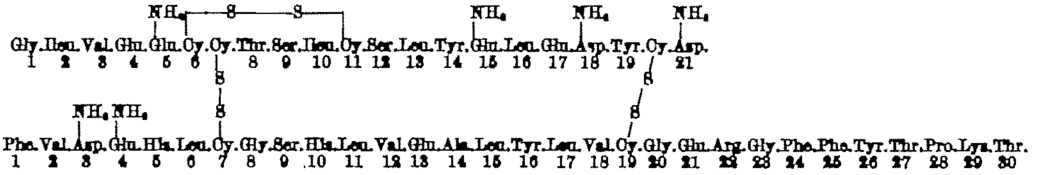

Gly.Ileu.Val.Glu.Glu.Cy.Cy.Thr.Ser.Ileu.Cy.Ser.Leu.Tyr.Glu.Leu.Glu.Asp.Tyr.Cy.Asp.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21
NH₂ NH₂ NH₂ NH₂
S S S S S S
Phe.Val.Asp.Glu.His.Leu.Cy.Gly.Ser.His.Leu.Val.Glu.Ala.Leu.Tyr.Leu.Val.Cy.Gly.Glu.Arg.Gly.Phe.Phe.Tyr.Thr.Pro.Lys.Thr.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
NH₂ NH₂

Fig. 3. Structure of human insulin

essential for biological activity[6,7]. Berson and Yalow[8] demonstrated significant differences in the reaction of cattle and pig insulins with human anti-insulin serums of patients treated with mixed cattle and pig insulins. They suggested that this could be accounted for if most (or all) of the antibody produced was directed against the cattle insulin. From the close similarity of pig and human insulins, in particular the identical sequence in positions *A* 8, 9, 10, it might be expected that pig insulin would be a less-efficient producer of antibodies in man than cattle insulin.

We wish to thank Dr. F. E. Camps, Dr. D. Teare and Prof. Payling-Wright, of the University of London, for offering us facilities for obtaining the human pancreases; Dr. C. G. Pope, of the Wellcome Research Laboratories, for much assistance in extraction procedures; and Dr. F. Sanger, for encouragement and advice. One of us (D. S. H. W. N.) is indebted to the University of Cambridge for a grant from the Beebe Fund.

[1] Ryle, A. P., Sanger, F., Smith, L. F., and Kitai, R., *Biochem. J.*, 60, 541 (1955).

[2] Brown, H., Sanger, F., and Kitai, R., *Biochem. J.*, 60, 556 (1955).

[3] Harris, J. I., Sanger, F., and Naughton, M. A., *Arch. Biochem. and Biophys.*, 65, 427 (1956).

[4] Ishihara, Y., Saito, T., Ito, Y., and Fujino, M., *Nature*, 181, 1468 (1958).

[5] Hirs, C. H. W., *J. Biol. Chem.*, 219, 611 (1956).

[6] Harris, J. I., and Li, C. H., *J. Amer. Chem. Soc.*, 74, 2945 (1952).

[7] Nicol, D. S. H. W., *Biochem. J.*, 75, 395 (1960).

[8] Berson, S. A., and Yalow, R. S., *J. Clin. Invest.*, 38, 2017 (1959).

MECHANISM OF FORMALDEHYDE-INDUCED MUTAGENESIS. THE UNIQUENESS OF ADENYLIC ACID IN THE MEDIATION OF THE MUTAGENIC ACTIVITY OF FORMALDEHYDE

By Dr. THOMAS ALDERSON*

Institute of Animal Genetics, University of Edinburgh

IN a previous communication[1], I have reported that in experiments using a chemically defined and axenic treatment medium, formaldehyde exhibits no mutagenic activity towards *Drosophila melanogaster* by the larval feeding method, unless ribonucleic acid is present in the treatment medium. Further analysis of this phenomenon now indicates that adenylic acid is the active component of ribonucleic acid uniquely concerned; none of the remaining nucleotides (guanylate, uridylate, cytidylate) appears to be effective. Adenylate is apparently necessary in the treatment medium for the mediation of the mutagenic activity of formaldehyde.

The indication that adenylate was the most likely nucleotide to be involved came from consideration of the patterns of utilization of the ribonucleic acid nucleotides as growth requirements in *Drosophila melanogaster* larvae[2]. Essentially, purines and pyrimidines supplied singly cannot substitute completely for the ribonucleic acid polynucleotide, though adenylic acid, adenosine, guanylic acid, guanosine, and adenine all respectively increase growth in the order of effectiveness stated. Ribonucleic acid pyrimidine nucleosides and nucleotides supplied singly are not utilized; however, if either the pyrimidine nucleosides or nucleotides are administered simultaneously with adenylic acid, the growth-rate then obtained is indistinguishable from that with the equivalent amount of ribonucleic acid. When all the nucleotides except adenylate are supplied, growth is found to be even slower than in the absence of ribonucleic acid; however, when any of guanylate, uridylate, and cytidylate is supplied singly, but in conjunction with adenylate, the rate of growth is increased in each case. Thus, the requirement for ribonucleic acid is seen to be primarily a requirement for adenylate; and it might consequently be supposed that adenylate would be the most likely nucleotide concerned in the mediation of the mutagenic activity of formaldehyde. The following experiments were thus planned with these considerations in mind.

The design of experiments[1], the methods of treatment of larvae[3], and the brood-pattern determination of sex-linked recessive lethal mutation-rates[4] are as previously described. The treatment medium, as previously[1], is referred to as the synthetic medium (*sm*), when ribonucleic acid is omitted; addition of nucleotides is written as $sm + a + g + u + c$, to denote the nucleotides present. The concentration of each nucleotide is taken from the equivalent amount present in 0·4 per cent ribonucleic acid, assuming the four nucleotides are found in equimolar amounts in the ribonucleic acid polynucleotide. Thus, unless otherwise stated, each nucleotide is supplied at a concentration of 0·1 per cent, which approximates closely to the optimal concentration for the purine nucleotides on the synthetic medium[2]. Ordinary medium is the yeast–maize meal–treacle medium normally used for culturing *Drosophila* in this laboratory.

Tables 1 and 2 illustrate the results obtained when larvae are fed on *sm* + ribonucleic acid (0·4 per cent) for 15 and 18 hr. respectively, before transfer to the treatment medium for 24 hr.; after which they are allowed to complete development on ordinary food.

---

* Present address: Department of Genetics, University of Cambridge.

Table 1. EFFECT OF PURINE AND PYRIMIDINE NUCLEOTIDES ON THE MUTAGENIC ACTIVITY OF FORMALDEHYDE, WHEN 15-HR. LARVAE ARE TREATED FOR 24 HR.

Treatment medium	*sm*+*g*+*u*+*c*	*sm*+*a*+*g*+*u*+*c*	*sm*+*a*+*g*+*u*+*c* delayed	*sm*+*A*+*g*+*u*+*c*
Molarity of formaldehyde	2·0 × 10^{-2} *M*			
Total larval developmental time in days	5·5	5·0	5·5	5·0
Per cent survivors	76·6	71·0	70·0	71·6
First broods				
No. chrom.*	574	696	458	560
No. leth.	4	16	12	0
Per cent leth.	0·70	2·30	2·62	0·00
Second broods				
No. chrom.	414	363	381	371
No. leth.	0	1	2	0
Per cent leth.	0·00	0·27	0·52	0·00

* No. chrom., total number of chromosomes examined; No. leth., number of lethal chromosomes; per cent leth., percentage of sex-linked recessive lethal mutations.

Table 2. EFFECT OF PURINE AND PYRIMIDINE NUCLEOTIDES ON THE MUTAGENIC ACTIVITY OF FORMALDEHYDE, WHEN 18-HR. LARVAE ARE TREATED FOR 24 HR.

Treatment medium	*sm*+*g*+*u*+*c*	*sm*+*a*+*g*+*u*+*c*	*sm*+*a*+*g*+*u*+*c* delayed	*sm*+*A*+*g*+*u*+*c*
Molarity of formaldehyde	2·0 × 10^{-2} *M*			
Total larval developmental time in days	5·5	5·0	5·5	5·0
Per cent survivors	75	80·6	53·2	70
First broods				
No. chrom.	567	565	730	577
No. leth.	2	16	10	5
Per cent leth.	0·35	2·83	1·37	0·86
Second broods				
No. chrom.	450	533	525	561
No. leth.	0	0	6	1
Per cent leth.	0·00	0·00	1·14	0·18

Since development is quicker when adenylate is present in the treatment medium, a treatment was carried out where development was slowed down on the adenylate-containing synthetic medium (*sm*+*a*+*g*+*u*+*c* delayed), to obtain a developmental time comparable with the treatment where adenylate is absent. This modification of the treatment medium has been used previously[1], and is achieved by halving the cholesterol concentration, and substituting 0·004 per cent choline for the lecithin. A treatment where 0·05 per cent adenine (*A*), which is approximately equimolar with 0·1 per cent adenylate, replaces adenylate is also listed; this treatment has the advantage that it gives a comparable developmental time with the *sm* + *a* + *g* + *u* + *c*, and the disadvantage that adenine is known to be anti-mutagenic for formaldehyde-induced mutagenesis on a yeast–glucose medium[3,4].

In both series (Tables 1 and 2), significant formaldehyde-induced mutagenic activity is found where adenylate is present in the treatment medium, whereas little or no activity is detectable in its absence. The first brood difference between *sm* + *a* + *g* + *u* + *c* and *sm* + *a* + *g* + *u* + *c* delayed is not significant in either series (χ^2 = 0·12 and 3·46, with 1 d.f., respectively), but whereas the second brood difference in Table 1 is not significant (χ^2 = 0·29, with 1 d.f.), the second brood difference in Table 2 is significant (χ^2 = 6·13, with 1 d.f.). However, if the two broods of Table 2 are summated, giving mutation-rates over the two broods of 1·45 per cent for *sm* + *a* + *g* + *u* + *c* and 1·27 per cent for *sm* + *a* + *g* + *u* + *c* delayed, the mutational response is approximately equal (χ^2 = 0·145, with 1 d.f.). This slight shift in brood patterns, where a decrease in the first brood response is followed by a corresponding increase in the second brood response, is usually characteristic of the presence of a slightly more advanced germ-tract during the period of treatment. This tendency is not expected after 'delayed' treatment, though it sometimes occurs (Table 2). A slight trend in this direction is also found in some 'delayed' treatments on a medium containing ribonucleic acid. Adenine, although giving a comparable developmental time with the *sm* + *a* + *g* + *u* + *c*, shows little or no effect, in keeping with its property as an anti-mutagen for formaldehyde-induced mutagenesis.

A further experiment, which was carried out together with one of the ribonucleic acid series[1], is illustrated in Table 3. Here, the mutagenic activity of formaldehyde was studied by treating 24-hr. larvae for 24 hr. on *sm*, *sm*+ribonucleic acid, and *sm*+*a*+*c*; in the latter treatment, cytidylate was added at a concentration of 0·025 per cent, since the *Drosophila* Oregon-*K* stock used has a partial requirement for cytidylate[5]. As seen, adenylate is as effective as ribonucleic acid in the level of formaldehyde-induced mutations produced.

It does not appear to matter whether adenylate is present as the free mononucleotide or bound in the ribonucleic acid polynucleotide. But the mutagenic activity of formaldehyde seems dependent on the presence of adenylate within the treatment medium, since feeding with ribonucleic acid before or after treatment has no effect. Adenylate, therefore, apparently functions within the treatment medium as the necessary mediating agent in formaldehyde-induced mutagenesis.

Reactivity of Ribonucleic Acid (and its Constituent Nucleotides) with Formaldehyde

It has been revealed by spectrophotometric methods[6] that formaldehyde actively combines with the amino-groups of the purines and pyrimidines of ribonucleic acid; the binding of formaldehyde by ribonucleic acid polynucleotides appears to be a specific function of the amino-groups of their bases[6,7]. This has been further demonstrated by the reactivity

Table 3. EFFECT OF RIBONUCLEIC ACID AND ADENYLIC ACID ON THE MUTAGENIC ACTIVITY OF FORMALDEHYDE, WHEN 24-HR. LARVAE ARE TREATED FOR 24 HR.

Treatment medium	*sm*	*sm*+*RNA* (0·4 per cent)	*sm*+*a*+*c*
Molarity of formaldehyde		2·0 × 10^{-2} *M*	
Total larval developmental time in days	5·5	5·0	5·0
Per cent survivors	61·8	62·6	63·6
First broods			
No. chrom.	579	602	608
No. leth.	2	21	28
Per cent leth.	0·34	3·50	4·61
Second broods			
No. chrom.	412	370	421
No. leth.	1	2	4
Per cent leth.	0·24	0·54	0·95

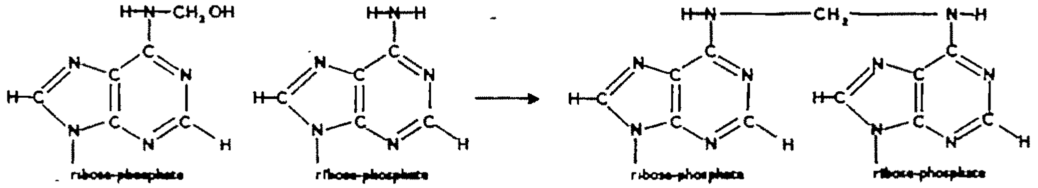


Fig. 1. Methylene bridge formation between the amino-groups of two adenylic acid molecules

of formaldehyde with various synthetic polynucleotides[7]; only polyadenylic and polycytidylic acid react readily with formaldehyde, whereas the uridylic and inosinic acid polymers do not. (The latter two polymers do not carry amino-groups.) Further, the reactivity of formaldehyde with the amino-groups of the individual ribonucleic acid mononucleotides appears to be in the preferential order of adenylate, cytidylate and guanylate[8].

Formaldehyde reacts rapidly with free amino-groups, and more slowly with hydrogen-bonded amino-groups; this difference of reaction is therefore useful for the study of hydrogen-bonding through the amino-groups of the ribonucleic acid bases. Thus, the reactivity of formaldehyde and ribonucleic acid at the two temperature-levels of 25° C. and 45° C. shows a difference in rate of 19 times; a similar experiment using an appropriate mixture of mononucleotides shows a difference in rate of only 6 times[8]. Increase of temperature, therefore, besides increasing the reactivity of formaldehyde with the free amino-groups of purines and pyrimidines, also increases the extent of its reactivity with ribonucleic acid, by freeing the hydrogen-bonds involving the amino-groups of the purine and pyrimidine bases.

The concentration of formaldehyde also undoubtedly influences the type of reaction involved[8]. It seems likely that at low (0·1 per cent) formaldehyde concentrations, formaldehyde reacts by forming the monomethylol derivative ($-NH-CH_2OH$); and at higher (1·0 per cent) concentrations, the dimethylol derivative ($-N=(CH_2OH)_2$). Reaction-products of formaldehyde with the amino-groups of adenylate can also be in the form of Schiff's base[8] ($-N=CH_2$); it is probable, however, that this grouping always involves the primary production of the monomethylol derivative.

Under the conditions of my experiments, formaldehyde is added to the treatment medium containing ribonucleic acid or adenylate at a temperature of 60° C.; considerable reaction of formaldehyde with the amino-groups of ribonucleic acid and adenylate must therefore take place. Also, since a low (0·064 per cent) formaldehyde concentration is used, a predominance of monomethylol groupings is to be expected, especially as there is a high ribonucleic acid or adenylate concentration present.

The main point of interest, however, is the possible formation of a proportion of dimeric forms, resulting in the linking together of two adenylate molecules through their amino-groups ($-NH-CH_2-NH-$) by a methylene-bridge, as seen in Fig. 1. This derivative is probably formed by condensation of the monomethylol grouping on the amino-group of one adenylic acid molecule with the free amino-group of another adenylic acid molecule. It has been concluded in a study of the loss of formaldehyde from ribonucleic acid after treatment with formaldehyde[7] that two forms of formaldehyde-binding occur: a labile form (probably the methylol derivative, which is relatively quickly lost); and a more stable form, with a slowly reversible binding. A larger proportion of the formaldehyde appears to be in the labile form at early stages of the reaction, whereas at later stages more stable linkages are predominant. It is suggested[7] that the stable linkages are of the dimeric form ($-NH-CH_2-NH-$). The ease of formation of methylene-bridges by formaldehyde after reaction with proteins has already been established[10]. This type of reaction-product (Fig. 1), which is believed to be the effective metabolite under consideration, can also be formed by polymerization from the methylene derivative (Schiff's base); in this case, a polymerization structure of indefinite length could be formed by virtue of this grouping. Additional cyclic products of the type portrayed in Fig. 2 are also possible.

For purposes of discussion, the postulated metabolite will be taken as its simplest structure, namely, two adenylic acid molecules linked together by a single methylene-bridge; this will be referred to as $\overline{AA}$. It is the thesis of this discussion that the utilization of the postulated metabolite in deoxyribonucleic acid synthesis constitutes the mechanism for its mutagenic activity.

Observations on the sensitivity pattern of response of larval germ-cells to the mutagenic activity of formaldehyde[11] suggest that the sensitive period of its activity coincides with the auxocyte stage in primary spermatocyte development, namely, the protracted growth stage which precedes meiosis in the larval testis. It is also likely that this interphase period of the auxocyte stage is the time at which deoxyribonucleic acid is being synthesized.

It will be instructive at this point to consider briefly normal synthesis of deoxyribonucleic acid and the mechanism of spontaneous mutation.

Nucleic Acid Synthesis and the Mechanism of Spontaneous Mutation

In the process of deoxyribonucleic acid replication, it is assumed that each newly synthesized deoxyribonucleic acid chain is formed along a pre-existing complementary chain, as in the model for deoxyribonucleic acid proposed by Watson and Crick[12]. In this model, specificity of replication is achieved by imposing certain restrictions on the possible pairing arrangement of the four nucleotide bases: thus, adenine can only pair with thymine; and guanine only with cytosine. Either member of a given pair can occur on either chain, but its associated partner

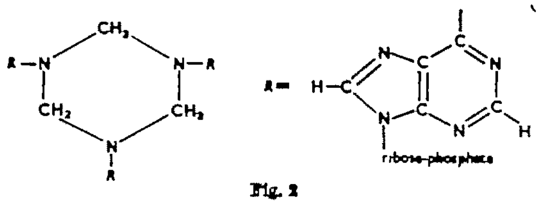
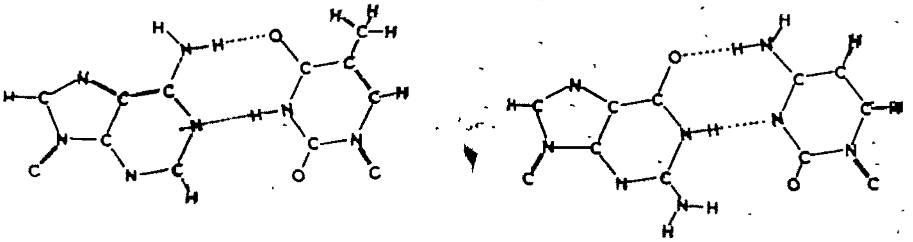
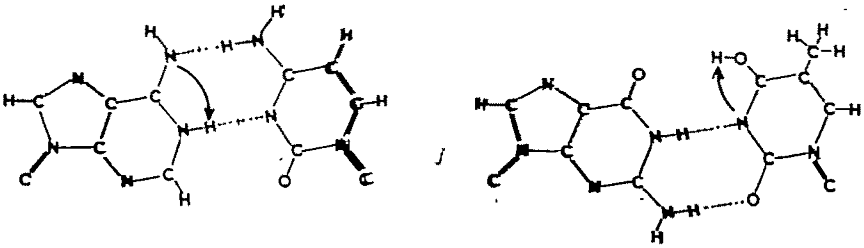


Fig. 2



Adenine (normal amino-form) Thymine (normal keto-form) Guanine (normal keto-form) Cytosine (normal amino-form)

Fig. 3. Pairing of the deoxyribonucleic acid bases when present in their normal tautomeric forms. Hydrogen bonds are shown dotted. The glucosidic bond is thickly marked, and one carbon atom of the sugar is shown



Adenine (rare imino-form) Cytosine (normal amino-form) Guanine (normal keto-form) Thymine (rare enol-form)

Fig. 4. Pairing of the deoxyribonucleic acid bases when a rare tautomeride of one of the bases occurs

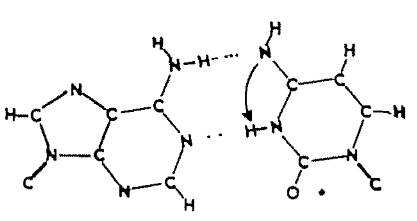
on the other chain must be the other member of the pair. This restriction is made, since although the bases can exist in a number of tautomeric forms, under physiological conditions one particular tautomeride of each base is assumed to predominate (Fig. 3).

Since the bases are tautomeric, however, it is possible for certain hydrogen atoms to change their positions occasionally, so that a base can exist in a rare tautomeric form. For example, adenine, in its normal amino-form, pairs with thymine; but if there is a tautomeric shift of one of its hydrogen atoms to give the imino-form, it can pair with cytosine (Fig. 4). The next time pairing occurs, the adenine (having resumed its more normal tautomeric form) will pair with thymine, and the cytosine will pair with guanine, thus resulting in a change in the sequence of bases. (A tautomeric shift in thymine whereby it can pair by mistake with guanine, and lead to a similar change in base sequence, is illustrated in Fig. 4.) This change in the sequence of bases by mistaken pairing, due to the presence of a rare tautomeride of one of the bases at the time of deoxyribonucleic acid replication, is believed to be the mechanism of spontaneous mutation[12].

It is now possible to consider the utilization of the postulated metabolite ($\overline{AA}$) in deoxyribonucleic acid synthesis, and the mechanism of its mutagenic activity. This metabolite possesses the correct hydrogen-bonding properties for base-pairing in the Watson and Crick model for deoxyribonucleic acid[12]; and it is interesting to note that the length of the methylene-bridge (3·7 Å.) approximates closely with the distance of 3·4 Å. between adjacent nucleotides of the same deoxyribonucleic acid chain.

Utilization of the Postulated Metabolite in Deoxyribonucleic Acid Synthesis; a Mechanism for its Mutagenic Activity

The presence of thymine (T) and cytosine (C) as adjacent nucleotides on the pre-existing deoxyribonucleic acid chain is the most obvious sequence by which the metabolite ($\overline{AA}$) could be incorporated into replicating deoxyribonucleic acid, resulting in a change in the base sequence. A prerequisite for forced pairing is that the first adenylate incorporated pairs normally, that is, with thymine; and the other adenylate, which is linked to it, thus forms a pairing mistake with cytosine. This pairing mistake could be accommodated either by tautomeric shift of one of the hydrogen atoms of the adenylate molecule (Fig. 4), or by tautomeric shift in the cytosine with which it is attempting to pair (Fig. 5). In subsequent replications, the incorporated metabolite ($\overline{AA}$) attaches to itself its normal complementary bases (TT), thus changing the original sequence, as illustrated by example in Fig. 6, from $GCATCAG$ to $GCATTAG$. Once the change in base sequence has been initiated on incorporation of $\overline{AA}$ into replicating deoxyribonucleic acid, the methylene-bridge linkage is no longer necessary, since the mistake is fixed. It should be noted that besides needing an appropriate sequence for activity, the $\overline{AA}$ metabolite could miss an opportunity to produce a change in sequence



Adenine (normal amino-form) Cytosine (rare imino-form)

Fig. 5. Pairing between adenine and cytosine when cytosine is in its rare tautomeric form

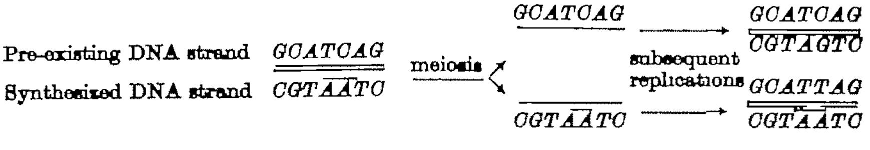


Fig. 6. Mechanism by which the postulated metabolite ($\overline{AA}$) can produce a change in the base sequence of deoxyribonucleic acid

by being initially incorporated at a *TT* sequence. Related mechanisms by which mutagenic purine and pyrimidine analogues can produce a change in the sequence of bases by their incorporation into bacteriophage deoxyribonucleic acid have been suggested by Freese[13].

During the preceding discussion, the instance where two adenylate molecules only are linked together has been considered; but larger metabolites are possible. When adenylate molecules are free in the medium, a metabolite of indefinite length could theoretically be formed. However, in the case of larger metabolites being formed by reaction of formaldehyde with ribonucleic acid, a restriction of their size would be expected, since the span of the methylene-bridge only allows linkage of adjacent adenylate molecules, which is limited by the sequence of bases along the ribonucleic acid chain. Such metabolites as are formed within ribonucleic acid would afterwards be liberated by hydrolysis of the ribonucleic acid sugar–phosphate bonds during breakdown of the ribonucleic acid into its constituent nucleotides in the gut of the larvæ; methylene-bridge linkages in proteins have been shown to be resistant to acid hydrolysis[10].

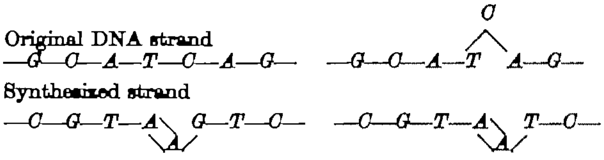
Larger metabolites are less easily incorporated into a necessary base sequence of deoxyribonucleic acid for effective utilization; for example, $\overline{AAA}$ would probably need a base sequence of *TTC*, *TCT*, or perhaps *TCC*, to initiate a change in base sequence.

In the present system, adenylate is the only ribonucleic acid base nucleotide utilized to any extent. Furthermore, as previously noted, the reactivity of formaldehyde with the amino-groups of the individual ribonucleic acid mononucleotides appears to be in the preferential order of adenylate, cytidylate and guanylate. Therefore, although other effective combinations of linked bases are theoretically possible, for example, $\overline{AC}$, $\overline{CC}$, $\overline{GG}$, and others, the $\overline{AA}$ metabolite (and perhaps an $\overline{AC}$ metabolite), would be expected to be the only significant metabolite in this system. Further, the possible utilization of a $\overline{UU}$ metabolite cannot be completely excluded in these experiments (Table 1), since the *Drosophila* stock used has a partial requirement for cytidylate[4]. Thus, the formation of appropriately linked nucleotide molecules of the type described may represent, *a priori*, a way by which specific mutagens and potential cancer chemotherapeutic agents can be constructed.

A recent investigation[14] has examined the possibilities whereby non-complementary bases can be accommodated within the two-stranded helical framework of polyribonucleotides and deoxyribonucleic acids. The authors studied the effects of varying proportions of non-complementary bases incorporated into pairs of complementary polyribonucleotides which are known to form two-stranded helices like deoxyribonucleic acid. Mixing curves were used to study the quantitative aspects of the interaction of polyadenylate (poly *A*) or polyuridylate (poly *U*) with a series of single-stranded poly *AU* copolymers. On the results of these experiments, it is concluded that non-complementary nucleotide residues in the copolymer do not remain within the helix, but loop out of the helix to allow hydrogen-bonded base pairing of subsequent regions of nucleotides which are in register. This observation is compatible with model building on the Pauling–Corey space-filling nucleotide model, where non-complementary nucleotide residues can be rotated out of the helix to allow a continuity of base pairs along its entire length. This model leaves the non-complementary base pointing radially out of the helix axis, and allows an adjacent nucleotide residue to move into the vacancy created, without stress. In addition, similar loops containing two, three or more nucleotides are also possible. In all cases, the regularity of the helix in the vicinity of the loop is unaffected, both the 3·4 Å. separation and 36° translation of successive nucleotides being maintained.

In view of the similarity of essential structure between the poly $(A + U)$ helix and deoxyribonucleic acid, it seems likely that any base pair mismatchings arising during deoxyribonucleic acid synthesis could also be accommodated by loop formation[14].

The authors discuss hypothetical models for the origin of point mutation, and, translating their models to fit the present discussion of the mutagenic mode of action of the postulated $\overline{AA}$ metabolite, the following mechanisms are suggested:



The original DNA strand remains identical in each case.

Adenine, as seen in Tables 1 and 2, has little or no capacity for mediating formaldehyde-induced mutagenesis. Formaldehyde should be able to link together two adenine molecules, in the same way as postulated for adenylate, but its free amino-group at the 9-position of the purine ring may be blocked by additional reaction with formaldehyde, thus preventing the ribose sugar attachment. This condition would be expected to debar the utilization of adenine in nucleic acid synthesis; and this is supported by the fact that I have now shown (unpublished results) that adenosine is as effective as adenylate in the mediation of formaldehyde-induced mutagenesis.

In should be noted in conclusion that the results and interpretation detailed here are entirely compatible with observations made with these test-substances on a formaldehyde-containing yeast-glucose treatment medium (unpublished work).

My acknowledgments are due to the Medical Research Council for financial support of this work, and to Prof. C. H. Waddington for supplying the laboratory facilities.

[1] Alderson, T., *Nature*, 185, 904 (1960).
[2] Sang, J. H., *Proc. Roy. Soc. Edin.*, B, 66, 339 (1957).
[3] Alderson, T., *Nature*, 179, 974 (1957).
[4] Alderson, T., *Nature*, 182, 508 (1958).
[5] Ellis, J. F., *Physiol. Zool.*, 32, 29 (1959).
[6] Fraenkel-Conrat, H., *Biochim. Biophys. Acta*, 15, 307 (1954).
[7] Staehelin, M., *Biochim. Biophys. Acta*, 29, 410 (1958).
[8] Doty, P., Boedtker, H., Fresco, J. R., Haselkorn, R., and Litt, M., *Proc. U.S. Nat. Acad. Sci.*, 45, 482 (1959).
[9] Staehelin, M., *Experientia*, 15, 413 (1959).
[10] Fraenkel-Conrat, H., and Olcott, H. S., *J. Biol. Chem.*, 174, 827 (1948).
[11] Auerbach, C., and Moser, H., *Z. Vererbungslehre*, 85, 479 (1953).
[12] Watson, J. D., and Crick, F. H. C., *Cold Spring Harbor Symp. Quant. Biol.*, 18, 123 (1953).
[13] Freese, E., *J. Molec. Biol.*, 1, 87 (1959).
[14] Fresco, J. R., and Alberts, B. M., *Proc. U.S. Nat. Acad. Sci.*, 45, 311 (1960).

LETTERS TO THE EDITORS

ASTRONOMY

Roughness of the Moon as a Radar Reflector

In a recent communication[1] Hughes has suggested that the law of scattering of radio waves by the lunar surface is consistent with scattering by a rough surface which has irregularities much greater than the radio wave-length, and such that the root mean square value of the slope is about 1 in 20, or 3°. The law of scattering as a function of angle of incidence which, on this model, would be the same as the distribution of the slope of the irregular surface, was found from radar observations to be given by:

$$\sigma = \sigma_0 \exp\{-10\theta\}$$

where σ is the effective scattering area and θ the angle of incidence.

It is of interest to compare this with the distribution of the slope of the lunar surface as determined optically. Fujinami, Ina and Kawai[2] have made photometric measurements of the profile of the Moon's silhouette, as observed during a partial eclipse. Measurements of the elevation of the lunar surface in seconds of arc were made for every degree around the limb. It is a simple matter to obtain a value for the slope of the lunar surface from each successive pair of readings. The distribution of these values, without regard to sign, is shown as a histogram in Fig. 1. The exponential law $\exp(-10\theta)$ is shown as a dotted line for comparison. It will be seen that there is close agreement except for angles less than 1°. (The law proposed by Hughes was stated to apply over the range 3–14°.) The root mean square value of the slope, as determined from the optical measurements, is 3·3°.

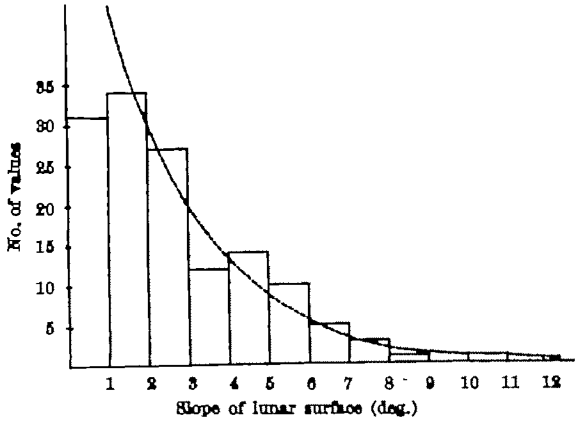


Fig. 1. The distribution of the values of the slope of the lunar surface as determined from the optical measurements of Fujinami, Ina and Kawai. The dotted line is the exponential function $\exp(-10\theta)$

This agreement is interesting; but it is, perhaps, surprising, because the optical measurements refer only to structure with a horizontal scale larger than about 30 km. The lunar surface could contain structure of a smaller scale, which would not be resolved optically, but which was larger than the radio wave-length. If the root mean square value of the slope of this smaller-scale structure were comparable with or larger than 3°, the overall distribution of the slope would extend to angles too large to fit the radio observations. The fact that agreement is obtained when only structure larger than 30 km. is considered suggests that the smaller structure, if it exists, has a root mean square value of slope considerably less than 3°.

B. H. BRIGGS

Cavendish Laboratory,
Cambridge.

---

[1] Hughes, V. A., *Nature*, 186, 873 (1960).

[2] Fujinami, S., Ina, T., and Kawai, S., *Pub. Astro. Soc. Japan*, 6, 67 (1954).

GEOPHYSICS

Evaluation of the Second, Fourth and Sixth Harmonics in the Earth's Gravitational Potential

In an article[1] in *Nature* in 1958, it was explained how the rate of rotation of the orbital plane of an Earth satellite (the rate of regression of the nodes) could be used to evaluate the even harmonics in the Earth's gravitational potential U. At an exterior point distant r from the Earth's centre and having co-latitude θ, U may be expressed in terms of Legendre polynomials P_n as:

$$U = \frac{GM}{r}\left\{1 - \sum_{n=2}^{\infty} J_n \left(\frac{R}{r}\right)^n P_n(\cos\theta)\right\} \quad (1)$$

where G is the gravitational constant, M the mass of the Earth, R its equatorial radius, and the J_n are constants to be determined. J_1 is zero if the equator is chosen to pass through the Earth's centre of mass. The motion of a satellite in the gravitational field specified by equation (1) has been investigated theoretically[2-4], and the rate of rotation of the orbital plane, $\dot{\Omega}$, may in principle be expressed in the form:

$$\dot{\Omega} = \sum_{n=2}^{\infty} J_n F_n + \sum_{m=2}^{\infty} \sum_{n=2}^{\infty} J_m J_n F_{mn} + \ldots \quad (2)$$

where the F_n and F_{mn} are functions of the orbital elements. Since J_2 is of order 10^{-3}, the J_n are of order 10^{-6} when $n > 2$, and the F_n are of the same order as the F_{mn}, only the J_2^2 term in the second series in equation (2) need be considered, and even in that term an approximate value of J_2 is adequate. Thus each observed value of $\dot{\Omega}$ provides one linear relation between the J_n, and observed values from k satellites provide k simultaneous equations between the J_n. These equations are not ill-conditioned if the k orbits differ widely enough. It happens that the odd-numbered J_n have little effect on $\dot{\Omega}$, and the available values[5] for J_3 and J_5, namely:

$$\left.\begin{aligned} J_3 &= (-2{\cdot}4 \pm 0{\cdot}3) \times 10^{-6} \\ J_5 &= (-0{\cdot}1 \pm 0{\cdot}1) \times 10^{-6} \end{aligned}\right\} \quad (3)$$

can be substituted into equation (2) without introducing significant error. Thus k satellites with widely different orbits—and, in particular, with widely differing orbital inclinations—will yield values of $J_2, J_4, \ldots J_{2k}$ if we are prepared to assume that the contributions of $J_3, J_5 \ldots$ and of $J_{2k+2}, J_{2k+4}, \ldots$ are negligible.

This process has been applied to the orbits of the satellites *Sputnik* 2 (1957β, inclination $i = 65°$), *Vanguard* 1 (1958β2, $i = 34°$) and *Explorer* 7 (1959ι1, $i = 51°$), and the following values of J_2, J_4 and J_6 have been obtained:

$$\left.\begin{aligned} J_2 &= (1082 \cdot 79 \pm 0 \cdot 15) \times 10^{-6} \\ J_4 &= (-1 \cdot 4 \pm 0 \cdot 2) \times 10^{-6} \\ J_6 &= (0 \cdot 9 \pm 0 \cdot 8) \times 10^{-6} \end{aligned}\right\} \qquad (4)$$

The errors quoted are standard deviations due to observational error. In deriving these values, the effect of atmospheric rotation on $\dot{\Omega}$ and the effects of the Sun and Moon were taken into account. It is possible that errors larger than those quoted in equation (4) might be caused by the neglect of J_8, J_{10}, etc.; but it is significant that the above set of values is consistent with that derived[6] using the *Explorer* 4 satellite (1958ε) instead of *Explorer* 7, and with the values of J_2 and J_4 obtained by O'Keefe *et al.*[5] using different observational information and ignoring J_6. Thus there is reason for hoping that the errors due to the neglected higher J_n will not much exceed the errors quoted in equation (4).

If the Earth's flattening f is defined as the difference between the equatorial and polar diameters, divided by the equatorial diameter, and the meridional section is taken as elliptic, as has been customary in the past, the new value of J_2 gives $1/f = 298 \cdot 24 \pm 0 \cdot 02$, as compared with the value of 297·1 which was most generally accepted[7] before the advent of satellites.

A fuller account of this work is being published elsewhere.

D. G. KING-HELE

Royal Aircraft Establishment,
Farnborough, Hants.
June 24.

[1] Merson, R. H., and King-Hele, D. G., *Nature*, 182, 640 (1958).
[2] King-Hele, D. G., *Proc. Roy. Soc.*, A, 247, 49 (1958).
[3] Groves, G. V., *Proc. Roy. Soc.*, A, 254, 48 (1960).
[4] Merson, R. H., Ministry of Aviation Report (to be published).
[5] O'Keefe, J. A., Eckels, A., and Squires, R. K., *Astro. J.*, 64, 245 (1959).
[6] King-Hele, D. G., paper presented at tenth Int. Astronautical Cong., London (1959).
[7] Jeffreys, H., "The Earth", third ed. (Camb. Univ. Press, 1952).

Oscillatory Character of Amplitude Curves for Seismic Body Waves

THE importance of studying the amplitudes of seismic body waves in relation to the structure of the Earth's mantle has been emphasized by several authors[1,2]. In previous investigations[3-6], however, only general features of amplitude curves in limited distance intervals were given. Combining observations of four Middle European seismic stations—Prague, Jena, Collmberg and Potsdam—we obtained a sufficient set of homogeneous data to derive the fine structure of amplitude curves for P-, PP- and S-waves.

Maximum ground amplitudes A in μ and periods T in sec. for individual waves could be estimated by special analysis of 275 well-recorded earthquakes. Using corresponding station corrections[7], the local effects on amplitudes of body waves were eliminated. The eventual effects of the earthquake mechanism were considerably minimized by the proximity of the stations. The number of observations was as follows: 501 for PH, 166 for PV, 520 for SH, all in the range of 10°–100°, and 258 for PPH in the range of 15°–160°. Epicentral distances Δ were computed from *ISS* parameters, and from 1950 from *BCIS* or *USCGS* parameters, respectively.

Introducing:

$$A^*_i = \log A_i/T_i - M_i \qquad (1)$$

for $i = PH, PV, PPH, SH$, where the magnitudes:

$$M_i = \frac{1}{n} \sum_{j=1}^{n} M_i^j \qquad (2)$$

for j = Prague, Jena, Collmberg, Potsdam were determined on the basis of the second approximation of the magnitude calibrating functions for body waves[7], we can take the graphical representation of the dependence (A^*_i, Δ) as the amplitude curve for the corresponding wave. The whole set of observations for an individual wave was divided into natural intervals, which were represented by their centres of gravity (large crosses in Fig. 1). Through these representative points the amplitude curve was then drafted allowing for the tendency of detailed distribution of the observations. Thus the fine structure of amplitude curves could be investigated with a considerable degree of certainty.

Two partial sections of amplitude curves with the points of observation and corresponding representative points for horizontal components of P- and PP-waves in the distance range near the '20° discontinuity' are shown in Fig. 1. The oscillatory character of the amplitude curves can be clearly seen. This

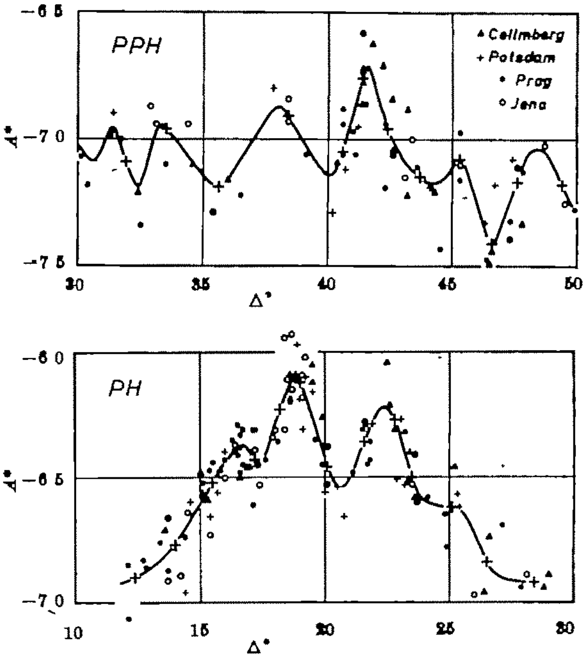


Fig. 1. Sections of amplitude curves for horizontal component of P- and PP-waves. A^*, Reduced amplitude according to equation (1); Δ, epicentral distance in degrees; large +, representative points of natural intervals

phenomenon was also found for other waves being investigated in several distance ranges.

A similar oscillatory tendency of the amplitude curve for P-waves can be observed by detailed investigation of the seismic data of underground nuclear explosions published recently[8]; the number of observations in this case, however, is insufficient for detailed conclusions. In comparison with amplitude curves reported in this communication these observations seem to show regional influences due to the probably regional structure of the upper mantle[8,9]. The oscillations observed in this distance range are evidently connected with the surface field of waves diffracted at the asthenosphere low-velocity layer[10].

A more detailed account of this work will be published in the Gerlands Beiträge zur Geophysik.

J. Vaněk*

Geophysical Institute,
Czechoslovak Academy of Sciences,
Prague.

J. Stelzner

Institut f. Bodendynamik u. Erdbebenforschung,
Deutsche Akademie der Wissenschaften,
Jena.

* Visiting assistant professor, Geophysical Institute, Karl Marx University, Leipzig.

[1] Jeffreys, H., *Mon. Not. Roy. Astro. Soc.*, Geophys. Supp., 6, 348 (1951).
[2] Lehmann, I., *Trans. Amer. Geophys. Union*, 34, 477 (1953).
[3] Gutenberg, B., *Bull. Seism. Soc. Amer.*, 38, 121 (1948).
[4] De Bremaecker, J. Cl., *Bull. Seism. Soc. Amer.*, 45, 219 (1955).
[5] Ruprechtová, L., *Studia geophys. geodaet.*, 2, 397 (1958).
[6] Vaněk, J., *Annali di Geofisica*, 12, 239 (1959).
[7] Vaněk, J., and Stelzner, J., *Travaux Inst. Géophys. Acad. Tchécosl. Sci.*, No. 126 (1960).
[8] Romney, C., *J. Geophys. Res.*, 64, 1489 (1959).
[9] Dorman, J., Ewing, M., and Oliver, J., *Bull. Seism. Soc. Amer.*, 50, 87 (1960).
[10] Ben-Menahem, A., *Bull. Seism. Soc. Amer.*, 50, 15 (1960).

PHYSICS

Speed of the Superconducting-Normal Transition in Tin Films

We have carried out some experiments to study the rate at which resistance is restored in a superconducting tin film by the application of a magnetic field above the critical value. No direct experiment of this kind has previously been reported, although Woodford and Feucht[1], using a radiofrequency method, inferred that the transition in an evaporated film of an unspecified metal probably occurred in less than 10^{-8} sec. The question is of some importance both from a fundamental point of view and in determining the lower limit of the switching time of superconducting circuit devices such as the cryotron.

In our experiments, tin films with the characteristic 'dumb-bell' shape were evaporated on to glass slides, the central region of the films being approximately 1 cm. long, 100–400μ wide and 1000 Å. thick. The slides fitted closely into a small solenoid (1 cm. long × 0·3 cm. × 0·1 cm.) which produced a magnetic field of 29·5 oersteds/amp. The solenoid had an inductance of 0·3 μH. and was fed through a 50 Ω coaxial cable with a rectangular current pulse which had a rise time of 10 mμsec., a length of 0·3 μsec. and a maximum amplitude of 2 amp. Experiments were normally carried out about 0·1 deg. K. below the transition temperature where the critical field was ≃ 150 oersteds. The pulsed field provided by the solenoid was superposed on a steady field supplied by an electromagnet. The restoration of resistance was observed by displaying on an oscilloscope, after suitable amplification, the potential difference across the film produced by a constant current, the value of this current being limited to ∼ 1 m.amp. by the Joule heating in the film while in the normal state. The normal resistance of the films was in the region of a few ohms so that the signals had an amplitude of a few millivolts.

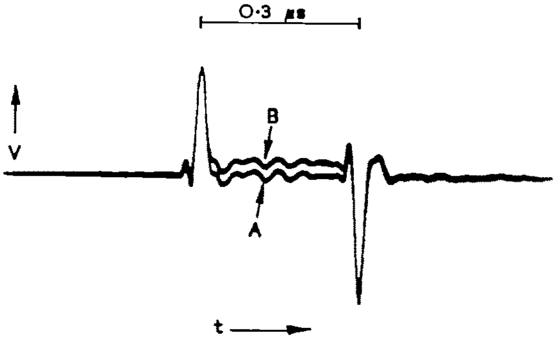


Fig. 1. Restoration of resistance in a tin film of width 250μ, thickness 1000 Å. and length 1 cm. Trace *A*, zero current through the film. Trace *B*, 1 m.amp. through the film

Fig. 1 shows two superposed oscilloscope traces representing the potential difference across a typical film with and without a direct current through it. The positive and negative spikes are due to the inductive electromotive force which arises at the beginning and end of the field pulse. No delay is observable between the instant at which the pulsed magnetic field becomes constant and the restoration of resistance, and since the two traces are parallel there is no evidence of a progressive growth of resistance; there is also no evidence of any resistance remaining after the end of the pulse. This behaviour was independent of the amount by which the pulsed field exceeded the threshold value. From Fig. 1 we deduce that the transition from the superconducting to the normal state and vice versa takes place within the overall resolution of 15 mμsec., which implies that the relaxation time for the destruction of superconductivity is less than ∼ 10^{-8} sec. It would require a much more complicated apparatus to lower this limit significantly.

Acknowledgment is made to the Admiralty for permission to publish this communication.

D. J. Oliver
M. J. Rayner
E. H. Rhoderick

Services Electronics Research Laboratory,
Baldock, Herts.
July 1.

[1] Woodford, J. B., and Feucht, D. L., *Proc. Inst. Rad. Eng.*, 46, 1871 (1958).

Strengths of Acid-etched Glass Rods

The low breaking strength of normal glasses is usually regarded as being due to surface imperfections, and previous workers, particularly Greene[1], have directed attention to the increase in strength which occurs when the glass surface is etched with hydrofluoric acid. By measuring the rate at which a

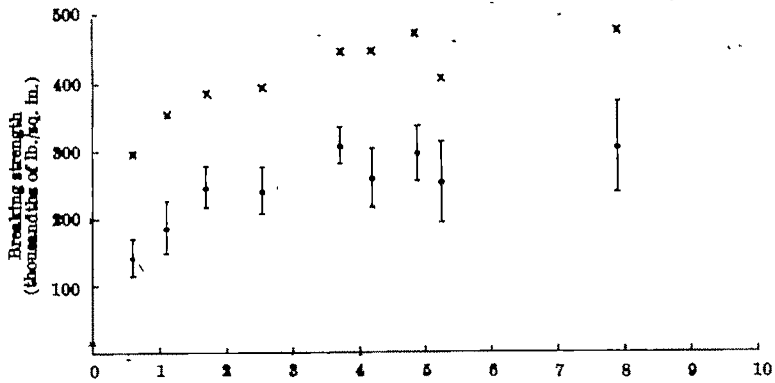


Fig. 1. Breaking strength as a function of depth of material removed from the surface. ×, Highest strength value in one group of rods; ●, mean strength and 95 per cent confidence limits for one group of rods

particular etching solution removes material from a glass surface it is possible to study the strength of etched specimens as a function of the depth of material removed from the surface. Such a study may give some information about the size and nature of the surface imperfections.

Commercially available soda-glass rods, of 6–8 mm. diameter, have been etched and broken in four point bending over a constant bending moment span of 1 in. The rod diameters and loads at fracture were measured and the breaking stresses calculated using the simple bending formula. Groups of rods (containing 16–32 rods) were given different periods of etching, and the depth of material removed from the surface of the rods was calculated for each group.

The variation of the mean breaking strength of these groups of rods, with depth of material removed from the surface, is shown in Fig. 1. Also shown on Fig. 1 are the 95 per cent confidence limits on the mean strength and the highest strength value recorded in each group of rods. Fig. 2 is a histogram comparing the distribution of breaking stresses for a group of rods which have been etched for 40 min. with that for unetched rods. The maximum strengths obtained with these bulk glass specimens are in the region 450,000–500,000 lb./sq. in. and closely approach the value obtained by Thomas[2] for fine glass fibres.

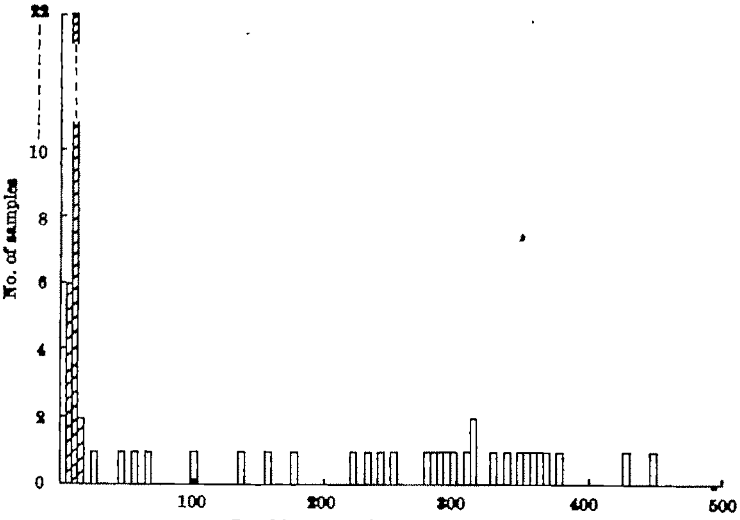


Fig. 2. Frequency of results as a function of breaking strength for etched (unshaded) and unetched (shaded) rods. The former were etched for 40 min.; depth removed from surface = 4.2 × 10^{-4} cm.

The glass rod used in these experiments had the following approximate composition by weight (percentages): SiO_2, 69; Na_2O, 16; CaO, 4; Al_2O_3, 3; MgO, 3.

The etching solution contained about 15 per cent hydrofluoric acid, 15 per cent sulphuric acid by weight and the remainder water.

Experiments are being continued to determine the effect on these results of varying the concentration, temperature and nature of the etchant; and of changing the thermal history, size and composition of the glass.

B. A. PROCTOR

Rolls-Royce, Ltd.,
Aerophysics Laboratory,
Littleover,
Derby.
June 22.

---

[1] Greene, C. H., *J. Amer. Cer. Soc.*, 39, 66 (1956).

[2] Thomas, W. F., *Nature*, 181, 1006 (1958); *Phys. and Chem. Glasses*, 1, 4 (1960).

Stimulated Optical Radiation in Ruby

Schawlow and Townes[1] have proposed a technique for the generation of very monochromatic radiation in the infra-red optical region of the spectrum using an alkali vapour as the active medium. Javan[2] and Sanders[3] have discussed proposals involving electron-excited gaseous systems. In this laboratory an optical pumping technique has been successfully applied to a fluorescent solid resulting in the attainment of negative temperatures and stimulated optical emission at a wave-length of 6943 Å.; the active material used was ruby (chromium in corundum).

A simplified energy-level diagram for triply ionized chromium in this crystal is shown in Fig. 1. When this material is irradiated with energy at a wave-length of about 5500 Å., chromium ions are excited to the $^4F_2$ state and then quickly lose some of their excitation energy through non-radiative transitions to the ^2E state[4]. This state then slowly decays by spontaneously emitting a sharp doublet the components of which at 300° K. are at 6943 Å. and 6929 Å. (Fig. 2*a*). Under very intense excitation the population of this metastable state (^2E) can become greater than that of the ground-state; this is the condition for negative temperatures and consequently amplification via stimulated emission.

To demonstrate the above effect a ruby crystal of 1-cm. dimensions coated on two parallel faces with silver was irradiated by a high-power flash lamp;

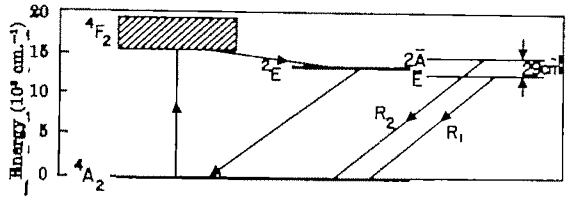


Fig. 1. Energy-level diagram of Cr^{3+} in corundum, showing pertinent processes

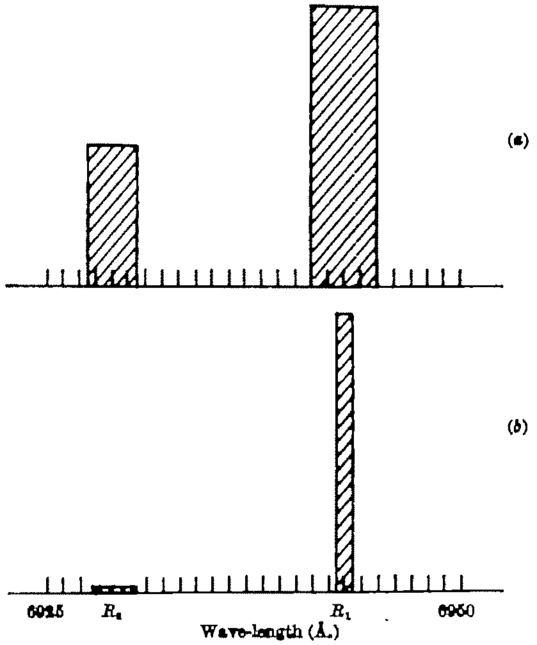


Fig. 2. Emission spectrum of ruby: a, low-power excitation; b, high-power excitation

the emission spectrum obtained under these conditions is shown in Fig. 2b. These results can be explained on the basis that negative temperatures were produced and regenerative amplification ensued. I expect, in principle, a considerably greater (~ 10^3) reduction in line width when mode selection techniques are used[1].

I gratefully acknowledge helpful discussions with G. Birnbaum, R. W. Hellwarth, L. C. Levitt, and R. A. Satten and am indebted to I. J. D'Haenens and C. K. Asawa for technical assistance in obtaining the measurements.

T. H. MAIMAN

Hughes Research Laboratories,
A Division of Hughes Aircraft Co.,
Malibu, California.

[1] Schawlow, A. L., and Townes, C. H., *Phys. Rev.*, 112, 1940 (1958).
[2] Javan, A., *Phys. Rev. Letters*, 3, 87 (1959).
[3] Sanders, J. H., *Phys. Rev. Letters*, 3, 86 (1959).
[4] Maiman, T. H., *Phys. Rev. Letters*, 4, 564 (1960).

METALLURGY

A Simple Method of investigating the Creep of Metals under Simple Shear

DR. K. H. JOLLIFFE and I[1] have investigated the creep of metals under simple shear by the use of a disk of the metal in question in which is cut a concentric circular annulus, the metal external to the annulus being securely gripped, while that internal to the annulus is subjected to a constant torque. We have shown that the behaviour of the metal in these circumstances is in many ways simpler and more informative than that exhibited by wires or rods under tension.

From the point of view of the industrial study of creep, the method has the disadvantage that the specimens are somewhat troublesome to prepare and measure. To get over this difficulty I have devised a method in which the specimen has the form shown in Fig. 1. In the plate *ABCD* (Fig. 1a) are cut rectangular grooves *MNOP*, *QRST*, as shown in cross-section in Fig. 1b. The metal *ABNM*, *TSCD* is securely held, and a force *F* applied to the metal *PORQ* in a direction parallel to the grooves. Under these conditions the shear stress distribution in the rectangular plates *MNOP*, *QRST* is not strictly uniform, as it is in the disk method, which is clear from the fact that the shear stress over the free ends must be zero. The distribution has been worked out by me[2] and by C. E. Inglis[3].

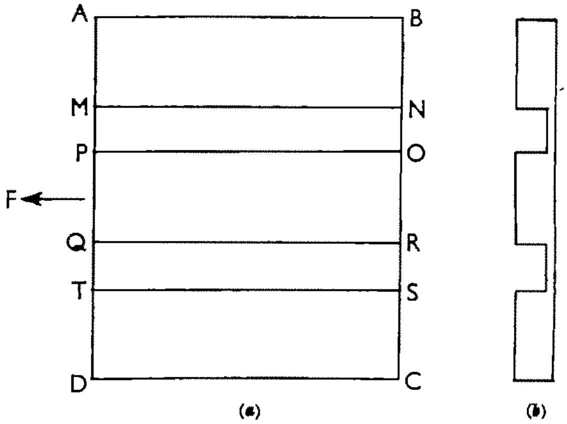


Fig. 1

Mr. D. B. Gilding has been working under my direction on the best form of the plate and has established that if the ratio of *MN* to *NO* is in the region of 7, the results on creep obtained with the disposition described correspond closely to those obtained by the method of Andrade and Jolliffe[1]. It seems possible that the new method may be of use in further investigations of creep and may also have applications to the problem of fatigue.

E. N. DA C. ANDRADE

Department of Metallurgy,
Imperial College of Science and Technology,
London, S.W.7.

[1] Andrade, E. N. da C., and Jolliffe, K. H., *Proc. Roy. Soc.*, A, 213, 3 (1952); 254, 291 (1960).
[2] Andrade, E. N. da C., *Proc. Roy. Soc.*, A, 85, 448 (1911).
[3] Inglis, C. E., *Proc. Roy. Soc.*, A, 103, 598 (1923).

An Improvement in the Ductility of Beryllium at High Temperatures

THE outstanding problem in beryllium metallurgy is the lack of ductility exhibited by the metal, both at room temperature and at elevated temperatures. At room temperature, brittleness can be attributed to the ease of cleavage of basal planes of the hexagonal lattice, and to the high yield-strength of the prismatic planes, while at temperatures above 400° C., intergranular failure predominates. A ductility maximum occurs at intermediate temperatures depending on the strain-rate used, tensile specimens failing with

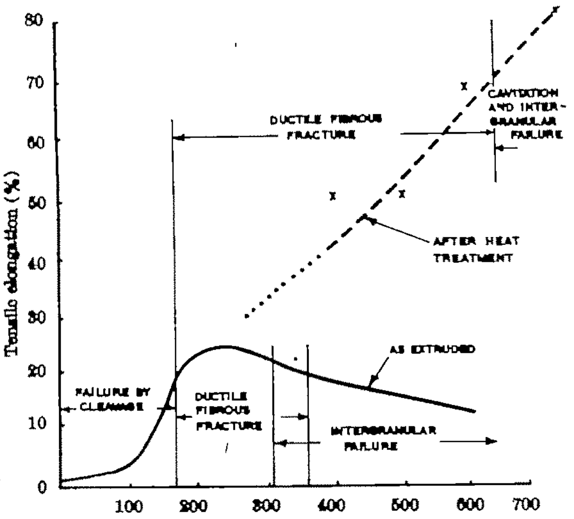


Fig. 1. Vacuum cast, pebble beryllium extruded at 1,050° C. 44 : 1 reduction

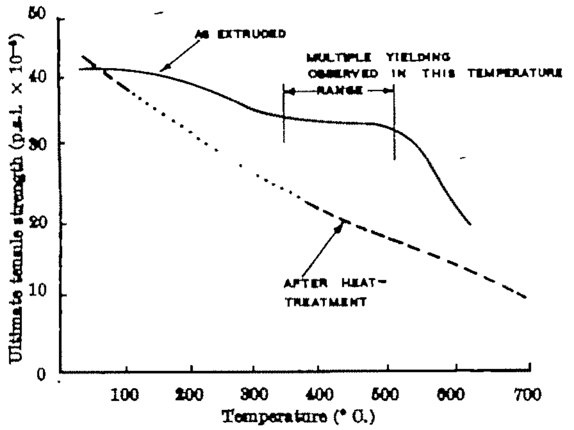


Fig. 2. Thermally reduced beryllium, vacuum cast and extruded at 1,050° C. 44 : 1 reduction

a ductile, fibrous fracture between 200° and 400° C. These fracture modes overlap, and two or more types of failure may be seen in any one tensile specimen.

Some increase in low-temperature ductility can be obtained by fabrication techniques which develop a texture in which the basal planes are oriented parallel to direction of working, so that loads applied in this direction exert little normal stress on basal cleavage planes. Additional resistance to cleavage is achieved by a reduction of grain size. Little has been done in the past to reduce the extent of intergranular failure, which becomes the predominant fracture mode in extruded beryllium rods as the temperature is increased above 400° C. Recent work at the Atomic Weapons Research Establishment, however, indicates that the temperature at which intergranular failure occurs can be raised by several hundred degrees by heat treating material of a suitable composition.

Fig. 1 shows the extent of the improvement in ductility that has been achieved in extruded ingot bar, fabricated from thermally reduced metal, after a heat treatment which involved heating the bar at 780° C. for 120 hr. followed by slowly cooling to room temperature over a further 120 hr. This treatment, which was insufficient to promote grain growth, apparently resulted in the precipitation of certain impurities from metastable solid solution.

Some reduction in strength also ensued from this treatment, as can be seen from a comparison of the 'as-received' and 'heat-treated' curves in Fig. 2. Of greater significance is the fact that the strength 'plateau', evident in tensile tests on the as-extruded material, between 350° and 500° C., was completely removed by the annealing treatment. This plateau was associated with multiple yielding phenomena, which can be symptomatic of the diffusion of solute impurities during the tensile test. No multiple yielding was found after the annealing treatment, and it is proposed that the solute elements concerned were precipitated, either during the treatment at 780° C. or during the subsequent equilibrium cooling. The reversibility of this precipitation treatment has been demonstrated in hot-hardness tests, re-solution appearing to occur at temperatures between 800° and 1,000° C.

The increase in ductility was associated with the disappearance of the intergranular type of failure usually inherent in beryllium at temperatures above 400° C. Comparative microstructures of the fracture modes in as-extruded and heat-treated specimens, tested at 600° C., are shown in Fig. 3.

The phenomenon was not associated merely with a softening of the matrix during annealing. A second bar of material, prepared in an identical way from purer electrolytic flake material, revealed little amelioration of tensile ductility after heat treatment as can be seen from Fig. 4. Furthermore, the hot

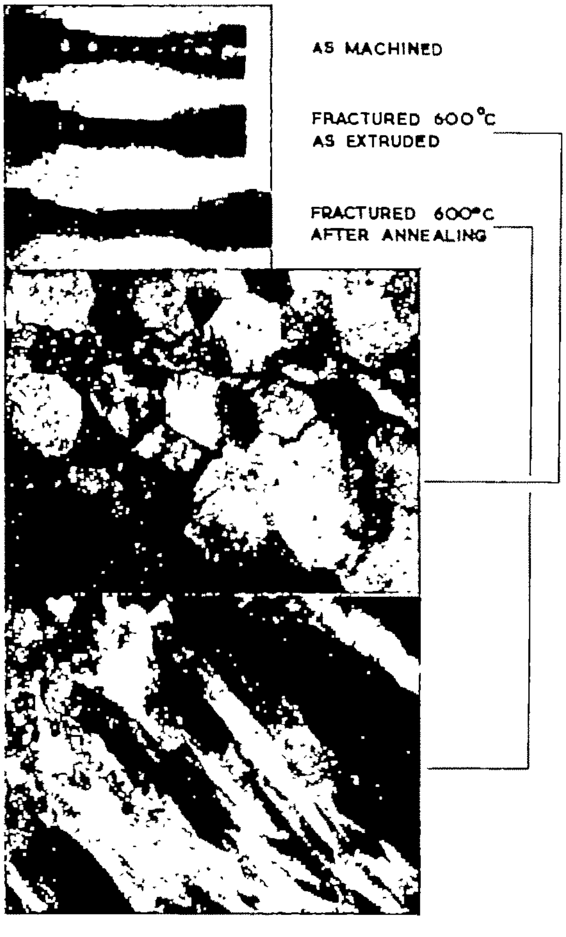


Fig. 3. (× c. 60)

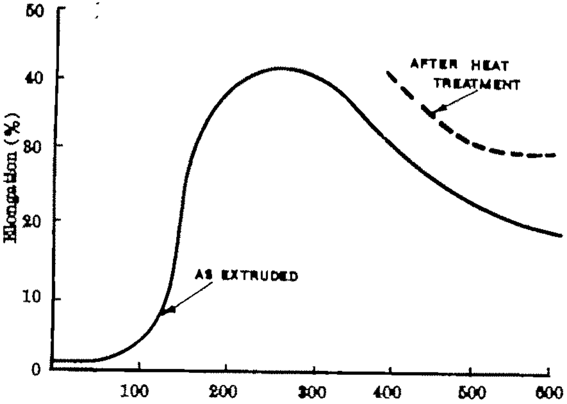


Fig. 4. Vacuum cast, electrolytic flake beryllium extruded at 1,050° C. 44 : 1 reduction

hardness characteristics of this material in the as-extruded condition were coincident with those of heat-treated thermally reduced material, and were unaffected by subsequent heat treatment. No multiple yielding was observed in this bar, even in the as-extruded state. The matrix properties of the two materials would appear to be similar after heat treatment, yet ductility is associated only with the thermally reduced material.

These, and other metallographic observations on the migration of impurities to grain boundaries in the more impure, thermally reduced metal, suggest that a specific impurity phase(s) in the more impure material artificially strengthens the boundaries at high temperatures, possibly by a keying action which prevents the boundaries shearing. This phase(s), which is either absent, or present to a smaller extent in the purer, electrolytic material, appears to migrate preferentially to the grain boundary region during the heat treatment.

This phenomenon is obviously of great importance in the metallurgy of beryllium at temperatures between 500° and 600° C., that is, within the temperature range where beryllium is to be used in nuclear reactors of the A.G.R. type, and indicates the possibility of alloying to improve the ductility at these temperatures.

A. Brown*
F. Morrow
A. J. Martin

Atomic Weapons Research Establishment,
Aldermaston.

---

* Attached staff from Babcock and Wilcox, Renfrew.

Hexagonal Modification of Black Chromium Electro-deposit

The formation of a hexagonal modification of an electro-deposited chromium has been discussed since the first announcement was made. In 1935, L. Wright *et al.*[1] determined the conditions for the production of the hexagonal form from chromic acid baths, and recently C. A. Snavely[2] fully examined the structural characteristics of the electro-deposited chromium from chromic acid baths containing sulphate ion.

The hexagonal modification of the black chromium electro-deposit has not been reported since the first report of black chromium was made by Siemense and Halske[3] in 1933.

The mixed crystal (hexagonal-closest-packed + body-centred cubic) was found in the black chromium electro-deposit obtained from the new bath containing chromic acid, acetic acid and urea. We were interested in this phenomenon and studied the formation of the hexagonal modification of the black chromium electro-deposit.

The baths used in this experiment were as follows: (1) chromic acid 3 *M*, acetic acid 0·05 *M* [3]; (2) chromic acid 3 *M*, acetic acid 0·05 *M*, urea 0·05 *M* [4]; (3) chromic acid 200 gm./l., glacial acetic acid 6 ml./l., nickel chloride 20 gm./l., vanadium oxide 7·1 gm./l. [5]. Precautions were taken to remove a sulphate ion contained in the chromic acid reagent. The specimens were made by electro-deposition on a copper wire at a current density of 100 amp./sq. dm. and at 15 ± 1° C. The time of electrolysis was about 3 hr. X-ray examination was made immediately after the end of electrolysis.

The X-ray diffraction analysis indicated that the structures of the electro-deposits obtained under the above conditions consisted of the mixed crystal —hexagonal - closest - packed + body - centred cube. The typical Debye–Scherrer photograph of the mixed crystals is shown in Fig. 1.

Wright *et al.*[1] stated that the factor influencing the formation of the hexagonal modification was the percentage of chromium existing in the cation in reduced chromic acid solutions. In the black chromium plating baths the mixed crystals were obtained under the conditions mentioned above in the absence of the trivalent chromium.

During the repeated electrolysis the pure hexagonal form appeared in the deposit which was electro-deposited for 14¼ hr. from the bath[2] (Fig. 2).

The effects of the bath temperature, the concentration of chromic ion and urea, and the time of electrolysis on the formation of the pure hexagonal structure were examined. However, it could not be determined which factor was responsible for the formation of the pure hexagonal structure.

The change of the structure of the mixed crystal to the body-centred cubic has been reported by several authors[3,4]. In this experiment, the mixed

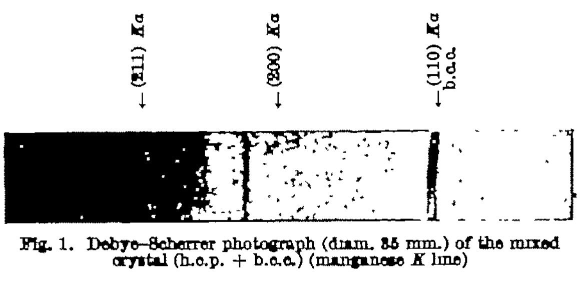


Fig. 1. Debye–Scherrer photograph (diam. 35 mm.) of the mixed crystal (h.c.p. + b.c.c.) (manganese *K* line)

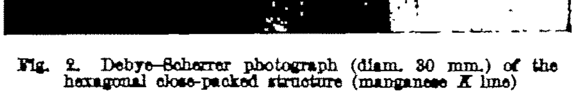


Fig. 2. Debye–Scherrer photograph (diam. 30 mm.) of the hexagonal close-packed structure (manganese *K* line)

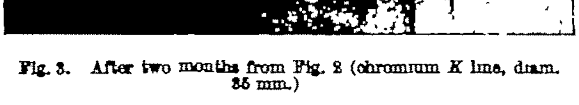


Fig. 3. After two months from Fig. 2 (chromium *K* line, diam. 35 mm.)

crystals changed to the body-centred cubic structure from time to time. On the contrary, the pure or almost pure hexagonal crystal did not change even after two months from the end of the electrolysis (Fig. 3). When this deposit was treated in a hydrogen atmosphere at 150° C., the structure changed to the body-centred cubic crystal.

C. A. Snavely[2] thought that there is a relation between the structure of the electro-deposited chromium and the *p*H of the cathode film during electrolysis. It is suggested from the above results that the *p*H of the cathode film during the electrolysis in the black chromium baths was higher.

We wish to thank Prof. Y. Shimomura and Mr. M. Kojima for the X-ray diffraction analysis.

HIDEYA OKADA
TAKEO ISHIDA

Department of Applied Chemistry,
University of Osaka Prefecture,
Sakai City, Osaka.

---

[1] Wright, L., Hirst, H., and Riley, J., *Discuss. Farad. Soc.*, 1253 (1935).

[2] Snavely, C. A., *Trans. Electrochem. Soc.*, 92, 537 (1947).

[3] Siemens and Halske, Ger. Pat. 754,360, Nov. 6, 1933.

[4] Ishida, T., Noda, Y., and Okada, H., *J. Metal Finishing Soc. Japan*, 10, 381 (1959).

[5] Quaely, M. F., Proc. Fourteenth Ann. Conv. Amer. Electroplaters' Soc., 48 (1953).

[6] Sasaki, K., and Sekito, S., *J. Soc. Chem. Indust. Japan*, 33, *B*, 482 (1930).

GEOLOGY

Stability of Epidote Minerals

A NUMBER of silicate minerals have proved difficult to synthesize by the commonly employed methods involving hydrothermal crystallization of glasses or reactive oxide mixes of suitable composition. Failure to synthesize a phase may be caused by the experimental conditions not being within the region where the phase is thermodynamically stable. But, in some cases, failure simply reflects a large nucleation barrier to the formation of the stable phase so that metastable phases which nucleate with ease form, and may persist indefinitely. Several workers[1–3] have considered this problem in relation to the epidote minerals, and the consistent failure of low-pressure synthesis could indicate that these phases may be stable only under relatively high-pressure conditions. Geological occurrence does not entirely support this proposition. The results presented here indicate that with these minerals nucleation is a sluggish process at low pressures, and if this step is by-passed, growth is readily achieved from the phases which normally form in synthesis. This sluggish nucleation is possibly related to the structure of the minerals.

Proof that the epidote minerals (zoisite, clinozoisite, epidote) are stable relative to the phases commonly formed in synthesis from their composition has been approached as follows. When zoisite is thermally decomposed at one atmosphere, reaction proceeds according to the reaction:

$$\underset{\text{zoisite}}{2Ca_2Al_3Si_3O_{12}(OH)} \rightarrow \underset{\text{anorthite}}{2CaAl_2Si_2O_8} + \underset{\text{wollastonite}}{CaSiO_3} + \underset{\text{gehlenite}}{CaAl_2SiO_7} + H_2O$$

Similar reactions can be written for other members of the epidote family. When zoisite synthesis is attempted at low pressures and temperatures from a mix of appropriate composition, phases on the right of the above equation tend to be formed, or if leaching of silica occurs hydrogarnets may form. In the present experiments two starting materials were used; an iron-poor clinozoisite and an epidote which, judging from refractive index, contained around 13 per cent iron sesquioxide (Fe_2O_3). These phases were first thermally decomposed to form the high-temperature assemblages and then mixtures of the epidote mineral and high-temperature products (that is, all the phases in the above equation) were sealed in small capsules with water and allowed to react for 30–80 days at 2,000 bars pressure and then examined by X-rays and microscope. With a mixture of epidote and decomposed epidote, it was found that epidote formed strongly at 505° and 630° C. while at 715° C. anorthite, garnet and magnetite were the dominant products. A mixture of clinozoisite and decomposed clinozoisite produced clinozoisite at 605° C. and anorthite and garnet (from refractive index and X-ray measurement close to grossularite) at 740° C. At 605° a few grains of garnet could be recognized, but growth of clinozoisite was spectacular. In two runs with epidote composition excess quartz was added and at 465° and 605° C. strong growth of epidote occurred.

These results indicate clearly that, relative to the normal products of synthesis, the epidote minerals are stable at moderate temperatures and water pressures. Thermodynamic consideration of entropy and changes in volume involved indicates that little pressure would be needed for their formation at low temperatures from suitable compositions. At temperatures around 300° C. and below, present results[4] indicate that zeolites will become stable. Work on other reactions involving calcium aluminosilicates in progress also demonstrates that this method of mixtures may be of value in proving relative stability of phases whenever it is suspected that the slow step in the reaction kinetics is nucleation.

This work has been supported by grants from Research Corporation and the Petroleum Research Fund, American Chemical Society.

W. S. FYFE

Geology Department,
University of California,
Berkeley.

---

[1] Ehlers, E. G., *J. Geol.*, 61, 231 (1953).

[2] Goldsmith, J. R., *J. Geol.*, 61, 439 (1953).

[3] Fyfe, W. S., Turner, F. J., and Verhoogen, J., "Metamorphic Reactions and Metamorphic Facies", Memoir 73, Geol. Soc. Amer. (1958).

[4] Coombs, D. S., Ellis, A. J., Fyfe, W. S., and Taylor, A. M., *Geochim. et Cosmochim. Acta*, 17, 53 (1959).

Relic-Soil on Limestone in South Wales

THE Worm's Head, part of the Nature Conservancy Gower Coast National Nature Reserve, lies at the south-western tip of the Gower Peninsula of Glamorganshire, South Wales. It is a Carboniferous limestone headland accessible only at low tide across a wave-cut limestone platform. On the southern side of the Inner Head (Ord. Surv. Grid Ref. *SS* 395873) is a section in Pleistocene deposits of a type recorded widely in Gower[1–3], and elsewhere in southern Britain. This can be summarized from the base upwards as follows: (1) Wave-cut limestone platform; (2) raised beach of calcite-cemented limestone pebbles banked against solid limestone; the *Patella* beach; (3) remnants of bright red sandy clay loam, 10–18 in. thick, containing rare limestone pebbles with red weathered outer zones; (4) brown loam containing abundant angular limestone, a periglacial head deposit. The thickness of this is variable from 0 to 10 ft.; (5) dull grey-brown stony sandy loam, glacial drift containing abundant Old Red Sandstone and Carboniferous grits and sandstones; where this is preserved on the flanks of the Worm's Head, the depth averages 4–6 ft.; (6) dull, grey-brown, sandy loam, almost stoneless, similar to the matrix of horizon 5, resting variously on horizons 2, 3 or 6.

The *Patella* beach (Horizon 2) includes fauna characteristic of a cold climate, and deposits overlying this beach elsewhere in Gower have been found to have included a fauna indicating "a climate more genial than that of the present day"[3]. Horizon 3 is interpreted here as relics of a soil which had developed on Carboniferous Limestone prior to the return of periglacial and glacial conditions responsible for Horizons 4–6.

The colour of Horizon 3 is red (Munsell colour $2.5YR4/6\text{-}5/8$). It is sticky and mouldable when wet, moderately massive when dry. Field texture, silty loam to silty clay loam, is heavier than that given by laboratory analysis. This, by the hydrometer method, is sandy clay loam (5·5 per cent American silt, 28 per cent clay). Organic carbon content is 4 per cent and free iron oxides (by Deb's method) 3 per cent. The clay fraction minerals are dominantly illite with a minor proportion of chlorite. Thin sections reveal a skeleton of clean sub-angular quartz of mainly fine sand size in a matrix of yellow-brown colour. There are rare, small, round concretionary flecks of calcite and roughly rounded dark red-brown segregation patches of iron oxides, the latter translucent with included quartz grains. Small, round or ovoid black opaque areas, reddish-brown in reflected light, are apparently also iron oxides. Between crossed polars the clay is markedly birefringent. There are moderately well and strongly oriented coatings around sand-grains and the general clay areas are seen as fine aggregates, in the terminology of Brewer and Haldane[4]. The fabric seen in sections of this material is similar to that described in rotlehm from Cyprus[5] and in material discussed by Dalrymple[6], notably a red clay from head deposit at Slindon, Sussex. Examination of slides, including the Dalrymple material, at the Institute of Archæology, University of London (by permission of Dr. I. Cornwall), showed comparable fabric also in rotlehm from Morocco. The oriented clay is not concentrated in channels or pores, but is uniformly distributed as coatings to grains throughout the sections examined. The orientation apparently results from alternate wetting and drying of the soil-clay *in situ* rather than from illuviation of mobile clay[7]. This fabric is closely comparable to that described for terra fusca[8], a soil of braunlehm type occurring on limestone in climates of humid conditions, slightly warmer than most of Britain. The occurrence of iron segregations and of small concretions is considered a stage in the process of rubefaction[9] leading in hotter climates to a development of terra rossa from terra fusca, and rotlehm from braunlehm.

The interpretation of this material, in field morphology close to siallitic terra rossa and in micromorphology close to terra fusca, is that it is a soil of transitional character between these two sub-types. The climate for its production is likely to have been essentially similar to that of south-western Britain to-day, but with warmer summers. The shallow soils developed on limestone on the mainland cliffs adjacent to the Worm's Head show in thin section weakly developed moderately oriented coatings to sand grains, but have a higher organic matter content and well-developed crumb or granular structure. It seems that only the first stages of transition from brown earth to terra fusca have been produced as a result of post-glacial conditions in this area. A detailed study of a range of soils on limestone in Glamorgan is likely to be interesting. In particular, it is of geological and pedological significance whether the red silty clay frequently preserved over limestone in the Vale of Glamorgan and Gower is a relict material or a result of post-glacial weathering. It is suggested that it may well prove to be an interglacial relic occurring locally south of the deposits of the last glaciation.

I am grateful to Dr. D. A. Osmond for helpful discussion on this topic.

D. F. BALL

The Nature Conservancy,
Headquarters for Wales and Bangor
Research Station,
Penrhos Road,
Bangor,
Caernarvonshire.

[1] Strahan, A., "The Geology of the South Wales Coalfield". Pt. 9 (H.M.S.O., 1907).

[2] George, T. N., *Proc. Geol. Assoc.*, **43**, 4, 291 (1932).

[3] George, T. N., *Geol. Mag.*, **70**, 208 (1933).

[4] Brewer, R., and Haldane, A. D., *Soil Sci.*, **84**, 301 (1957).

[5] Osmond, D. A., and Stephen, I., *J. Soil Sci.*, **8**, 1, 19 (1957).

[6] Dalrymple, J. B., *J. Soil Sci.*, **9**, 2, 199 (1958).

[7] Stephen, I., *Science Prog.*, **48**, 322 (1960).

[8] Kubiena, W. L., "The Soils of Europe" (Murby, 1953).

[9] Kubiena, W. L., Proc. Sixth Int. Congr. Soil Sci., **E**, 247 (1956).

CRYSTALLOGRAPHY

Crystal Growth in Paraffin

AN increased interest in crystallization phenomena, especially in polymeric materials, is shown by the number of publications devoted to the subject[1]. I originally published observations of crystal growth of a dislocation mechanism in polymeric material[2]; however, some observations remained unpublished and increased interest in this general area prompts this communication.

In an attempt to study growth mechanisms in polymeric material by starting with paraffin and building up to longer-chain polymers, some thought was given to how the dislocation promoting the growth is introduced. Frank[3] proposed that this dislocation is introduced into the nucleus as a result of a buckling mechanism. It was thought that this process may be checked by purposely introducing impurities to cause strain that may aid the buckling process.

Pure paraffins (hexatricontane and pentatricontane) were crystallized from solutions of petroleum ether on electron microscope grids. The resulting crystals grown were regular lozenge-shaped with dislocation spirals very clearly evident (Fig. 1). These crystals are familiar and have been previously reported by other workers[4] and are used as a standard. Into the same solutions from which these standard crystals have been grown, small amounts of 'impurity' material are added, and the new crystals grown are

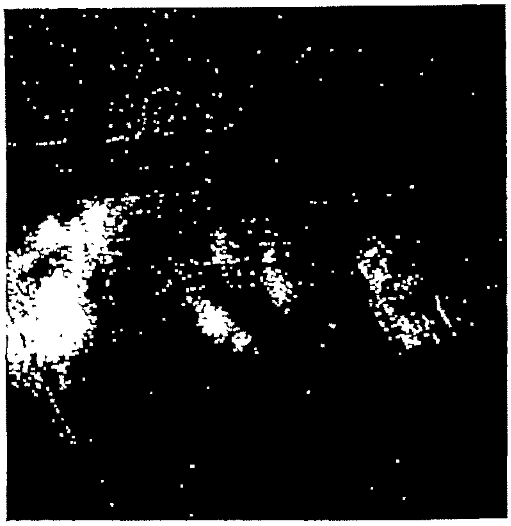


Fig. 1

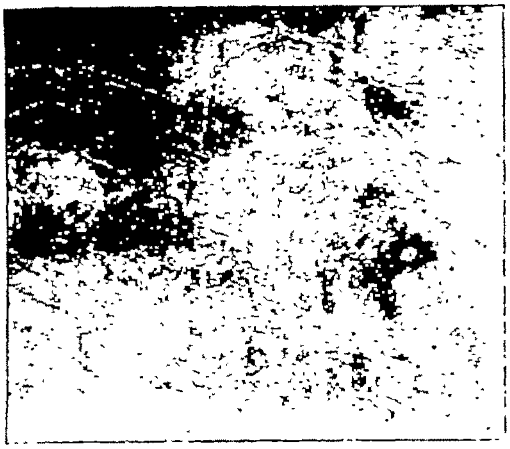


Fig. 2

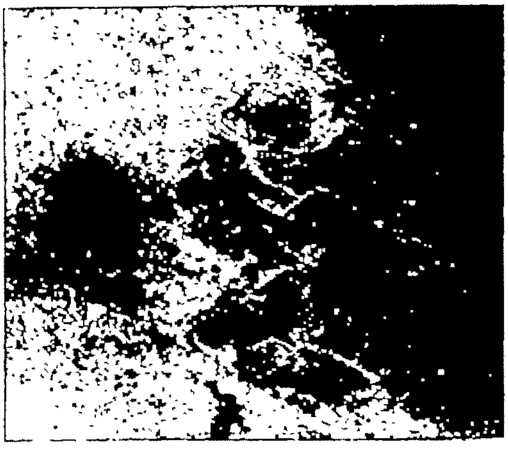


Fig. 3

examined. Impurities in the form of material with small particle sizes (dyes and colloids) were tried. None of these was successful in introducing any changes in the resulting crystals. However, small amounts of hexatricontane, either solid or from solution, when added to pentatricontane solution, and vice versa, altered the growth mechanism. The resulting crystals were changed in morphology and had many more dislocation spirals evident per growth area. (A typical example is shown in Fig. 2.) It is felt that the impurity paraffin may aid in formation of dislocations as a result of its misfit with the host paraffin.

A phenomenon of similar type may be occurring in polymeric material. Fig. 3 shows crystals grown from solution of 'Marlex No. 20' (linear polymethylene) from xylene.

R. J. Jaccodine

Bell Telephone Laboratories, Inc.,
Allentown,
Pennsylvania.

---

[1] "Growth and Perfection of Crystals", edit. by Doremus, R., Roberts, B. W., and Turnbull, D. (J. Wiley and Sons, New York, 1958).

[2] Jaccodine, R. J., *Nature*, 176, 305 (1955).

[3] Frank, F. C., "Faraday Society Discussion on Crystal Growth", No. 5 (1948); *Phil. Mag.*, 42, 1014 (1951).

[4] Dawson, I. M., and Vand, V., *Nature*, 167, 476 (1951). Forty, A. J., "Advances in Physics", 3, No. 9 (1954).

Five Co-ordinated Titanium in $K_2Ti_2O_5$

It is widely believed that oxygen atoms may be extracted at random from the lattices of metallic oxides, and X-ray powder photographs have suggested that little or no modification of the structure of the original stoichiometric substance occurs. In particular, evidence has been adduced that the perovskite lattice can persist between the limits ABO_3—$ABO_{2.5}$, provided that the six co-ordinated ion B is one of the metals, titanium, vanadium, cobalt or iron[1]. In order to evaluate this proposal, we are examining the crystal structures of ordered, oxygen-deficient compounds in which the ionic radii comply with the rules enunciated by Goldschmidt[2] for the perovskite structure. $K_2Ti_2O_5$ was recently reported by Schmitz-Dumont and Reckhard[3] to have a large unit cell of low symmetry, and this could, perhaps, be due to the regular omission of some of the oxygens from a perovskite lattice. We now wish to report briefly that a complete X-ray structure determination does not support this view.

Crystals of $K_2Ti_2O_5$ which are formed by slowly cooling a melt of potassium carbonate and titanium dioxide in the molar proportions 1 : 2 decompose rapidly in moist air, and require protection during X-ray exposures. They crystallize as monoclinic needles with the unit cell dimensions $a = 11{\cdot}374$, $b = 3{\cdot}799$, $c = 6{\cdot}616$ Å., $\beta = 100{\cdot}10°$, and the structure which was derived unambiguously from Patterson and Fourier projections satisfies the space-group $C2/m$. The titanium atoms are each co-ordinated to five oxygens grouped as a slightly distorted trigonal bipyramid. Two of these have an edge in common (Fig. 1), and this double unit forms an endless string elongated along y. Strings are joined to one another by having corners (oxygen atoms) in common, and this results in the formation of a two-dimensional sheet or layer of composition $(Ti_2O_5)^{2-}$. The layers are held together by the potassium atoms (Fig. 2), which have a curious unsymmetrical environment of eight oxygens, bearing only a superficial resemblance to the cubic site of the perovskite structure.

Instead of creating vacancies, the loss of some of the oxygen atoms has caused the remainder to regroup into a configuration around the titanium

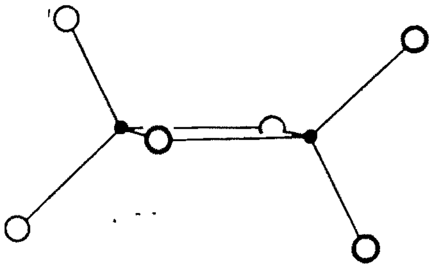


Fig. 1. Double trigonal–bipyramidal groups of oxygen (large circles) around titanium (small circles), seen in projection

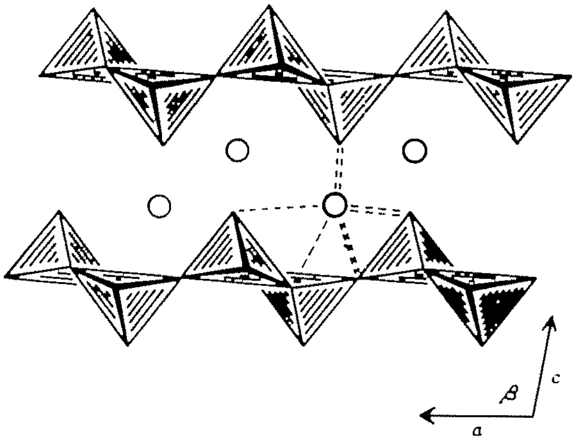


Fig. 2. Projection of the structure of $K_2Ti_2O_5$ on to (010), drawn as linked polyhedra. The potassium atoms are shown as circles, and the bonds to the nearest oxygens are drawn as broken lines for one of them

atom that is so unusual for this element that it has never, to our knowledge, been reported before. The structure of $K_2Ti_2O_5$, as a whole, has certain similarities to that of V_2O_5 in which, as in $KVO_3.H_2O$, the vanadium has five-fold co-ordination of a similar kind[4]. In the magnetoplumbite structures some of the Fe^{3+} ions also have the trigonal bipyramidal co-ordination[5]. Oxygen deficiencies in perovskites containing one or other of these cations might therefore be expected to cause, at the very least, a local rearrangement of oxygens from octahedral to trigonal bipyramidal and in this sense the term 'anion vacancy' has little real significance.

STEN ANDERSSON*

Department of Chemistry,
University of Melbourne.

A. D. WADSLEY

Division of Mineral Chemistry,
Commonwealth Scientific and Industrial
Research Organization,
Chemical Research Laboratories,
Melbourne.

---

* On leave from the University of Stockholm.

[1] Erchak, M., Fankuchen, I., and Ward, R., *J. Amer. Chem. Soc.*, **68**, 2085 (1946). Jonker, G. H., *Physica*, **20**, 1118 (1954). Kestigian, M., Dickenson, J. G., and Ward, R., *J. Amer. Chem. Soc.*, **79**, 5598 (1957).

[2] Goldschmidt, V. M., Barth, T., and Lunge, G., *Skr. norske Vidensk. Akad., Matem.-Naturvid. Kl.*, No. 7 (1925).

[3] Schmitz-Dumont, O., and Reckhard, H., *Monatsh. Chemie*, **90**, 134 (1959).

[4] Bystrom, A., Wilhelmi, K.-A., and Brotzen, O., *Acta Chem. Scand.*, **7**, 801 (1954). Christ, C. L., Clark J. R., and Evans, H. T., *Acta Cryst.*, **7**, 801 (1954).

[5] Braun, P. B., *Nature*, **170**, 708 (1952).

CHEMISTRY

Ultra-violet Absorption Spectra of the Diazines

No rotational analysis of an electronic transition has been reported for a molecule containing as many as ten atoms. However, preliminary spectrograms of pyrazine (Fig. 1) showed fine structure clearly susceptible to analysis (Fig. 2). Twelve bands which were relatively free from overlapping were photographed in the fourth order of a 150,000-line grating, and the rotational constants and accurate band centres were obtained. Similar treatment was possible for the 3200 Å. absorption of pyrimidine and the 3700 Å. absorption by pyridazine. The constants obtained for the respective 0–0 bands are:

	ν_0	$\bar{B}_0'' = \frac{A_0'' + B_0''}{2}$	$\bar{B}_0' = \frac{A_0' + B_0'}{2}$
Pyrazine	30,875·80 cm.$^{-1}$	0·2048 cm.$^{-1}$	0·2036 cm.$^{-1}$
Pyrimidine	31,072·5$_6$	0·205$_3$	0·204$_7$
Pyridazine	26,648·75	0·2034	0·2030

Resolved perpendicular structure of a hybrid band of pyridazine (Fig. 3) gives, from the average spacing of the P_Q branches, a very rough value for the inertial constant $(C' - \bar{B}') \simeq (C_0'' - \bar{B}_0'')$, namely, $0·10_5$ cm.$^{-1}$. However, for each molecule, the lack of other precise data prevents determination of the geometrical structures. Parameters which give agreement with the observed $\bar{B}_0''$-value of pyrazine are shown in Fig. 1.

Since each 0–0 band is clearly of the parallel type, the electronic transition moment must in each case be parallel to the axis of largest inertia and perpendicular to the plane of the molecule.

Partial vibrational analyses have been given for the systems of pyrazine[1,2] and pyrimidine[3], but evidently not for that of pyridazine. Precise measurements of about 800 sharp Q branch edges of pyridazine, as well as of fine structures of eleven bands, have therefore been made, between 25,675 cm.$^{-1}$ and 28,775 cm.$^{-1}$. It has been possible to arrange the

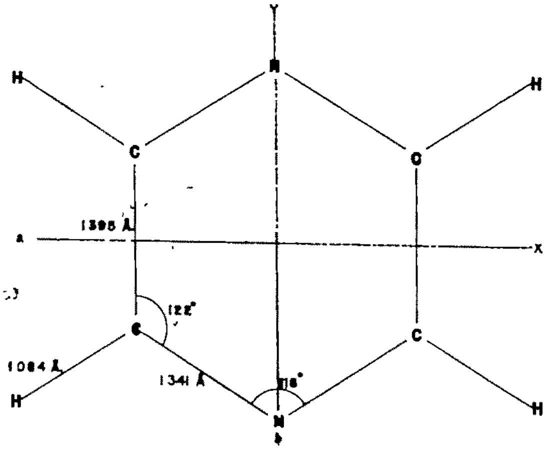


Fig. 1. Planar pyrazine (1,4 diazine). A nearly oblate symmetric top of point group D_{2h}. Note the choice of axes. Compare the point group C_{2v} for pyrimidine (1,3 diazine) and pyridazine, for each of which z is the two-fold axis and x is perpendicular to the molecular plane

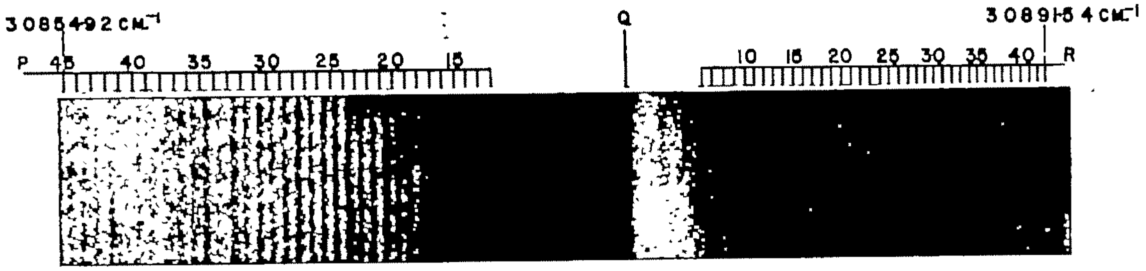


Fig. 1. 0–0 band of the 3200 system of pyrazine. Parallel structure typical for all three molecules. The Q-branch edge corresponds very closely to the band centre and is sharpest for pyridazine

bands into a single band system about the origin given above. Particularly sensitive checks of the vibrational analysis were found in 'hot' bands originating in the levels 664·80 cm.$^{-1}$ (ν''_{6a}) and 969·83 cm.$^{-1}$ (ν''_1). Each of these values agrees well with the infra-red and Raman spectra of pyridazine[4] and each is observed several times in the present spectrum. Almost all the bands are degraded slightly toward longer wave-lengths, but a weaker system of blue-degraded bands was found to originate at 27,182·8$_4$ cm.$^{-1}$ (Fig. 3) and could be included in the stronger system if it was assumed that the 534·0$_5$ cm.$^{-1}$ separation from the 0–0 band represents ν'_{6b}, a ring-stretching frequency of symmetry B_1. The assignment was confirmed by observation of the (0–1) and (1–1) bands of the same vibration and by observation of the perpendicular structure of Fig. 3. The most striking feature of the vibrational analysis is the decrease of ν_{6a} from 664·80 to 372·71 cm.$^{-1}$, but two other ground-state frequencies, ν''_{9a} = 1,153·1$_5$ cm.$^{-1}$ and ν''_{12} = 1,068·60 cm.$^{-1}$, and numerous excited-state frequencies of less-certain assignment, were also obtained. No out-of-plane vibrations are important in the spectrum, so it is concluded that the pyridazine molecule is planar in the excited electronic state, B_1.

The previous work on the vibrational assignments for pyrazine and pyrimidine has indicated that it will require more than one electronic transition per molecule to account for the observed bands. Since this was not necessary for pyridazine, it has seemed worth while to review the list of pyrazine bands given by Hirt[2] and the list of pyrimidine bands given by Uber[3]. Where available, the more accurate head measurements and band centres of the present work have been used. All the bands of pyrazine between 29,965 cm.$^{-1}$ and 32,053 cm.$^{-1}$, except the weakest, and all the main progressions of the pyrimidine spectrum, have been considered. Consistency with exact vibronic selection rules and with the infra-red and Raman spectra of the two molecules[4] has been imposed. A few re-assignments of the Raman spectra have been necessary. All the bands considered may be accounted for by the following fundamental vibrational frequencies and combinations of them about the respective 0–0 bands given above. For pyrazine: ν'_{6a} (A_g) = 582·61, ν''_4 (B_{2g}) = 257, ν'_4 = 477, ν''_5 (B_{2g}) = 596·06, ν'_5 = 414, ν''_{9a} (A_g) = 1,229, and ν'_{9a} = 1,108 cm.$^{-1}$. For pyrimidine: ν''_{6a} (A_1) = 679, ν'_{6a} = 530, ν''_{16a} (A_2) = 344, ν''_{12} (A_1) = 1,071, ν'_{12} = 1,015, ν''_1 (A_1) = 1,003, and ν'_1 = 1,291 cm.$^{-1}$. The reason for the prominence of non-planar vibrations, B_{2g} and A_2, in the spectra is indicated by the Franck–Condon principle: pyrazine and pyrimidine molecules are evidently slightly non-planar ('chair-form') in the excited electronic states, B_{1u} and B_1, respectively.

If the pyridazine molecule is planar in the excited state, while the related molecules are not, one may expect lower energies for excited pyridazine molecules than for excited pyrazine or pyrimidine molecules. The 4,300 cm.$^{-1}$ shift to lower energies of the pyridazine spectrum is thus readily understood. These tentative conclusions about configurations are being tested by accurate measurements of the band-heads of pyrazine and pyrimidine, by work on the dependence on temperature of each spectrum, and by examination of certain of the isotopically substituted compounds. A complete report of all this work will be published elsewhere.

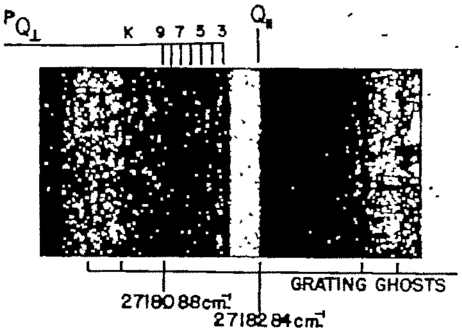


Fig. 3. Structure near the band centre of the hybrid band at 27,182·8$_4$ cm.$^{-1}$. Leading lines identify the Q-branch of the parallel component and several of the ^PQ-branches of the perpendicular component. On account of the slight asymmetry of the molecule, $^PQ_1$ and $^PQ_3$ are not observed as collected, line-like features

This investigation was supported in part by a grant from the Petroleum Research Fund administered by the American Chemical Society, for which we are grateful. We express appreciation also for initial support by the Research Corporation and for support of the work on pyrimidine by the Office of Ordnance Research under Project No. 005-*C* of Contract *DA*-33-008-*ORD*-1780 with Vanderbilt University.

K. KEITH INNES
JAMES A. MERRITT
WAYNE C. TINCHER
SHELBY G. TILFORD

Department of Chemistry,
Vanderbilt University,
Nashville
Tennessee.

Feb. 8.

---

[1] Ito, M., Shimada, R., Kuraishi, T., and Mizushima, W., *J. Chem. Phys.*, 26, 1508 (1957).

[2] Hirt, R. C., *Spectrochim. Acta*, 12, 114 (1958).

[3] Uber, F. M., *J. Chem. Phys.*, 9, 777 (1941).

[4] Lord, R. C., Marston, A. L., and Miller, F. A., *Spectrochim. Acta*, 9, 113 (1957).

Initial Stages of Oxidation of Coal

OUR knowledge on the initial stages of oxidation of coal in air or oxygen is far from complete, though it is long known that the first stage is the formation of coal–oxygen complex and peroxygen-like bodies[1]. It is this stage and onwards where information on the mechanism of the progress of oxidation is scant. We have recently found that in the first phase of coal oxidation dehydrogenation appears to be the main reaction, without any drastic destruction of the carbon structure of coal.

Earlier[2,3] it was shown that prolonged oxidation of coal at temperatures ranging from 170° C. to 220° C. leads to preferential oxidation of the non-aromatic part leaving the aromatic nucleus unaffected, and therefrom structural parameters of coal were deduced[4-7]. The same mode of oxidation at 170° C. in air has been adopted to follow up the initial chemical changes in case of high-rank vitrain. Samples of oxidized coal were drawn at small intervals of time at the initial stages. The material balance, ultimate analysis and functional group analysis, including methyl group estimation, were done for all these oxidized samples, and the results are given in Table 1. The input and output of carbon and hydrogen before and after oxidation at different stages are also shown.

The elemental balance indicates that dehydrogenation is the main reaction at the initial stages, the loss of carbon being comparatively small.

The nature of this dehydrogenation has been studied by treating the oxidized samples with sulphur[8]. It will be seen (Table 2) that the amenability to further dehydrogenation with sulphur[8] (Vesterberg's) progressively decreases with oxidation.

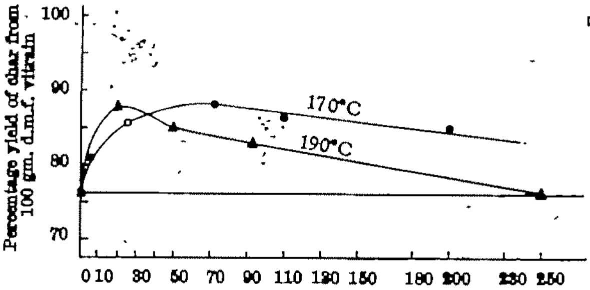


Fig. 1. Effect of oxidation on yield of char

The parallelism between the action of sulphur[8] and oxygen/air appears to be extended by the carbonization behaviour of such treated samples, for example, under both types of treatment: (1) caking property is undermined; (2) the yield of tar is inhibited; (3) the char yield increases, apparently, at the expense of the tar-forming structures. The yield of char progressively increases with the extent of oxidation and at the 72-hr. oxidation stage the yield of 'extra' char was found to be almost the same as is obtainable[8] from carbonization of the vitrain in presence of sulphur (Table 2). It has also been found that if the oxidation is continued beyond this stage, the yield of extra char decreases (Table 2), so much so, that after a time a stage is reached where the original yield of char is restored (Fig. 1).

Table 1. ELEMENTARY COMPOSITION AND ITS BALANCE AT DIFFERENT PERIODS OF OXIDATION
(Calculations based on 100-gm. unit coal basis)

Sample No.	Hr. of oxidation	Elementary analysis		Group analysis				Gain in weight (per cent)	Elementary balance					
									Input		Output		Percentage of elements lost	
		C (per cent)	H (per cent)	O_{OH} (per cent)	O_{COOH} (per cent)	O_{CO}+ unaccounted (per cent)	O_{CH_3} (per cent)		C (gm.)	H (gm.)	C (gm.)	H (gm.)	C	H
	Temperature, 170° C.													
1	0	87·8	5·32	1·20	0·20	3·0	2·8	—	87·8	5·32	—	—	—	
2	5	85·2	4·79	4·51	0·94	2·0	—	1·6	87·8	5·32	86·5	4·86	1·5	8·6
3	25	82·2	4·50	3·26	0·22	6·4	—	4·6	87·8	5·32	86·0	4·71	2·1	11·5
4	72	77·1	3·67	5·28	0·82	10·8	1·7	7·8	87·8	5·32	83·1	3·96	5·4	25·6
5	200	74·4	3·38	—	—	—	—	8·1	87·8	5·32	80·4	3·65	8·4	31·4
	Temperature, 190° C.													
6	20	78·1	3·70	3·40	—	—	—	8·0	87·8	5·32	84·3	4·00	4·0	25·0

Table 2. DEHYDROGENATION (VESTERBERG'S) AND CARBONIZATION BEHAVIOUR OF A VITRAIN WITH PROGRESSIVE OXIDATION IN AIR
(Data given on the basis of 100-gm. unit vitrain)

Particulars of experiment	Dehydrogenation with sulphur at 200°–260° C. Total cadmium sulphide formed (gm.)	Gray–King carbonization assay, yield of:		
		Coke or char (gm.)	Tar (gm.)	Extra yield of char (gm.)
(1) Original vitrain	—	76·2 (coke, *C*)	12·0	—
(2) Original vitrain treated with sulphur	63·2	87·2 (char)*	nil	11·0
(3) Vitrain oxidized at 170° C.				
(i) 5 hr.	45·9	81·0 (coke, *B*)	7·1	4·8
(ii) 25 hr.	41·3	85·7 (char)	2·2	9·5
(iii) 72 hr.	31·6	88·2 (char)	nil	12·0
(iv) 200 hr.	8·1	85·1 (char)	nil	8·9
(4) Vitrain oxidized at 190° C.				
(i) 20 hr.	31·0	88·0 (char)	nil	11·8
(ii) 250 hr.	—	76·4 (char)	nil	0·2

* Sulphur-free yield.

Though the effect of dehydrogenation caused either by air/oxygen or sulphur on the carbonization behaviour is almost the same, yet the overall reaction with sulphur and oxygen does not appear to be a complete parallel. Practically no loss of carbon occurs during sulphur dehydrogenation[8], whereas 4–5 per cent of the carbon of coal is lost during air dehydrogenation. How and whence this loss occurs during the initial stages of oxidation is not readily explicable at the moment; but the fact that the tar-forming part of carbon structure can be completely stabilized at a certain stage of coal oxidation (Table 2) would possibly indicate that the loss at this stage must not have resulted at least from the destruction of tar-forming bodies.

The above phenomenon of air dehydrogenation and its consequent effects on the carbonization behaviour have also been observed to be true at other temperatures of oxidation as well. The only difference is that the higher the temperature, the shorter is the period required to cause the above chemical changes. The rate of this oxidative dehydrogenation reaction has also been found to be approximately doubled for each 10° C. rise in temperature (Table 1).

The inhibition of the tar formation on oxidation of coal has been common knowledge for a long time, but the causes of its inhibition at the initial stages of oxidation now have become evident from our work. The decrease or the complete inhibition of the formation of tar is not due to the destruction of tar-forming bodies, but apparently to their reorganization. Further, these findings on the initial stages of oxidation, *vis-à-vis* the action of sulphur[8] on coal, obviously raise some pertinent questions relating to the peripheral structure of coal which will be dealt with elsewhere.

S. K. CHAKRABARTTY
B. K. MAZUMDAR
A. LAHIRI

Central Fuel Research Institute,
Jealgora, Bihar, India.

[1] Jones, R. P., and Townend, D. T. A., *Trans. Farad. Soc.*, **42**, 297 (1946).

[2] Mazumdar, B. K., Anand, K. S., Roy, S. N., and Lahiri, A., *Brennst.-Chemie*, **38**, 305 (1957).

[3] Mazumdar, B. K., Chakrabartty, S. K., Saha, M., Anand, K. S., and Lahiri, A., *Fuel*, **38**, 469 (1959).

[4] Mazumdar, B. K., Chakrabartty, S. K., and Lahiri, A., *J. Sci. Indust. Res.*, **16**, B, 275 (1957).

[5] Mazumdar, B. K., and Lahiri, A., *Fuel*, **37**, 495 (1958).

[6] Chakrabartty, S. K., Mazumdar, B. K., and Lahiri, A., *Fuel*, **37**, 498 (1958).

[7] Chakrabartty, S. K., Mazumdar, B. K., Roy, S. N., and Lahiri, A., *Brennst.-Chemie*, **41**, 5, 138 (1960).

[8] Mazumdar, B. K., Choudhury, S. S., Chakrabartty, S. K., and Lahiri, A., *J. Sci. Indust. Res.*, 19, *B*, 509 (1958). Mazumdar, B. K., Chakrabartty, S. K., Choudhury, S. S., and Lahiri, A., Symp. Proc. Nature of Coal, Central Fuel Research Institute, India, Feb. 1959, 219.

Simultaneous Measurement of Adsorption and Electrodekinetic Parameters at Metal Surfaces

A RECENT communication by Blomgren and Bockris[1] described a radiochemical technique for the measurement of adsorption on metal surfaces, the metal being deposited on the mica window of a gas proportional counter. The metallized window serves as an electrode at which adsorption and the usual electrodekinetic parameters may be measured simultaneously. An obvious disadvantage of the above method, the introduction of a counter into an electrolytic cell, has been avoided by a technique developed in this Laboratory for the study of the poisoning by antimony of the hydrogen evolution reaction on nickel. The method employs radioactive adsorbates in conjunction with the 'transparent-cathode' technique of Joliot[2]. The latter required modification in detail but not in principle.

The technical problem was to find a simple method of placing a thin metal window on a glass vessel in such a way as to obtain a water-tight seal without introducing any source of impurity into the cell. It was found that the desired result could be obtained by holding annealed gold foil against a heavy, polished lip of a circular aperture by mechanical means only. A cross-section through such an aperture in the base of a spherical 'Pyrex' flask is shown in Fig. 1a. The foil (nickel-plated in this case) is held in a nickel 'holder' (hatched region) in which it had previously been annealed. The holder is shown in plan in Fig. 1b, the cross-section shown in (a) being taken through the dotted line. The upper and lower parts of the brass clamp, Fig. 1a, are held together by four bolts threaded into the upper, horse-shoe shaped, part. The foil is placed directly against the polished glass lip and the mechanical pressure is transmitted through a rubber washer and a rubber ring, shown in solid black cross-section. The foil used in the present work was 1/100 mm. thick and supported readily 50 cm. of water on an unsupported area of 2 cm.^{2}. Thinner foil could undoubtedly be used, if it can be found free from pin-holes.

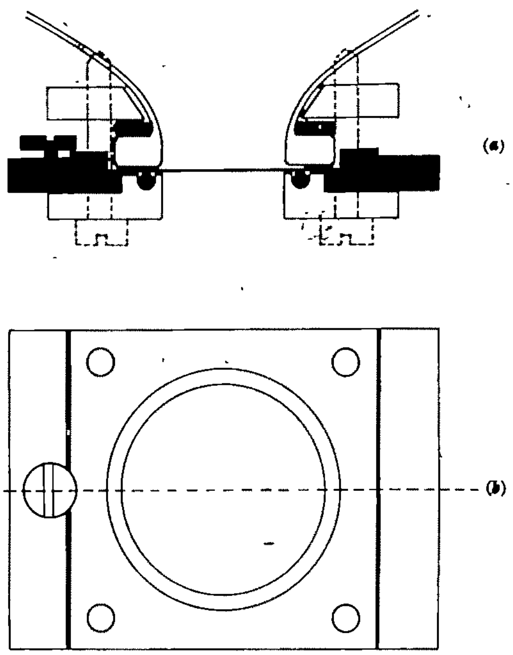


Fig. 1. *a*, Gold-foil window clamped in position; *b*, nickel holder for annealing foil

The above device permits simultaneous measurement of over-potential and amount of radiopoison adsorbed on the electrode. Some typical results are shown in Fig 2, for the poisoning by antimony of cathodic hydrogen evolution on electrodeposited nickel in 0·1 *N* sulphuric acid solution. The solution had been purified by pre-electrolysis before coming into contact with the nickel-plated foil. Fig. 2 shows the increase in cathodic overpotential for a given current (5×10^{-4} amp.cm.$^{-2}$) as a function of the amount of antimony (marked with antimony-124) adsorbed on the cathode. It was shown experimentally that the background due to antimony-124

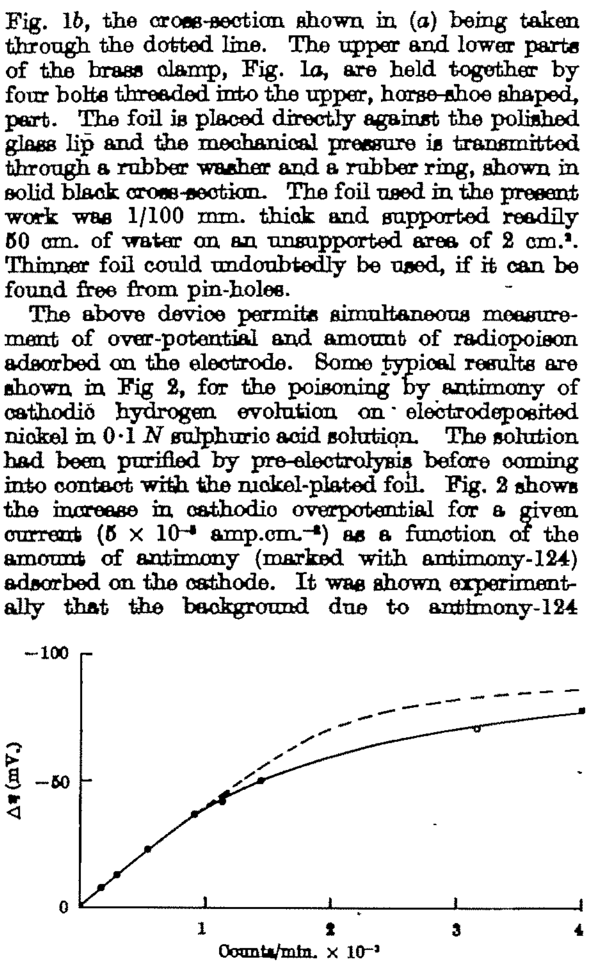


Fig. 2. Variation of over-voltage with amount of antimony adsorbed; - - -, theoretical; ——, experimental

dispersed in solution (400 ml.) was negligible. The theoretical curve, Fig. 2, was made to coincide with the initial part of the experimental curve by assuming that one atom of antimony deposited on a pure nickel surface alters the hydrogen-evolution characteristics of $2 \cdot 6\gamma$ surface nickel atoms, where $\gamma > 1$ is the surface roughness factor. Experimental details and theory will be given elsewhere.

A. M. PEERS

Laboratoire Curie,
Institut du Radium,
11 Rue Pierre-Curie, Paris, 5.

[1] Blomgren, E. A., and Bockris, J. O'M., *Nature*, 186, 305 (1960).

[2] Joliot, F., *J. Chim. Phys.*, 27, 119 (1930).

MR. PEERS presents a solution to the technical problem of mounting a metal film in contact with a solution in such a way that cements, etc., do not cause contamination of the solution. Mr. Peers's solution of this problem is not compatible with the gradual approach of solution to the metal surface which is a characteristic feature of the method described by us. This method of gradual approach is necessary when the solution background exceeds a small fraction of the radiation from the adsorbed amount (Fig. 1 in our communication). However, Mr. Peers points out that the background from his solution was negligible compared with the activity of the adsorbed amount. Simple computation indicates that the maximum concentration of adsorbable species in the solution has to be smaller than about 10^{-6} mole $l.^{-1}$ in Mr. Peers's method. Our technique enables determinations of adsorbed amounts (with a precision of 0·1 of a monolayer) up to concentrations of adsorbate in the solution of about 10^{-3} mole $l.^{-1}$.

It may be mentioned that the problem of bringing the metal film in contact with the solution without causing contamination to the solution has also been solved by us, though in a different way from that now described by Mr. Peers. One method used by us consists in mounting the metal foil flush on a holder in such a way that the foil covers the edges and sides of the holder. Another technique consists of evaporating a metal film on a mica foil fused to the edges of a glass cylinder which surrounds the counter, using a low-melting glass. These details were excluded from our brief communication. A full account of the results will be published elsewhere.

E. A. BLOMGREN

Stanford Research Institute
Southern California Laboratories,
South Pasadena, California.

J. O'M. BOCKRIS

John Harrison Laboratory of Chemistry,
University of Pennsylvania, Philadelphia, 4.

Structure of the Trinuclear Basic Acetates

THE trivalent metal ions, for example, Cr^{3+}, Fe^{3+} and Al^{3+} form a variety of basic acetates which are usually supposed to contain complex ions of the type $[M_3(Ac)_6(OH)_2]^+$ (refs. 1 and 2). In addition, a very few compounds containing only one hydroxyl group have been described[3]. The whole group of compounds is of considerable interest in view of their unusual magnetic properties[3,4].

The following are among the most significant findings of the many studies which have been reported. (1) The great majority of compounds contain six or more acetate groups for each group of three metal ions. (2) Trinuclear complexes are formed only if the complex ion can be formulated to contain either hydroxyl groups or water molecules, that is, one cannot replace 'hydroxyl' groups by halide ions. (3) Strong magnetic interactions occur between the metal ions[3,4].

Here I wish to propose a structure for the group of compounds based on the experimental evidence. First, we suppose that each metal ion is octahedrally co-ordinated by negative ions or polar molecules, for this is the only type of co-ordination known for the Cr^{3+} ion. This excludes structures related to that of the cupric acetate dimer involving direct metal–metal bonds. Next, we remember that magnetic interactions between metal atoms joined by one or two hydroxyl groups, for example, between Cr^{3+} ions, are usually weak while interactions via oxide ions are often strong[5]. Finally, we note that acetate groups often link pairs of metal atoms, as in basic beryllium and zinc acetates[6].

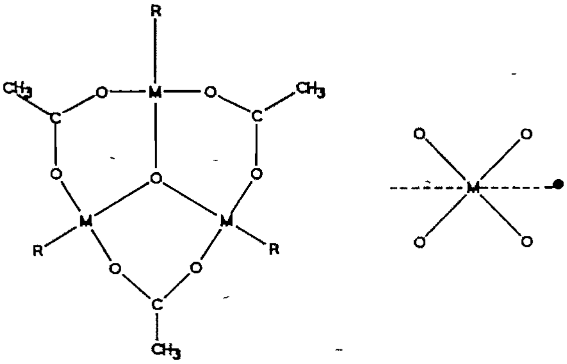


Fig. 1. Proposed structure for the $[M_3(Ac)_6O]^+$ ion: *a*, projected on to the M_3O plane; *b*, seen along an M—O direction, the dotted line indicating the M_3O plane

These considerations suggest that the structure basic to the whole group of compounds may be represented as in Fig. 1. The three metal atoms are arranged in an equilateral triangle about a central O^{--} ion. The positions *trans* to the O^{--} ion may be occupied by any of the ligands normally associating with trivalent transition-metal ions, for example, water, amines, further acetate groups and halide ions. By varying these groups a variety of different complexes can be obtained. The six acetate groups complete the octahedral co-ordination about the metal ions, each one lying completely to one side of the plane of the metal ions and linking a pair of them. A simple geometrical construction shows that this structure builds very nicely if the usual bond-lengths are assumed.

The proposed structure is closely related to that of basic beryllium acetate. It differs in that the central O^{--} ion is trigonally rather than tetrahedrally co-ordinated. (Trigonally co-ordinated O^{--} ions occur in the rutile type oxides TiO_2 (ref. 6), etc.) The apparent requirement for at least one hydroxyl group in the complex is explained if it is assumed that it is really an O^{--} ion which is involved; if OH^- were really present as such it is difficult to see why it should not be replaced, for example, by halide ions.

While other structures are possible, for example, the metal ions might lie at the vertices of an equilateral triangle with two hydroxyl groups, one above and one below the centroid of the triangle, none builds so neatly.

L. E. Orgel

Department of Theoretical Chemistry,
University Chemical Laboratory,
Lensfield Road, Cambridge.

[1] "Gmelins Handbuch der Chemie", System No. 50 (1938).

[2] Starke, K., *J. Inorg. and Nucl. Chem.*, 13, 254 (1960).

[3] Welo, L. A., *Phil. Mag.*, 6, 481 (1928).

[4] Wucher, J., and Gijsman, H. M., *Physica*, 20, 361 (1954).

[5] Wilmarth, W. K., Graff, H., and Justin, S. T., *J. Amer. Chem. Soc.*, 78, 2683 (1956).

[6] Wells, A. F., "Structural Inorganic Chemistry", second ed. (Oxford Univ. Press, 1950).

Positions of Thorium and Uranium in the Periodic Table

Element 90 of the Periodic Table, thorium, ordinarily appears as the first element of the actinide series, appended below cerium at the bottom of Table 1. This construction gives the impression that thorium is the second member of a series starting with actinium in the scandium group, just as cerium is the second member of a series starting with lanthanum in the scandium group. From the point of view of alloying behaviour it is inconsistent to consider thorium as related to the scandium group. During the course of a continuing investigation into the alloying behaviour of scandium and titanium group elements with the platinum metals, it was noted that thorium behaves as if it were a member of the titanium group. Evidence is given in Table 1 in which the crystal structure of an intermetallic compound of composition AB_3 is identified in the usual manner by the prototype of the compound family. Crystal structure data pertaining to certain of these compounds have been published[1], and for the remainder will be published shortly.

Table 1. Crystal Structures of AB_3 Intermetallic Compounds

B element	Group IV *A* element				
	Ti	Zr	Hf	Th	U
Rh	Cu_3Au	Cu_3Au	Cu_3Au	Cu_3Au	Cu_3Au
Ir	Cu_3Au	Cu_3Au	Cu_3Au	—*	Cu_3Au
Pd	$TiNi_3$	$TiNi_3$	$TiNi_3$	$TiNi_3$	$TiNi_3$
Pt	Cu_3Au	$TiNi_3$	$TiNi_3$	$ThPt_3$	$MgCd_3$

B element	Group III *A* element				
	Sc	Y	La	Ho	Ac
Rh	Cu_3Au	—*	—*	—*	?
Ir	?	—*	—*	—*	?
Pd	Cu_3Au	Cu_3Au	Cu_3Au	Cu_3Au	?
Pt	Cu_3Au	Cu_3Au	—*	Cu_3Au	?

* No compound of AB_3 composition exists; in its place are two phases, one of which is a Laves phase, AB_2.

It is instructive to consider the series of AB_3 compounds in which the *B* element is palladium. Those compounds in which the *A* element is titanium, zirconium, hafnium, thorium or uranium all have the $TiNi_3$-type structure, but those in which the *A* element is scandium, yttrium, lanthanum or holmium have the Cu_3Au-type structure. Likewise, the elements titanium to uranium form a compound having the Cu_3Au-type structure when *B* is rhodium, but the *A* elements yttrium, lanthanum and holmium do not form any AB_3 compound with rhodium.

The recognition of the resemblance of thorium to titanium, zirconium and hafnium is not new. In fact, an older version[2] of the Periodic Table placed thorium, palladium and uranium in the titanium, vanadium and chromium groups, respectively. The evidence for such a construction was largely the crystal structure resemblance among the heavy elements.

A recent review by Makarov[3] discusses the similarity between the 5*f* elements (thorium and those following it) and elements of the titanium, vanadium and chromium groups. A major point made by Makarov is that the 5*f* elements exhibit a well-established resemblance to the titanium, vanadium and chromium group elements, but that this resemblance has been obscured by the more recent concept that the transactinium elements are characterized by the presence of electrons in the 5*f* shell. Makarov points out that the most convincing evidence for the similarity between thorium and uranium, and the titanium, vanadium and chromium group elements is the formation of continuous or extensive series of isomorphous solid solutions of β-thorium and γ-uranium with the body-centred cubic forms of titanium, zirconium, hafnium, niobium and molybdenum. It seems to me that this argument actually indicates a closer resemblance between uranium and zirconium than between uranium and molybdenum, because the extent of solid solubility is much greater in the uranium–zirconium system than in the uranium–molybdenum system. Furthermore, my newly reported results and other recent data mentioned below do not support the earlier point of view that uranium resembles the chromium group elements. I have found a compound URh_3 of Cu_3Au-type, but it has been shown[4] that there is no $MoRh_3$ compound of the Cu_3Au-type. Previous work[5] had established a compound UPd_3 of the $TiNi_3$-type, but no $MoPd_3$ (ref. 6) compound was reported.

In summary, the data on AB_3 compounds discussed above indicate that both thorium and uranium resemble the titanium group elements, and furthermore that uranium bears little resemblance to molybdenum of the chromium group. It is considered that the concept in which both thorium and uranium are members of the titanium group is not inconsistent with the 'thoride' hypothesis advanced by Zachariasen[7], according to which thorium, not actinium, is the parent element of the heavy-metal series.

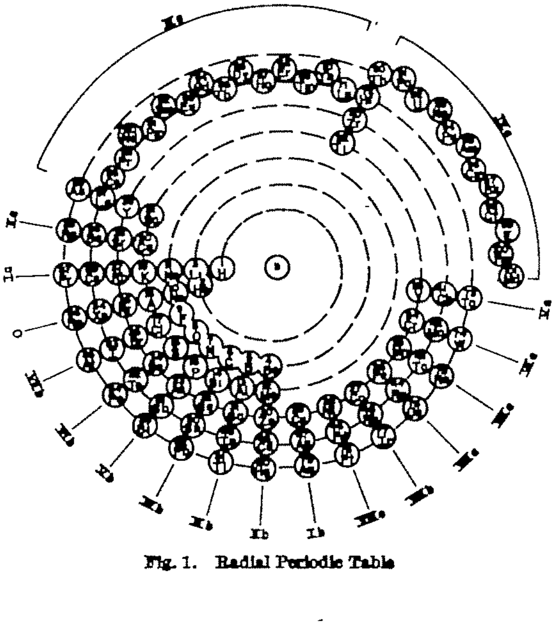


Fig. 1. Radial Periodic Table

It is thought that a Periodic Table which is realistic from the point of view of transition alloy behaviour should show thorium in a dual role, first as a member of the titanium group and secondly, as the parent of a thoride series. A possible form of such a diagram is shown in Fig. 1. There are two major advantages to this radial form of the Table. First, the lanthanide and thoride series are shown in their proper groups, rather than appended. Secondly, no implication is made that the thorides are a 'heavy rare earth' series. (It is recognized that evidence exists for considering the elements from americium on as related to the lanthinides.) An admitted disadvantage of the radial form is the dissimilarity to the familiar and useful rectangular table.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

A. E. DWIGHT

Argonne National Laboratory,
Argonne.

[1] Dwight, A. E., and Beck, P. A., *Trans. Amer. Inst. Mech. Eng.*, 215, 976 (1959).

[2] Deming, H. G., "General Chemistry" as quoted in twenty-third ed., "Handbook of Chemistry and Physics" (1959).

[3] Makarov, E. S., "Crystal Chemistry of Simple Compounds of U, Th, Pu and Np" (1958).

[4] Raub, E., *Z. Metallk.*, 45, 23 (1954).

[5] Heal, T. J., and Williams, G. I., *Acta Cryst.*, 8, 494 (1955).

[6] Haworth, C. W., and Hume-Rothery, W., *J. Inst. Metals*, 87, 265 (1959).

[7] Zachariasen, W. H., "Crystal Chemistry of the 5f Elements" in "The Actinide Elements", Seaborg, G. T., and Katz, J. J. (1954).

BIOCHEMISTRY

Phosphoproteins and Mitochondrial and Cell Water

IN previous communications[1,2] it was shown that several antihistamine drugs in concentrations which do not affect respiration or phosphorylation reduce the rate of swelling of isolated mitochondria and also diminish the rate of extrusion of water by these particles. It was found that the drugs greatly reduce the rate of turnover of phosphoprotein phosphorus in such systems.[2] This work has now been extended, and it has been found that a variety of agents which affect mitochondrial swelling and 'contraction' also affect the phosphorylation of proteins. A similar relation appears in liver slices taking up and extruding water under appropriate conditions. Amytal and azide inhibit mitochondrial 'contraction'[3], whereas 2,4-dinitrophenol does not. Phosphoprotein–phosphorus falls to low levels during swelling, and compounds which prevent this change preserve the phosphoproteins; this, however, might be a secondary phenomenon. During 'contraction' there is phosphorylation of protein; this is shown in Table 1, which also shows the effects of amytal, azide, 2,4-dinitrophenol and 'Phenergan', a phenothiazine antihistamine drug. It will be seen that there is a correlation between the increase in optical density of the mitochondrial suspension and the phosphorylation of protein. If the time-course of 'contraction' is followed, there is a close correlation between these two processes. Furthermore, if the mitochondria are allowed to re-swell, this event is preceded by a fall in phosphoprotein-level, even in the presence of excess adenosine triphosphate.

If liver slices are incubated anaerobically at 38° for 30 min., they take up water, which is extruded on admission of oxygen. 'Phenergan', which is known to protect liver slices from certain types of injury[3,4], inhibits this extrusion of water in much the same manner as it reduces mitochondrial 'contraction'. In Table 2 is shown an experiment with such a system. It can be seen that a diminution of extrusion of water by the drug is accompanied by failure to phosphorylate protein, though adenosine triphosphate-levels are the same as in the control. This relationship has been observed under other conditions in which extrusion of water is prevented (for example, after prolonged anoxia) even though adenosine triphosphate synthesis occurs normally. If phosphorus-32 is present in the medium, the phosphoprotein–phosphorus turns over rapidly, the specific activity of the newly formed phosphoprotein approaching that of the newly formed adenosine triphosphate within 60 min. 'Phenergan' greatly reduces the rate of turnover, but these experiments are complicated by the compartmentalization of inorganic phosphate and adenosine triphosphate within the cell. It should be noted that, under certain conditions, the antihistamine drugs will protect liver slices and permit water extrusion and potassium accumulation in circumstances in which the controls will do neither. This has been excellently demonstrated by McLean[4] for slices cut from the liver of vitamin E-deficient rats. This effect is a further complication in work with slices. It may represent protection of the phosphorylating system by inhibitor.

Table 1. EFFECT OF INHIBITORS OF MITOCHONDRIAL 'CONTRACTION' ON PROTEIN PHOSPHORYLATION

Mitochondria isolated in 0·25 M sucrose containing 10^{-3} M versene were swollen by suspension in 0 02 M trihydroxymethylaminomethane hydrochloride, pH 7·2 for 90 min. Mitochondria derived from 500 mgm. liver placed in a system containing 3×10^{-3} M adenosine triphosphate, 3×10^{-3} M manganese chloride and final volume 10 ml. Change ΔE in optical density was observed in optical cells of 1 mm. light-path. Temperature, 20°. For phosphoprotein determination, the method of Schmidt and Thannhauser was adapted for estimation of small amounts of inorganic phosphate liberated from phosphoprotein by alkaline hydrolysis

Mitochondria	ΔE/20 min.	Phosphoprotein–phosphorus (μgm./gm. original liver)	ΔP
Initially swollen	—	1·84	—
Control	0·176	5 24	3·4
2,4-Dinitrophenol (10^{-4})	0 170	4 64	2·8
'Amytal' (10^{-3} M)	0·060	2·7	0·86
Azide (2×10^{-3} M)	0·018	2·20	0 36
Initially swollen	—	3 20	—
Control	0·150	6·00	2·80
'Phenergan' (10^{-4})	0·082	4·40	1 20

It may be argued that phosphoprotein-levels merely reflect adenosine triphosphate-levels, much as in the case of phosphocreatine. Against this view is the fact that there is considerable excess of adenosine triphosphate in the mitochondrial experiments. In the slice, however, such an explanation is more likely, since the levels of adenosine triphosphate and phosphoprotein are of the same order; but there is no evidence from *in vitro* studies with cell-free preparations or slices that 'Phenergan' interferes with adenosine triphosphate synthesis or turnover-rates at the concentrations used.

It is therefore suggested that there is a direct relationship between movement of water and phosphorylation of protein, both in mitochondria and in whole cells. It is also suggested that the reactions regulating these processes are:

$$\text{ATP} + \text{protein} \rightleftarrows \text{ADP} + \text{phosphoprotein} \quad (1)$$

$$\text{ATP} \rightarrow \text{ADP} + \text{inorganic phosphate} \quad (2)$$

$$\text{phosphoprotein} \rightarrow \text{protein} + \text{inorganic phosphate} \quad (3)$$

Table 2. EFFECT OF 'PHENERGAN' ON WATER EXTRUSION, ADENOSINE TRIPHOSPHATE- AND PHOSPHOPROTEIN-LEVELS OF SLICES

Slices about 200 mgm. wet weight were placed in Krebs–Ringer, containing sodium bicarbonate and gassed for first 30 min. with 95 per cent nitrogen–5 per cent carbon dioxide. For aerobic recovery, the gas was 95 per cent oxygen–5 per cent carbon dioxide. Temperature, 38°. Slices were removed from vessels, blotted and weighed, then dried at 105°. For adenosine triphosphate and phosphoprotein determinations, duplicate slices were used, the whole flask contents being deproteinized and homogenized. 'Phenergan' at 10^{-4} *M* was placed in the flasks at the start of aerobic recovery

Slice	Percentage of dry weight Control	 10^{-4} *M* 'Phenergan'	Adenosine triphosphate (μmoles P/gm. wet weight) Control	 10^{-4} *M* 'Phenergan'	Phosphoprotein–phosphorus (μmoles P/gm. wet weight) Control ΔP	 10^{-4} *M* 'Phenergan' ΔP
Initial	28·0	—	1·7	—	1·00	—
30-min. anoxia	21·0	—	0·54	—	0·54	—
30-min. oxygen	22·0	23·0	0·87	0·72	0·76 (0·22)	0·63 (0·09)
60-min. oxygen	24·0	23·0	1·05	1·10	0·80 (0·26)	0·65 (0·11)
90-min. oxygen	25·0	23·0	1·25	1·20	0·76 (0·22)	0·65 (0·11)

All these reactions occur in liver mitochondria and slices. It is to be noted that reaction 2 will degrade phosphoprotein by causing reversal of reaction 1, and that reactions 1 and 3 together can constitute an adenosine triphosphatase. Reactions 2 and 3 will therefore act in concert to catalyse cell degradation under unfavourable conditions. Inhibition of any one of the three reactions will tend to protect. The results so far available suggest reaction 1 as the site of action of the antihistamines, but this itself may be a complex system.

Finally, 'Benadryl' and 'Phenergan' afford potent protection against mitochondrial swelling due to glutathione and much reduce the rate of swelling induced by β-hydroxybutyrate; this again suggests the attractive idea that the single mechanism underlies all these abnormal shifts of water. The importance of the system inhibited by the drugs is illustrated by the fact that they protect rats against liver injury due to thioacetamide[5] and to nutritional deficiency[6], and will also protect mice against murine hepatitis virus[7].

This work has been supported in part by United States Public Health Service grant No. C-4534 and by Chas. Pfizer and Company, Inc.

J. D. JUDAH

Wistar Institute of Anatomy and Biology,
Philadelphia, Pa.

---

[1] Judah, J. D., *Nature*, 185, 390 (1960).

[2] Judah, J. D., *Exp. Cell Res.*, 19, 404 (1960).

[3] Lehninger, A. L., *J. Biol. Chem.*, 234, 2465 (1959).

[4] McLean, A. E. M., *Nature*, 185, 191 (1960).

[5] Gallagher, C. H., Gupta, D. N., Judah, J. D., and Rees, K. R., *J. Path. Bact.*, 72, 193 (1956).

[6] McLean, A. E. M., *Nature*, 185, 936 (1960).

[7] Judah, J. D., Bjotvedt, G., and Vainio, T., *Nature* (in the press).

Protection against Liver Injury due to Murine Hepatitis Virus

PREVIOUS work has shown that antihistamine drugs protect against liver injury caused by a variety of agents[1] both in the whole animal and *in vitro*. Judah has also shown that these compounds inhibit mitochondrial swelling *in vitro*, and has indicated a possible mechanism of action[1,2]. McLean[3] has shown that the antihistamine 'Phenergan' will protect rats against nutritional liver necrosis and has demonstrated *in vitro* effects of this drug with slices cut from the livers of rats on necrogenic diets.

In the present communication, it is shown that the antihistamine drug 'Benadryl' affords significant protection to mice infected with murine hepatitis virus (MHV 3) (Dick, Niven and Gledhill[4]). In addition, mouse liver macrophages and parenchymal cells grown in organ culture (Bang and Warwick[5]) were protected by 'Benadryl' from the cytolytic effect of the hepatitis virus.

The murine hepatitis virus was obtained from Dr. Gledhill and inoculated intraperitoneally into adult *C 57/Bl* 6 mice in this laboratory. When these mice became ill, they were killed and their livers made into suspensions as a source of virus inoculum in subsequent experiments. The *LD*50 of virus necessary to cause deaths in the mice within 5 days was established, and it was also found that this dose killed nearly all the animals within 7 days after infection. If 'Benadryl' was administered at the same time as the virus, and a dose of 100 mgm./kgm. body-weight given daily throughout the experiment, a substantial diminution of the number of deaths was found. Table 1 shows the results of this protection experiment. On analysis, it is found that *P* is less than 0·001 even on the seventh day of the experiment, so that protection is highly significant. Subsidiary tests for protection were also used: thus the level of blood malic dehydrogenase was determined at intervals during such experiments (Table 2) and it was found that both 'Benadryl' and 'Phenergan' prevented the marked rise of this enzyme in the serum which is associated with liver injury.

The livers of mice treated with 'Benadryl' and of control mice were also examined histologically. The earliest change is a focal necrosis, clearly seen on the third day, but already present on the second day. This stage is indistinguishable in both groups of mice. However, by the fourth day, the control mice showed confluent areas of necrosis, all liver lobules being affected, and many completely destroyed. In contrast, the mice treated with 'Benadryl' showed very marked preservation of the liver, the lesions still retaining their focal character.

Virus concentration in the livers of treated and control mice was determined on the fourth day after

Table 1. PROTECTION OF MICE AGAINST MOUSE HEPATITIS VIRUS 3. The animals were randomly selected male *C* 57 black mice, weight range 20–22 gm. They were inoculated intraperitoneally with 0·05 ml. of liver suspension and at the same time, where indicated, 'Benadryl' was injected subcutaneously in the appropriate dose

Treatment	No. of animals inoculated	Survivors on day: 5	 6	 7
Control	68	34	21	11
'Benadryl' (100 mgm./kgm.)	61	48	38	26

Table 2. BLOOD SERUM-LEVELS OF MALIC DEHYDROGENASE

Treatment	No. of animals	Malic dehydrogenase, as μmoles DPN reduced/ml. serum/hr.
Controls	4	10·0 (range 7–12)
MHV 3	5	30·0 (range 23–36)
MHV 3, and treated with 'Benadryl'	5	18·0 (range 14–20)

inoculation, when mice in both groups were killed and their livers made into suspensions which were inoculated intraperitoneally, in serial dilutions, into other mice. The results revealed substantially the same concentration of virus in livers from mice treated with 'Benadryl' and control animals, which implies that the effect of the drug was to prevent necrosis of the liver cell, rather than to act directly on the virus. This is in keeping with the hypothesis[2] that the antihistamines inhibit a general mechanism of degradation.

In order to simplify the work, organ cultures of mouse liver on reconstituted collagen were infected with mouse hepatitis virus according to the technique of Bang and Warwick (whose medium was modified to contain 30 per cent of a mixture of calf serum and chick embryo extract in the proportions of 3 : 1). It was found, in keeping with their results, that macrophages are first destroyed by this virus within 24–28 hr. after infection, but that two days later lesions caused by virus also appeared in the hepatic cells, ultimately destroying the entire culture. 'Benadryl' afforded complete protection against injury to both types of cell, in concentrations of 10^{-4}–10^{-6} *M* when added at the same time as the virus. The same protection was observed by the addition of anti-mouse hepatitis virus 6 immune mouse serum, whereas normal mouse serum was without effect.

The presence of hepatitis virus in cultures was determined by inoculation of culture fluids and cells, respectively, into *C57/Bl* 6 mice. Virus was always recovered from control cultures even after several passages through mouse liver organ cultures, but culture fluids from cultures treated with 'Benadryl' showed only minimal amounts of virus. These findings are being further investigated.

It is possible that necrosis of liver cells in an animal infected with hepatitis virus is not directly caused by multiplication of the virus within the cell. 'Benadryl' prevents or delays considerably the necrosis of the cell, but has little or no effect on multiplication of the virus in liver tissue of infected animals. This is supported by the fact that the livers show the same amount of virus present in both groups of animals at the very time that histological and biochemical observations indicate a considerable reduction in the death of cells in the treated animals. This concept may undergo revision in the light of results obtained in organ cultures. However, the results also support the view of a general mechanism of liver injury. This may be taken to involve the system responsible for the maintenance of water and electrolyte balance in the whole cells and possibly the mitochondria, and the inference is supported by the work of McLean and of Judah already cited.

This work has been supported in part by United States Public Health Service grant No. *C*-4584 and by Chas. Pfizer and Co., Inc.

J. D. Judah
G. Bjotvedt
T. Vainio

Wistar Institute of Anatomy and Biology,
Philadelphia, Pa.

---

[1] Gallagher, C. H., Gupta, D. N., Judah, J. D., and Rees, K. R., *J. Path. Bact.*, 72, 193 (1956).

[2] Judah, J. D., *Nature*, 185, 390 (1960); *Exp. Cell Res.*, 19, 404 (1960).

[3] Judah, J. D., *Nature* (preceding communication).

[4] McLean, A. E. M., *Nature*, 185, 191 and 936 (1960).

[5] Dick, C. W. A., Niven, J. S., and Gledhill, A. W., *Brit. J. Exp. Path.*, 37, 90 (1956).

[6] Bang, F. B., and Warwick, A., *Virology*, 9, 716 (1959).

Selective Cytochemical Demonstration of Arginine Groups in Nucleoprotein in the Cell Nucleus

USEFUL information should accrue from cytochemical measurements of the arginine contained in the basic proteins linked to deoxyribonucleic acid in the nucleus. The specific Sakaguchi reaction for arginine has been modified for microspectrophotometry[1].

The main obstacles to its reliable exploitation for the purpose mentioned are: (i) the contribution of arginine groups not involved in the deoxyribonucleic acid–protein complex; (2) the stain in surrounding cytoplasm, necessitating the use of isolated nuclei, with concurrent artefacts; (3) removal of material from the specimen by the strongly alkaline reagent mixture.

We have examined the effect of prior anhydrous benzoylation[2] on this reaction, and the applicability of freeze-drying and freeze-substitution which would minimize some fixation artefacts[3]. Benzoyl chloride reacts at cytoplasmic protein groups but leaves certain nuclear groups unblocked[2,4].

We find that when anhydrous benzoylation (2–3½ hr.) is applied to tissue specimens and is followed by the Sakaguchi procedure[1], the colour reaction of arginine groups is completely prevented in the cell cytoplasm, while a definite nuclear reaction persists. This holds true (with one exception noted later) for all material so far examined, namely, sections or smears from many tissues (and sperm) from rat and mouse, as well as locust testis and root tips of *Vicia* and *Trillium*. Frozen-dried, frozen-substituted and Lewitsky-fixed specimens all give this characteristic effect after benzoylation. Measurements on rat liver made thus will be reported elsewhere[5]. *p*-Nitrobenzoyl chloride[4] produces a similar result.

A complication in the interpretation of the results of the normal Sakaguchi method itself is shown by our further observation that frozen-dried or frozen-substituted tissues, fixed in sections or smears by absolute ethanol and treated by the Sakaguchi method alone, show in general no nuclear reaction, either by eye or two-wave-length spectrophotometry, except in the sperm head. A normal reaction is seen in the cytoplasm. This is in contrast to the relatively strong nuclear reaction found after various chemical fixatives, for example, in Lewitsky's fluid, and raises the question of diffusion artefacts in the fixation and reaction. This has been examined by interference microscope measurements of the changes in dry mass of cell nuclei exposed to the Sakaguchi reaction mixture, after various initial treatments. The results (Table 1) show that the negative nuclear reaction in frozen-dried or frozen-substituted specimens is due to a very considerable removal of nuclear material in the strongly alkaline medium. This is largely extracted into the medium, although some may be adsorbed and contribute to the observed cytoplasmic reaction for arginine. Coating the specimen with 'Celloidin' does not prevent this loss. The extraction can be prevented either by benzoylation or, in part, by treatment with Lewitsky's fluid (Table 1). In the latter case there is an apparent greater retention after 'Celloidin' coating[4], although re-distribution of dissolved material under the 'Celloidin' film must then be a possible source of error. Results very similar to those in Table 1 have also been obtained on frozen-dried tissue sections (with and without benzoylation).

Table 1. CHANGES IN DRY MASS OF INDIVIDUAL CELL NUCLEI AFTER EXPOSURE TO SAKAGUCHI REACTION MEDIUM

Treatment*	Material†	No. of samples	No. of nuclei	Dry mass‡ of nucleus after exposure§ (per cent)
None	Mouse kidney	2	‖	<10
	Mouse liver	2		<10
	Rat liver	2		<10
	Mouse sperm heads	1	6	100
Benzoylated (2½–3 hr.)	Mouse kidney	1	6	95
	Mouse liver	3	12	99
	Rat liver	1	5	103
	Mouse sperm heads	1	3	105
Lewitsky (ref. 1)	Mouse kidney	3	10	63
	Mouse liver	1	3	40¶
	Mouse sperm heads	1	8	100
Lewitsky ('Celloidin' coated) (ref. 1)	Mouse kidney	1	6	76
	Rat liver	1	8	91

* All smears were initially frozen-substituted in methanol (minimum 24 hr.), then fixed in ethanol for ½–1 hr. (Extension of fixation to 24 hr. does not change the behaviour.)

† Smears containing whole cells and whole nuclei. Homogeneous nuclei of regular geometry were selected for measurement.

‡ Measured using Baker interference microscope, with half-shade eye-piece and × 100 shearing objective. Corrected for any change in measured area of nucleus. The same nucleus was measured in each case, in water, before and after treatment, and the final value expressed as percentage of the initial value. No significance is attached to changes of less than 10 per cent. (Means for all nuclei are recorded.)

§ Medium is 0·6 per cent sodium hydroxide (30 ml.) + 1·2 per cent sodium hypochlorite (1·2 ml.) + 70 per cent ethanol (1 ml.). Exposed 3 min., then washed with water.

‖ Exact measurements could not be performed here after exposure; all nuclei in the field were swollen and of extremely low dry mass. 'Celloidin'-coated samples gave the same results.

¶ Approximate only, due to considerable swelling.

These observations lead us to conclude:

(1) Benzoyl chloride, in the anhydrous medium, reacts at the guanidino groups of arginine (cf. ref. 7 for a similar benzoylation of arginine side-chains in isolated proteins). This reaction proceeds in the proteins in the cell cytoplasm, and probably in some nuclear proteins; but a certain fraction of nuclear protein arginine is unable to react with this reagent. This fraction alone is revealed by the subsequent Sakaguchi reaction which cannot proceed at acylated guanidino groups. The most probable reason for the non-availability of this nuclear arginine fraction is that these are the arginine side-chains considered to be bound in salt linkage[8] to deoxyribonucleic acid phosphate groups. It is presumed that these arginine side-chains, in contrast to those in other situations, are held in the charged form even in the anhydrous pyridine–acetonitrile medium and so cannot be acylated. However, all types of arginine side-chains are reactive in the Sakaguchi method due to discharge in the aqueous alkali which must (for this same reason) be employed.

Further evidence for the above interpretation is that, while the reaction is in general confined to the cell nucleus and, in fact, virtually to the chromosomes in dividing cells, a cytoplasmic reaction is also found in one case, namely, where a high accumulation of ribonucleoprotein is present, that is, in the basal strongly basophilic region of active pancreatic acinar cells (in contrast to the negative cytoplasm of neighbouring cells of other types), and also in certain plant root meristem cells. Presumably salt-linked arginine groups are present there, too. The blocking reaction is not sensitive to prior water treatment, as it is in the case of histidine groups[3,4], again consistent with a stable salt linkage. Prolonged benzoylation (18 hr.) does not abolish the reaction, that is, a merely kinetic difference is not involved.

(2) While it is preferable to employ freeze-drying or freeze-substitution, to avoid initial diffusion errors, these processes (followed by ethanol fixation) leave the nucleoprotein soluble in the alkaline medium, and this must be countered by treatment of the type described. Benzoyl chloride is presumably effective in this instance due to the insolubilizing effect of benzoyl groups introduced at other sites in the nucleoprotein (an effect we have confirmed on isolated calf thymus histone). Even after such treatment, the possibility of diffusion errors, below the limits of total mass measurements by interferometry of the present type, remains in the Sakaguchi method.

(3) The method described can be applied to tissue specimens without isolation of nuclei, for the microspectrophotometric measurement of the nuclear arginine fraction in question. Measurements to support and extend these observations will be reported elsewhere[5].

The plant material used was kindly supplied by Dr. J. Chayen and Mr. L. F. LaCour.

E. A. BARNARD
L. G. E. BELL

Department of Zoology,
University of London, King's College,
Strand, London, W.C.2.

[1] McLeish, J., Bell, L. G. E., LaCour, L. F., and Chayen, J., *Exp. Cell Res.*, 12, 120 (1957).

[2] Barnard, E. A., and Danielli, J. F., *Nature*, 178, 1450 (1956).

[3] Bell, L. G. E., in "Physical Techniques in Biological Research", 3, edit. by Oster, G., and Pollister, A. W. (Academic Press, New York, 1956).

[4] Barnard, E. A., in "General Cytochemical Methods", 2, edit. by Danielli, J. F. (Academic Press, New York, 1960; in the press).

[5] Barnard, E. A., and Looney, W. B. (in preparation).

[6] Baker, J. R., *Quart. J. Micro. Sci.*, 85, 1 (1944).

[7] Olcott, H. S., and Fraenkel-Conrat, H., *Indust. Eng. Chem.*, 38, 104 (1946).

[8] Wilkins, M. H. F., *Biochem. Soc. Symp.*, 14, 13 (1957).

Reversible Dissociation of Ribonucleic Acid

THE work reported here was prompted by the observation that when infectious ribonucleic acid, isolated from Ehrlich ascites cells infected with Mengo encephalomyelitis virus[1], was incubated with crystalline bovine plasma albumin in solutions of physiological ionic strength, its biological activity was lost or sharply inhibited. No loss of infectivity was observed when mixtures of these two substances were incubated in concentrated solutions of sodium chloride (0·6–1·0 *M*). However, infectivity was not regained when protein–ribonucleic acid mixtures in physiological saline were made 0·64 *M* with respect to sodium chloride. The biological activity of the Mengo ribonucleic acid and of the Mengo ribonucleic acid–bovine plasma albumin mixtures was assayed by a plaque method employing monolayers of Earle's *L* strain mouse fibroblasts[2].

The ribonucleic acid used in the experiments described here was isolated from Ehrlich ascites tumour cells by the phenol method previously described[3]. The fraction of high molecular weight was separated from material of low molecular weight by precipitation in 1 *M* sodium chloride. In the analytical ultracentrifuge this fraction showed two peaks with sedimentation velocities of 16–18 S. and 32–34 S., respectively, the component sedimenting

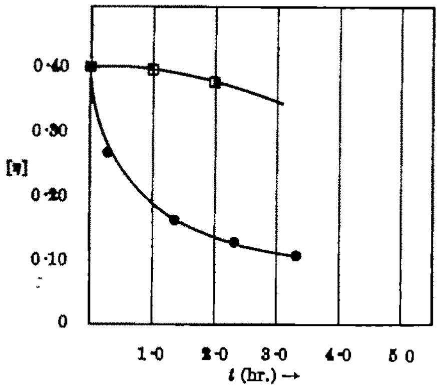


Fig. 1. Intrinsic viscosity of ribonucleic acid (1·2 mgm./ml.), —□—; and of a ribonucleic acid (1·2 mgm./ml.)–α-lactalbumin (5 mgm./ml.) mixture, —○— in physiological saline

more rapidly comprising 60–65 per cent of the total. All ultracentrifugal analyses were performed in the 'Spinco' model *E* ultracentrifuge, using either schlieren optics or ultra-violet absorption and the 'Analytrol' with the microanalyser attachment[4].

The interaction of ribonucleic acid with three different proteins, namely, bovine plasma albumin, bovine γ-globulin, and α-lactalbumin (kindly supplied by D. Martin Kronman, Eastern Regional Laboratories, United States Department of Agriculture) has been studied. Under the proper conditions, the admixture of protein and ribonucleic acid in solutions of physiological ionic strength results in the conversion of the 16 S. and 32 S. components or ribonucleic acid into components sedimenting more slowly. Since these changes in sedimentation properties are accompanied by a decrease in the viscosity and turbidity of the solutions, it seems reasonable to assume that they reflect a dissociation of the ribonucleic acid. The degree of dissociation depends on the protein used, the ratio of protein to ribonucleic acid concentration, and the absolute concentrations of each. The dissociation can be partially or completely reversed by making the solution 1 *M* with respect to sodium chloride or 0·01 *M* in magnesium sulphate. Neither the conversion of ribonucleic acid into slowly sedimenting components in physiological saline solution nor the regeneration of the rapidly sedimenting components occurs rapidly. At 4° C., 2–4 hr. are required for the first process, and a somewhat longer period is required for the second.

At concentrations of ribonucleic acid greater than 1 mgm./ml., bovine plasma albumin did not affect the sedimentation velocity of the nucleic acid. However, in a solution containing 20 and 400 μgm./ml. of ribonucleic acid and bovine plasma albumin, respectively, most of the nucleic acid was found to sediment with the bovine plasma albumin peak. The sedimentation constant of the latter increased from 4·3 to 5·1–5·3 S. The rapidly sedimenting components of ribonucleic acid were regained when the solution was made 1 *M* with respect to sodium chloride, or 0·01 *M* with respect to magnesium sulphate.

α-Lactalbumin is a protein with a molecular weight of 15–17,000 and a sedimentation constant of 1·6 S. Because of its small size, it is particularly well suited for studies of ribonucleic acid–protein interaction. Fig. 1 shows the changes in the intrinsic viscosity of a ribonucleic acid solution (1·2 mgm./ml.) when incubated with α-lactalbumin (5 mgm./ml.). Although incubation of the ribonucleic acid alone produced a decrease in the viscosity of the solution, it was slight compared with the very rapid decrease which resulted from addition of protein. In a similar mixture, incubated for 12 hr. at 4° C., a new peak with a sedimentation constant of 3·0 S. appeared. The addition of sodium chloride only partially reversed the dissociation.

It was possible to dissociate ribonucleic acid by means of bovine γ-globulin at all concentrations of ribonucleic acid and protein. The degree of dissociation depended on the ratio of protein to ribonucleic acid. At high ratios there was complete dissociation, and all the ribonucleic acid travelled with the protein peak in the ultracentrifuge. At lower ratios there was less dissociation. It was possible to reverse the dissociation in mixtures containing low concentrations of ribonucleic acid and a low ratio of protein to ribonucleic acid, while only partial reversal was obtained under other conditions.

In Fig. 2, the distribution of sedimentation constants observed by means of ultra-violet optics in a mixture containing 50 μgm./ml. bovine γ-globulin and 25 μgm./ml. ribonucleic acid is presented. The distribution shown in Fig. 2*A* was obtained after the mixture had stood for 2 hr. in 0·14 *M* sodium chloride, buffered at *p*H 7·0 with phosphate of ionic strength 0·01. At that time, an aliquot was made 0·01 *M* with respect to magnesium sulphate. The distribution in Fig. 2*B* was obtained with the latter aliquot 3 hr. after the addition of magnesium salt. Since the protein contributed only about 5 per cent of the optical density, the distributions are essentially those of the ribonucleic acid.

Our results suggest that ribonucleic acid exists in dynamic equilibrium with sub-units, and that the equilibrium is shifted towards dissociation by binding of the sub-units by protein. If this is true, it should be possible to demonstrate such an equilibrium without the use of protein. A partial separation of the 16–18 S. component in the ultracentrifuge by means of a partition cell[4] did give fractions the sedimentation properties of which changed with time so as to approach those of the original solution. The fractions were unstable and regenerated the high molecular weight (32 S.) peak only if fractionation had been inefficient.

One may sum up these findings by saying that the dissociation of ribonucleic acid is a reversible process if it is not carried too far. If it is assumed that the irreversible dissociation does not involve degradation,

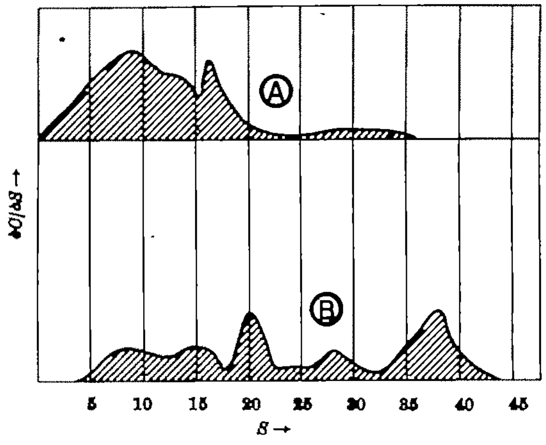


Fig. 2. Sedimentation distribution of two mixtures containing 50 μgm./ml. bovine γ-globulin and 25 μgm./ml. ribonucleic acid: (*A*) 3 hr. after mixing in physiological saline; (*B*) 6 hr. after mixing and 3 hr. after making the mixture 0·01 *M* with respect to magnesium ions

but rather a failure to re-assemble the molecule in a specific order by random processes, the measured sedimentation constant of 3·0 S. and intrinsic viscosity of 0·1 (Fig. 1) obtained with a mixture of ribonucleic acid and α-lactalbumin may be used to estimate the probable sub-unit size at 35–75 nucleotides. Considering only the reversible dissociation seen with bovine γ-globulin and bovine plasma albumin, the sedimentation results (Fig. 2) can be employed to estimate an upper limit of 200 nucleotides for the sub-unit size.

The results of Loring *et al.*[5] would suggest that the ribonucleic acid of tobacco mosaic virus is capable of reversible dissociation into sub-units, with retention of potential biological activity. The recovery of infectivity implies a specific re-assemblage of the ribonucleic acid molecules.

This work has been supported by grants from the National Institutes of Health (*C*-4534 and 2*G*-142-*C*1), the American Cancer Society (*E*-89), and the Samuel S. Fels Fund.

R. A. Brown
K. A. O. Ellem*
J. S. Colter

Wistar Institute of Anatomy and Biology,
36th Street at Spruce,
Philadelphia 4.

* Travelling Fellow of the N.S.W. State Cancer Council.

[1] Colter, J. S., Bird, H. H., and Brown, R. A., *Nature*, 179, 859 (1957).

[2] Ellem, K. A. O., and Colter, J. S., *Virology* (in the press).

[3] Colter, J. S., and Brown, R. A., *Science*, 124, 1077 (1956).

[4] Schachman, H. K., "The Ultracentrifuge in Biochemistry" (Academic Press, New York, 1959).

[5] Loring, H. S., Fujimoto, Y., and Eng, L. F., *Proc. U.S. Nat. Acad. Sci.*, 45, 287 (1959).

Carbohydrates of *Ecklonia radiata*

In connexion with our work on the chemistry of cellulose and related carbohydrates, it was found desirable to investigate certain properties of algal polysaccharides. In seeking a source of these materials we noted that Australian species of brown algæ appear to have received little chemical study, although the carbohydrates of *Ecklonia maxima*, *Laminaria pallida* and *Bifurcaria brassicaeformis* of South Africa have been investigated[1]. The northern hemisphere species, especially of the genus *Laminaria*, have been studied in considerable detail[2,3]: large seasonal variations occur in the contents of laminarin (0–30 per cent), alginic acid (10–30 per cent) and mannitol (0–30 per cent); the fucoidin content is low and less variable[3,4].

Recently we have made a preliminary study of the carbohydrate components of *Ecklonia radiata* (Ag.) J. Ag., which occurs in the sub-littoral zone of the southern coasts of Australia. Fresh whole seaweed, collected in autumn at Point Lonsdale, Victoria, was milled through breaker plates in a Bauer defibrator and the carbohydrates were extracted from the milled material with 1 per cent hydrochloric acid by a two-stage steeping treatment, essentially as described by Black *et al.*[5]. On allowing the solution to stand for several days, little or no insoluble laminarin was precipitated. One fraction (I) of polysaccharides was precipitated by the addition of ethanol to a concentration of 74 per cent, another (II) by further addition of ethanol to the supernatant to a final concentration of 85 per cent. The polysaccharides (I + II) were obtained in a yield of about 6 per cent by redissolving the precipitates in a small amount of water and triturating with ethanol and ether. Fraction I consisted of laminarin and fucoidin; fraction II almost entirely of laminarin. Fractional precipitation of I with ethanol gave only a partial separation of the soluble laminarin and fucoidin. However, part of the fucoidin could be removed on an anion-exchange resin (a similar method has been used by Unrau, A., and Smith, F.; personal communication), 'Duolite *A*4', after first passing the solution through 'Amberlite *IR*-120(H)' to remove calcium and other cations. A more satisfactory separation was achieved by treatment with cetyl trimethylammonium bromide. The polysaccharides were identified by infra-red spectroscopy and the components of their acid hydrolysates by chromatography, in some cases combined with infra-red examination of sugars eluted from chromatograms and freeze-dried.

Further work was done with samples collected in summer. Mannitol was extracted with butanol[1], and crystallized from butanol and from ethanol; it was characterized by chromatography, physical constants and infra-red spectroscopy. Alginic acid was obtained by alkaline extraction of plant material from which other carbohydrates had been removed. It was isolated as the free acid and sodium salt, which were compared with authentic samples. Analyses were carried out according to the methods developed by Cameron, Ross and Percival[6]. The average contents for December–January were found to be as follows:

	Laminae	Midrib*
Mannitol (per cent)	16	13
Alginic acid (per cent)	20	26
Laminarin (per cent)	5·4	1·8
Fucoidin (per cent)	1·0	1·2

* The 'midrib' is that portion of the frond, comprising the elongation of the stipe, from which the 'laminae' have been removed.

The seasonal variation in the content of the four carbohydrates is of interest in connexion with their biochemical function and possible utilization. This aspect of the work and others are receiving attention, and will be reported elsewhere. We wish to thank Miss S. Austin, Mr. K. J. Harrington and Mr. G. Davies for help with this work.

C. M. Stewart
H. G. Higgins

Division of Forest Products,
Commonwealth Scientific and Industrial
Research Organization, South Melbourne.

[1] Von Holdt, M. M., Lightelm, S. P., and Nunn, J. R., *J. Sci. Food Agric.*, 6, 193 (1955).

[2] Black, W. A. P., *J. Mar. Biol. Assoc. U.K.*, 29, 45, 379 (1950).

[3] Mori, T., "Advances in Carbohydrate Chemistry", 8, 315 (1953). (Review).

[4] Black, W. A. P., *J. Soc. Chem. Indust.*, 67, 165 (1948).

[5] Black, W. A. P., Cornhill, W. J., Dewar, E. T., and Woodward, F. N., *J. App. Chem.*, 1, 505 (1951).

[6] Cameron, M. C., Ross, A. G., and Percival, E. G. V., *J. Soc. Chem. Indust.*, 67, 161 (1948).

Fatty Acid Composition of the Lipids of Pasture Grasses

Little information is available on the total fatty acid composition of pasture grass lipids. Shorland[1,2] reported that the fatty acids of the acetone-soluble lipids of cocksfoot grass and of rye grass grown in New Zealand comprised about 3 per cent of the dry matter of the grass; ester-fractionation analysis showed that saturated acids (mostly palmitic) accounted for less than 20 per cent of the total acids and that the remaining unsaturated acids consisted largely of linoleic and linolenic acids. Details were not given of the analysis of the fatty acids of the acetone-insoluble lipids (phospholipids), though it was stated[1] that those from cocksfoot grass resembled the fatty acids of the corresponding acetone-soluble lipids, except for a somewhat lower mean unsaturation of the C_{18} unsaturated components. In earlier work Smith and Chibnall[3] isolated the phospholipid fatty acids of cocksfoot grass and showed that they consisted mainly of linoleic, linolenic and saturated components. Contrary to the assumption hitherto made that the acetone-soluble lipids of forage grasses are mainly triglycerides, plus unsaponifiable matter, Weenink[4] has recently shown that about 60 per cent of this lipid fraction of New Zealand grasses consists of galactosyl glyceryl esters of fatty acids, largely linolenic acid.

As part of investigations on the fate of dietary lipids in the rumen of the sheep a detailed analysis was made of the total fatty acids of artificially dried milled grass containing about 50 per cent of perennial ryegrass, 25 per cent of cocksfoot, 15 per cent of timothy grass and 10 per cent of Italian ryegrass grown in Aberdeenshire and cut in July 1959. The material was exhaustively extracted successively with hot 95 per cent ethanol and hot chloroform–methanol (2 : 1 by vol.). The lipids in each extract were hydrolysed with ethanolic potassium hydroxide, unsaponifiable matter was removed and the fatty acids were recovered. The fatty acids obtained from the ethanolic extract and from the chloroform–methanol extract, respectively, represented 2·02 and 0·27 per cent of the dried grass and hence 88·2 and 11·8 per cent of the total fatty acids.

Each group of fatty acids was converted to methyl esters for analysis by gas chromatography, employing polymerized ethylene glycol succinate (prepared as for the adipate[5]) as liquid phase at 170° C. and argon as carrier gas. In Table 1 is shown the composition of each group of acids and the resultant composition of the total fatty acids of the grass lipids.

Table 1. FATTY ACID COMPOSITION OF PASTURE GRASS LIPIDS
(Values as percentage by weight of total acids in each group)

Acid	Source of fatty acids		Total fatty acids
	Lipids extracted with ethanol	Lipids extracted with chloroform–methanol	
Myristic	1·2	0·8	1·1
Palmitic	14·4	26·8	15·9
Palmitoleic	2·5	2·6	2·5
Stearic	1 7	4·4	2·0
Oleic	3·2	5·1	3·4
Linoleic	12·8	15·4	13·2
Linolenic	64·2	39·6	61·3
Arachidic	—	2·1	0·2
Behenic	—	3·2	0 3

The two groups of fatty acids contributing to the total acids are broadly similar in composition, though the lipids of the chloroform–methanol extract contain relatively more palmitic acid and less linolenic acid than the lipids of the ethanol extract and, in addition, are characterized by the presence of small amounts of arachidic and behenic acids. The total fatty acid composition resembles closely that of the leaf lipids of maize[6] (another graminaceous plant) and also that of the lipids of clover-rich pasture[7]. Linolenic acid is the outstanding component, and the unsaturated C_{18} acids together make up more than 75 per cent of the total acids; of the saturated fatty acids present, palmitic acid predominates.

The lipids in each of the two extracts of the dried grass were subjected to a preliminary fractionation. The ethanol-soluble lipids were subjected to chromatography on silicic acid (cf. Garton and Duncan[8]); a fraction eluted with 5 per cent ether in light petroleum contained free fatty acids and neutral lipid. The free acids were isolated and found to comprise 13·5 per cent of the total fatty acids of the grass; their composition is shown in Table 2. Following saponification and removal of unsaponifiable matter, fatty acids accounted for 92 per cent of the remaining neutral lipid, which was thus taken to be triglyceride. These fatty acids represented only 3·3 per cent of the total fatty acids of the grass. Subsequent elution with 10 per cent methanol in ether removed lipid corresponding to 62 per cent of the ethanol-soluble lipids. This fraction apparently consists of galactosyl glyceryl esters as described by Weenink[4]; hydrolysis gave glycerol, galactose and fatty acids, of which linolenic acid accounted for 82·0 per cent (Table 2).

Table 2. FATTY ACID COMPOSITION OF FRACTIONS DERIVED FROM THE ETHANOL-SOLUBLE LIPIDS
(Values as percentage by weight of total acids in each group)

Acid		Source of fatty acids	
	Free fatty acids	Triglycerides	Fraction eluted with 10 per cent methanol in ether
Myristic	1·6	3·3	0 2
Palmitic	13·0	14·6	7·0
Palmitoleic	2·4	1·8	1·6
Stearic	1·6	2·9	1·5
Oleic	4·3	8·1	1·8
Linoleic	17·4	23·1	5·9
Linolenic	59·7	46·2	82 0

The lipids extracted with chloroform–methanol were separated into acetone-soluble and acetone-insoluble (phospholipid) portions. Of the total fatty acids in the lipids in the chloroform–methanol extract, 30 per cent (including almost all the arachidic acid and behenic acid) were present in the acetone-insoluble portion; the acetone-soluble lipids were relatively richer in linolenic acid than the acetone-insoluble lipids.

Further work on the nature of the lipids of grasses and other animal feeds is in progress.

G. A. GARTON

Rowett Research Institute,
Bucksburn, Aberdeen.

[1] Shorland, F. B., *Nature*, 153, 168 (1944).

[2] Shorland, F. B., *J. Sci. Food Agric.*, 4, 497 (1953).

[3] Smith, J. A. B., and Chibnall, A. C., *Biochem. J.*, 26, 1345 (1932).

[4] Weenink, R. O., *N.Z. J. Sci.*, 2, 273 (1959).

[5] James, A. T., personal communication; cf. Farquhar, J. W., Insull, W., Rosen, P., Stoffel, W., and Ahrens, E. H., in Supplement to *Nutrit. Rev.*, 17 (August 1959).

[6] Crombie, W. M., *J. Exp. Bot.*, 9, 254 (1958).

[7] Shorland, F. B., Weenink, R. O., and Johns, A. T., *Nature*, 175, 1129 (1955).

[8] Garton, G. A., and Duncan, W. R. H., *Biochem. J.*, 67, 340 (1957).

PHYSIOLOGY

A Biological Interval Analyser

A FREQUENT requirement in the analysis of biological data is the classification of time-intervals. Thus one might wish to know the most probable interval between heart-beats, or the most probable reaction time of forefinger movements in response to sound. The usual way of acquiring this sort of information is by manual measurements of relatively long biological records. This method, however, can

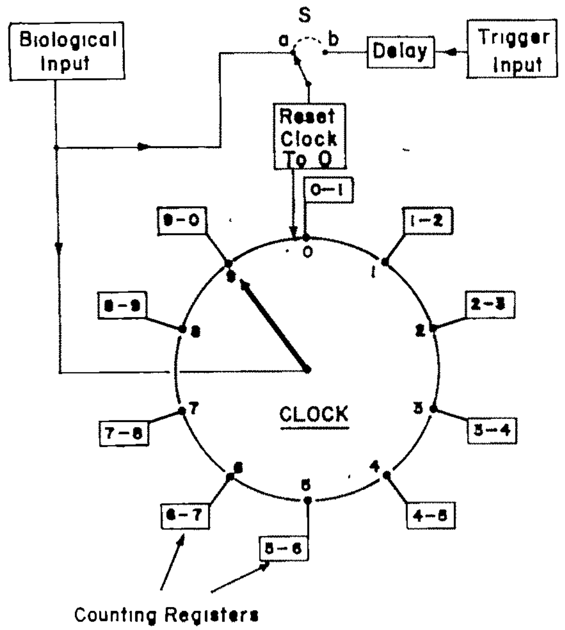


Fig. 1

become extremely time-consuming when the number of biological signals to be classified is large. An example may serve to illustrate our point. The neurons of the unanæsthetized, unstimulated cat's brain are in a state of continual 'spontaneous' activity. Their mean frequency of discharge per minute is constant (some 5–20/sec.) when observed over long periods of time, but it appears impossible to predict with certainty the exact time at which the next action potential in a series will occur. Cells in the resting visual cortex are also engaged in continual activity, but will respond to a flash of light focused upon the retina with an increased probability of discharge. One can state the relationship between stimulus and response in these circumstances only in terms of probability, since any particular flash of an identical series may or may not be followed by an action potential.

There are, thus, two questions one might reasonably ask about the behaviour of cells in the unanæsthetized cerebral cortex. (1) Is the resting discharge of the neurons random with respect to time? (2) What is the probability that an action potential will occur within a specified interval of time after the stimulation? The manual analysis of two minutes of record from cortical units may involve the measurement and classification of some 1,200 intervals and can occupy one full man-day. For this reason we have designed and built an electronic interval analyser which provides an instantaneous display of the completed analysis.

A functional diagram of this device is shown in the accompanying figure. The central component is a clock which connects the biological input in succession to each of ten digital counting registers. Suppose that we require to know the distribution of intervals between discharges of a single neuron in the 'resting' brain. The rate of revolution of the clock is first pre-set to a convenient value so that the biological signals are fed to each of the counting registers for, say, 100 m.sec. The switch S is set to position a. The first action potential causes the clock to jump from its resting position 9, to position 0, where in the absence of another action potential it rests for 100 m.sec. and then jumps to position 1. If the next action potential arrives during the next 100 m.sec., the event is recorded in counting register 1–2 and the clock is reset simultaneously to position 0. In this way, the intervals between successive action potentials are measured and classified. All intervals between action potentials that are greater than 9 × 100 m.sec. will be accumulated in register 9–0. At the end of a series of action potentials the counting registers of the instrument display numbers proportional to the probabilities of occurrence of various intervals between action potentials.

Another mode of operation of the analyser provides the probabilities that action potentials will occur at various times after the stimulation. For this operation the switch S is turned to b, when initiation of the clock-cycle is triggered by a pulse synchronous with stimulation. Suppose that the clock's rotation is pre-set so that it spends 20 m.sec. in each position. Suppose also that the frequency of repetition of a stimulus is 1 per sec. The first stimulus of a series will move the clock from position 9 to position 0 and initiate its stepwise progress. Should an action potential occur during the 20 m.sec. that the clock rests on position 2, then the event will be stored in register 2–3. The clock is not reset by this action potential, but continues to move consecutively through positions 3–9, distributing action potentials to the appropriate registers. Once the clock attains position 9 it waits there until the next stimulus begins the cycle again. At the end of the analysis, counts appear in the registers which are proportional to the probabilities of response 0–20, 20–40 . . . 160–180, 180–1,000 m.sec. after the stimulus. By use of the variable delay indicated in the figure, it is equally easy to obtain probabilities of response 180–200, 200–220, . . . m.sec. after the stimulation.

Although this instrument was specifically designed for the analysis of the behaviour of central neurons, its use is clearly not limited to this function. The same instrument could, for example, be employed with equal ease to make similar analyses of cardiac rhythm, respiratory activity, or animal behaviour in conditioning experiments.

G. K. Smith
B. Delisle Burns

Department of Physiology,
McGill University,
Montreal.

Depressing Activity of Meprobamate on the Reticulo-Endothelial System

Data in the literature point to tranquillizers as drugs having a certain influence on the responsiveness to infections. Patients treated with reserpine or chlorpromazine have decreased resistance to infectious diseases[1,2].

Chlorpromazine increases susceptibility of mice to infection with *Salmonella enteritidis*[3] and depresses the phagocytic activity of the reticulo-endothelial system[4]. The production of anti-*Salmonella typhimurium* agglutinins in rabbits is decreased by meprobamate[5]. Vinegar and Berger[6] found that the clearance-rate of carbon particles in blood of mice is depressed 24 hr. after the administration of a single high dose of certain tranquillizers. Meprobamate at two dose-levels (100 and 200 mgm./kgm.) does not affect clearing. They attributed the depression of the reticulo-endothelial system as due to the liberation of corticosteroids from the adrenal cortex caused by the tranquillizers. It is known in fact that corticosteroids inhibit the clearing of carbon particles by the reticulo-endothelial system[7,8] and that chlorpromazine induces adrenocorticotrophic hormone release from the hypophysis[9] and hypertrophy of the adrenal cortex[10]. On the other hand, adrenalectomy has been reported as a condition which does not affect clearing[8,11] and that the depression of the reticulo-endothelial system does not appear in adrenalectomized hydoxyzine-treated mice[6]. It seemed, therefore, of some interest to investigate the influence of meprobamate, given in therapeutical doses and for more than one single administration, on the reticulo-endothelial system and to have more evidence for supporting the theory of the interference of the adrenal cortex.

Table 1. CARBON CLEARANCE IN NORMAL, MEPROBAMATE-TREATED AND ADRENALECTOMIZED MICE
(Means ± standard errors)

Group	Days of treatment	K ($\times 10^{-3}$)	$T/2$	α
Controls (9)	—	12·8 ± 0·74	24′ ± 1·23	4·22 ± 0·23
Meprobamate-treated (6)	3	6·9 ± 0·43*	44′ ± 2·68*	2·79 ± 0·32†
Meprobamate-treated (6)	7	12·7 ± 0·96§	21′ ± 0·91§	3·83 ± 0·15§
Meprobamate-treated (6)	15	7·7 ± 0·96*	42′ ± 6·16†	3·42 ± 0·13‡
Adrenalectomized (14)	—	7·2 ± 0·57*	55′ ± 6·18*	2·72 ± 0·18*

Number of animals in parentheses. * $P < 0·001$; † $0·001 < P < 0·005$; ‡ $0·01 < P < 0·02$; § N.S.

Male Rockland-Swiss mice weighing 20 gm. were divided into three groups; one served as control and received saline, another was given subcutaneously 25 mgm./kgm. of meprobamate and another was adrenalectomized. Clearance of carbon particles was carried out as described by Heller *et al.*[12], and determined in the meprobamate-treated group after 3, 7 and 15 days of treatment, and in the adrenalectomized group after 7 days in the surviving animals. For each animal was then calculated: the phagocytic index (K), that is, the constant of the equation of disappearance of carbon from blood, the half-time of carbon disappearance ($T/2$) and the corrected phagocytic index (α), which measures the phagocytic activity per unit weight of liver and spleen. The results are summarized in Table 1. From the results it appears that the activity of the reticulo-endothelial system is strongly depressed at the beginning of the treatment with meprobamate, returns almost to normal after 7 days and is again depressed after 15 days. Our results for the effects of adrenalectomy do not agree with those of other authors and do not allow the possibility of investigating the effects of meprobamate on the adrenalectomized animals. So far as the mechanism by which meprobamate affects the reticulo-endothelial system is concerned, it may be supposed that the tranquillizer induces at the beginning a 'block' of the adrenal cortex function (depression of clearing) which returns to normal in a few days (almost normal clearing); the continuous administration of the tranquillizer leads later on to an increased secretion of adrenal corticoids which may explain the depressed activity of the reticulo-endothelial system after 15 days of treatment.

A. Del Vecchio
L. Bolis

Lab. Studi e Ricerche,
Istituto Ganassini,
Milan.

---

[1] Kline, N. S., *et al.*, *Dis. Nerv. Syst.*, 17, 352 (1956).
[2] Wardell, D. W., *Amer. J. Psychiat.*, 185, 235 (1956).
[3] Gross, H. J., and Norton, J., *Science*, 129, 784 (1959).
[4] Meier, R. M., *et al.*, *Fed. Proc.*, 16, 425 (1957).
[5] Compagnucci, M., *et al.*, *Boll. Soc. Ital. Biol. Sper.*, 35, 313 (1959).
[6] Vinegar, R., and Berger, F. M., *Proc. Soc. Exp. Biol. Med.*, 102, 88 (1959).
[7] Heller, J. H., in "Physiopathology of Reticulo-endothelial System" edit. by Halpern, 45 (Blackwell, Oxford, 1957).
[8] Bilbey, D. L., and Nicol, T., *Nature*, 182, 674 (1958).
[9] Hedahl, R. H., and Richards, J. P., *Amer. J. Physiol.*, 186, 225 (1956).
[10] Hormia, M., *Ann. Med. Exp. Fenn.*, 36, Supp. 3 (1958).
[11] Benacerraf, B., *et al.*, in "Physiopathology of Reticulo-endothelial System", edit. by Halpern, 67 (Blackwell, Oxford, 1957).
[12] Heller, J. H., *et al.*, *J. Endocrinol.*, 61, 235 (1957).

Anti-Fertility Action of a Monoamine Oxidase Inhibitor

An earlier communication has directed attention to the anti-inflammatory properties of inhibitors of monoamine oxidase[1]. Similar properties for iproniazid, one such substance, have been described independently[2]. The similarities between the vascular events of implantation of the fertilized ovum and of the inflammatory reaction, together with the low toxicity of certain monoamine oxidase inhibitors, prompted the trial of these compounds as orally administered inhibitors of conception. The work was also stimulated by reports of the effect of 5-hydroxytryptamine and iproniazid in terminating pregnancy in mice[3].

Female albino rats of the Wistar strain, weighing 150–250 gm., were caged with similar male rats (one male to every five or six females) for a mating period of 9 days, the males then being removed. Animals receiving the monoamine oxidase inhibitor did so in their drinking water. The drug used was (1-methyl-2-phenoxyethyl)hydrazinium (compound *HP*1275) obtained from Smith and Nephew Research, Ltd. The dosage ranged from 0·1 to 0·5 mgm. per ml. of drinking water. The nature of the experiment meant that both female and male rats received the drug throughout the period of mating. The females were, however, put on the drug 24 hr. before the males were added to their cage.

Table 1 shows that the higher dose led to complete suppression of fertility. Both female and male rats on this regime showed no obvious abnormality or disturbance of health. The lower dose-levels showed less-striking effects.

Table 1. EFFECT OF COMPOUND *HP*1275 ON THE INCIDENCE OF PREGNANCY IN RATS AND MICE

Concentration of *HP*1275 in drinking water (mgm./ml.)	Animal	Approximate dose (mgm./kgm./24 hr.)	No. of females	No. of females pregnant	Pregnant (per cent)
None	Rat	None	48	24	50
0·5	Rat	25	48	0	0
0·25	Rat	12	20	4	20
0·10	Rat	5	20	8	40
None	Mouse	None	48	9	19
0·5	Mouse	25	48	3	6

A similar experiment was conducted with mice, using a four-day mating period in which both males and females received 0·5 mgm./ml. of compound *HP*1275 in their drinking water. The results here were less impressive although the incidence of pregnancy was reduced. Female rats which had received 0·5 mgm./ml. of *HP*1275, when mated three weeks later without the addition of the drug to their drinking water, conceived normally. Of 24 females so treated, 11 became pregnant and delivered normal litters which survived.

Although the effect in rats was striking, interpretation is difficult. It is not certain whether the action of the drug is on the female or partly or wholly on the male. It has not yet been possible to devise an experiment in which animals of only one sex received the drug and yet in which there was an adequate mating period with minimal handling of the animals. However, other results indicate that the action is probably on the female[3].

Compound *HP*1275 has been administered to male and female rats for several months in doses up to 50 mgm./kgm./24 hr. without detectable clinical or histologicl aabnormalities. A general toxic basis for the anti-fertility effect of the drug is therefore rather less likely than a more specific action. However, it cannot be said to be established that the drug acts by inhibition of monoamine oxidase.

Two suggestions may be made. The compound may prevent the destruction of a vasoconstrictor amine at the site of implantation, thus preventing vascular changes essential for this process to be completed[1]. Alternatively, it may stimulate hormonal secretion in the pituitary-suprarenal axis of a nature unfavourable to the establishment of pregnancy. Such stimulation could be direct or indirect through the mediation of pressor amines.

W. G. Spector

Department of Morbid Anatomy,
University College Hospital Medical School,
London, W.C.1.

[1] Spector, W. G., and Willoughby, D. A., *Nature*, 186, 162 (1960).

[2] Setnikar, L., Salvaterra, M., and Temelcou, O., *Brit. J. Pharm.*, 14, 484 (1959).

[3] Poulson, E., Botros, M., and Robson, J. M., *Science*, 131, 1101 (1960).

Reversibility of an Inherited Metabolic Block (Inborn Error of Metabolism)

The irreversibility and permanence of the basic defects in 'inborn errors of metabolism' have been regarded hitherto as essential pre-requisites of the condition as defined by Garrod[1]. The question is whether in the light of the following observations this aspect of Garrod's concept can yet be universally maintained.

We have had the opportunity of observing two siblings with sporadic goitrous cretinism, which condition is known to arise from a genetically transmitted failure of thyroid hormone synthesis[2]. In our cases the metabolic block was found to be an inability of the thyroid to hold inorganic iodide and convert it to organic iodine (abnormally high uptake of iodine-131 during the first hours after the administration of the tracer, with a subsequent drop to abnormally low levels, low serum-protein-bound iodine-127; see Table 1). The resulting clinical manifestations were in both siblings a large, partly diffuse and partly nodular goitre, and severe myxœdema. The short-termed administration of massive doses of active thyroid principles (90 mgm. 'Triac' or equivalent doses of desiccated thyroid within 6–9 days) resulted each time in a protracted clinical remission lasting without additional therapy 6–7 months (altogether this 'stosstherapy' was performed five times). Studies of thyroid function performed at 2, 3 and 4 months of the therapy-free remissions revealed a practically normal pattern of thyroid function, thus incidentally also ruling out a fortuitious ingestion of thyroid substances[3,4].

In a third sibling, who only recently came under our observation and who was clinically and functionally perfectly like those previously studied, the same therapeutic procedure also resulted in a protracted and complete clinical remission which so far lasts 8 months. Thyroid function studies performed at early stages of the therapy-free remission revealed a low-normal pattern. The most striking and unexpected result of isotope studies was obtained at almost 6 months after the administration of the 'Triac stoss' (Table 1). The figures show that the thyroid gland which, according to universally accepted views must be the site of an inherited metabolic block at an early stage of hormone synthesis, was by that time not only capable of holding abnormally large amounts of iodine (6 days after the administration of the tracer, thyroidal collection was still 41 per cent) but also of converting it at a high rate to organic-bound iodine. That at least part of the protein-bound iodine released into the circulation was biologically active may be inferred from the clinical state of the patient, who was both euthyroid and agoitrous. Chromatographic study of the circulating iodine compounds could unfortunately not be undertaken, as the dose of iodine-131 administered was too small for this purpose. It will be the subject of further investigations.

This is, to the best of our knowledge, the first time that a genetically transmitted, that is, inborn, error of metabolism was at least temporarily repaired and converted into normal metabolic channels functioning at a higher rate even than normal. It is worthy of note that this effect was achieved by the extraneous administration of massive doses of sub-

Table 1

	Thyroidal uptake of iodine-131 (per cent of dose)						Urinary iodine-131 excretion (per cent of dose)		Serum iodine-131 precip. with trichloracetic acid (per cent of total activity)			Serum iodine-131 extracted with butanol (per cent of total activity)		Serum protein-bound iodine-127 (mcgm./100 ml.). Normal range: 3·5–5·5
	2 hr.	24 hr.	48 hr.	72 hr.	96 hr.	144 hr.	24 hr.	48 hr.	24 hr.	48 hr.	72 hr.	48 hr.	72 hr.	
Before therapy	60·0	30·0	15·0				22·5 ?	14·0						>1
6 months after 90 mgm. 'Triac' in 9 days	32·0	90·0	52·0	50·0	48·5	41·0	6·9	3·2	55	80	91	93·5	87·5	3·2

stances chemically like the physiological end-product of the previously defective metabolic process.

HERMAN ZONDEK
HANNAH E. LESZYNSKY

Department of Internal Medicine,
Bikur Cholim Hospital,
Jerusalem.

JOSEPH A. STEIN

Radioisotope Laboratory,
Radium Institute,
Rothschild Hadassah University Hospital,
Jerusalem.

[1] Garrod, A. E., *Lancet*, ii, 142 (1908).
[2] Hutchison, J. H., and McGirr, E. M., *J. Clin. Endocrinol. and Met.* 14, 869 (1954).
[3] Zondek, H., Leszynsky, H. E., and Zondek, G. W., *Acta Endocrinol.*, 29, 47 (1958).
[4] Zondek, H., Leszynsky, H. E., and Zondek, G. W., *Brit. Med. J.*, i, 340 (1959).

Effect of Wheat Gluten on the Peristaltic Reflex

SENSITIVITY to wheat or rye gluten is the essential mechanism in the pathogenesis of cœliac disease and idiopathic steatorrhœa. Such patients improve on a gluten-free diet and deteriorate on the re-introduction of gluten itself or its autoclaved and filtered peptic/tryptic digest into the diet[1]. In these diseases a disturbance of small intestinal function is a major factor[2].

The peristaltic reflex of the isolated intestine[3] was used to test the depressant activity of gluten and several of its fractions on intestinal motility. Perfusion of the autoclaved and filtered peptic/tryptic digest through the lumen did not produce any depression of this preparation. External administration, however, caused complete inhibition of longitudinal as well as circular muscle contraction. Movements returned while the material was still in the bath. This depression was also shown by an aqueous extract of gluten and was not affected by ultrafiltration. The ultrafiltrate of the aqueous extract was ten times as potent as the peptic/tryptic digest. All activity was abolished by acid hydrolysis. Incubation of the active material for a few minutes with small intestinal mucosa from the rat and with one specimen of human jejunal mucosa abolished the inhibitory effect.

The mechanism of this depressant effect of gluten fractions was studied with the help of the co-axially stimulated isolated guinea pig intestine[4]. The twitch response was markedly depressed for several minutes with either fraction. Assay of the acetylcholine output on the isolated guinea pig ileum treated with neostigmine and morphine[4] showed a significant depression with the addition of either material. In preliminary experiments, the synthesis of acetylcholine by small intestinal cholinacetylase[5] was not affected by the addition of the ultrafiltrate of the aqueous extract of gluten.

The conclusion is drawn that wheat gluten which is pathogenic in cœliac disease and idiopathic steatorrhœa contains a factor which depresses the peristaltic reflex of an isolated strip of intestine. This factor is heat-stable, resistant to peptic/tryptic digestion and not removed by ultrafiltration. It is sensitive to acid hydrolysis and digestion with small intestinal mucosa. It depresses acetylcholine output, but synthesis does not appear to be affected at moderate dosage-levels. It may therefore prevent release of acetylcholine from the inactive bound state.

R. SCHNEIDER
H. BISHOP
B. SHAW*
A. C. FRAZER

Department of Medical Biochemistry
and Pharmacology,
University of Birmingham.

* Present address: Boots Pure Drug Co., Ltd., Research Department, Chemistry Division, Island Street, Nottingham.

[1] Frazer, A. C., Fletcher, R. F., Ross, Constance A. C., Shaw, B., Sammons, H. G., and Schneider, R., *Lancet*, ii, 252 (1959).
[2] Anderson, C. M., Frazer, A. C., French, J. M., Gerrard, J. W., Sammons, H. G., and Smellie, J. M., *Lancet*, i, 836 (1952).
[3] Bulbring, E., Crema, A., and Saxby, O. B., *Brit. J. Pharmacol.*, 13, 440 (1958).
[4] Paton, W. D. M., *Brit. J. Pharmacol.*, 12, 119 (1957).
[5] Feldberg, W., and Lin, R. C. Y., *J. Physiol.*, 111, 96 (1950).

HÆMATOLOGY

Substance from Erythrocytes of Blood Group A

BLOOD group substances from erythrocytes have been claimed to be glycolipids, while those from secretions were described as mucopolysaccharides. It has been suggested that glycolipids from erythrocytes owe their blood group activity to the contamination by secretions like blood group substances[1]. The problem of identity or relationship between these two kinds of blood group substances may be solved only if their chemical and serological properties are directly compared.

The present communication describes the isolation and properties of a human blood group A substance from erythrocytes. Determinations of isoagglutination inhibition and hæmolysis (Forssman) inhibition tests were made using as a control the original sample of blood group A substance (kindly given by Prof. W. T. J. Morgan and Dr. W. M. Watkins of the Lister Institute, London) hereafter referred to as a 'standard A substance'.

Pooled, washed, human A erythrocytes were extracted with 4·05 vol. of 96 per cent w/w ethanol for 24 hr. at room temperature. The extract was Seitz-filtered and cooled to −7° C. A precipitate, 'crude A substance', which formed was centrifuged at −7° C., washed with acetone and dried in a vacuum. Its blood group activity, as measured by the isoagglutination inhibition test, was 2–5 per cent of the activity of the standard A substance; it did not contain O, H, Rh, M, N, P factors and exhibited no influenza virus hæmagglutination inhibition activity. Chemical analysis revealed 15·5 per cent reducing sugars as galactose, 2·6 per cent hexosamine, 3·4 per cent phosphorus, 2·0 per cent nitrogen; the glucosamine/galactosamine ratio[2] was 1 : 4.

The crude substance was extracted with acetone, ethyl ether, and petroleum ether successively, then dissolved in boiling methanol, filtered while hot, and the extract was cooled to 0° C. The precipitate formed ('precipitate M') contained 26·3 per cent reducing sugar, 5·0 per cent hexosamine, 1·4 per cent phosphorus. Its activity was about 10 per cent of that of the standard substance.

A sample of 'precipitate M' has been further purified by chromatography on a cellulose column. Two fractions emerged from the column: fraction I in

Table 1. CHEMICAL COMPOSITION OF A PREPARATIONS

Preparation	N	Sphingosine	Hexosamine	Reducing sugars	Galactosamine : glucosamine ratio	P	Blood group activity*	Forssman activity*
Precipitate M	2·2	—	5·07	28·0	5 : 1	1·38	10	50
Fraction I	—	—	4·82	26·0	—	1·4	5	25
Fraction II	2·3	1·4	9·4	47·6	1 : 1	0·3	25	100

* Expressed as percentage of the activity of standard A substance.

chloroform/ethanol/water, 16 : 4 : 1, and fraction II in chloroform/methanol/water, 5 : 15 : 1. They represented about 90 and 5 per cent of the chromatographed material, respectively. The properties of the two fractions are shown in Table 1. Fraction II was soluble in both water and organic solvents (pyridine, hot methanol, mixtures of chloroform and methanol). In water it forms a somewhat opalescent solution, exhibiting a considerable viscosity. This substance gave no reaction with *p*-dimethylaminobenzaldehyde described by Aminoff, Morgan and Watkins[3]. Galactose, glucosamine and galactosamine were identified in this material by means of paper chromatography in butanol/pyridine/water solvent. Fucose content of this material was 0·8–2·0 per cent. Fraction II may be further purified by extracting it with a large volume of hot 95 per cent acetone, then by cold precipitation from hot methanolic solution and finally by pyridine extraction and absorption on alumina, essentially after the method of Klenk and Lauenstein[4]. One of our best preparations obtained by the above methods contained 16·6 per cent hexosamine, 60 per cent reducing sugars, 2·7 per cent nitrogen and 1·37 per cent sphingosine nitrogen[5]. The sum of sphingosine and hexosamine nitrogen represented 98·8 per cent of the total nitrogen. The galactosamine/glucosamine ratio was 6 : 1[2]. Analytical values suggest that this material is hexosamine-sphingosine-trihexoside somewhat similar to preparations of red cell blood group substances described by Yamakawa and Suzuki[6]. The preparation was not tested for homogeneity, but fraction II did display two hexosamine-containing components in fractional solubility tests with methanol; the percentage ratio of the components amounted to 78 and 22 per cent. The activity of fraction II was about 12·5 per cent of the activity of standard substance. However, with a small number of anti-A sera, the erythrocyte substance was 10–20 times as active as standard A substance, but both appeared to be less active when tested against these particular sera than against the usual ones. The possibility cannot be excluded that these sera contained some unknown antibody against other components of the erythrocyte surface. The hæmagglutination inhibition activity has also been tested by Prof. W. T. J. Morgan against various anti-A reagents. Substances obtained from erythrocytes when tested against rabbit anti-human red cells sera were active in dilution of about 10^5, while when tested against rabbit anti-mucoid A substance sera showed activity of a lower order (about 10^4).

It is interesting to note that neither substances obtained from A red cells nor from O red cells contained O or H antigen.

The blood group activity of our preparations was not destroyed by treatment with hot 0·05 *N* sodium carbonate for 15 min., and no N-acetylhexosamine colour has developed on subsequent treatment with Ehrlich reagent[3]. This is exactly opposite to what has been found with substances obtained from body fluids[7]. When the erythrocyte substance was treated with hot hydrochloric acid, *p*H 2·3, for 8 hr. the kinetics of both disappearance of activity and appearance of N-acetylhexosamine colour were similar to those found for the mucoid A substance.

The above results point to the fact that blood group substance as obtained from human erythrocytes is a different chemical entity from the blood group substance as obtained from human body fluids.

J. KOSCIELAK
K. ZAKRZEWSKI*

Department of Biochemistry,
Institute of Haematology,
Warsaw.

* Present address: United Nations Scientific Committee on the Effects of Atomic Radiation, New York 17.

[1] Kabat, H. A., "Blood Group Substances, their Chemistry and Immunochemistry", 121 (Academic Press, Inc., New York, 1956).
[2] Gardell, S., *Acta Chem. Scand.*, 7, 207 (1953).
[3] Aminoff, D., Morgan, W. T. J., and Watkins, W. M., *Biochem. J.*, 51, 379 (1952).
[4] Klenk, E., and Lauenstein, K., *Z. physiol. Chem.*, 291, 249 (1952).
[5] McKibbin, J. M., and Taylor, W. E., *J. Biol. Chem.*, 178, 29 (1944).
[6] Yamakawa, T., and Suzuki, S., *J. Biochem. Japan*, 39, 393 (1952).
[7] Morgan, W. T. J., *Experientia*, 3, 1 (1947).

Haptoglobin Types in 398 Blood Donors from Dakar (Senegal)

FROM results already published on the haptoglobin types in African populations, three points deserve attention. First, the Hp (1–1) type is very frequent. Secondly, the Hp (1–2) modified type, described by Connel and Smithies, is present much more often than in European populations[1]. Thirdly, the so-called ahaptoglobinæmic sera, which are so rare in the latter, were found in Africa with a frequency of up to 40 per cent[1,2].

In the present work, we have studied 398 serum samples from blood donors registered at the Centre Fédéral de Transfusion Sanguine, Dakar. The technique of electrophoresis in starch gel was that previously used by us[3], in a borate buffer at *p*H 8·3. In addition, a control in a phosphate buffer at *p*H 7·0 (ref. 4) was made on all the samples in which the characteristic bands of the Hp (1–2) or Hp (2–2) types were missing. It was thus very easy to distinguish the so-called ahaptoglobinæmic sera from those belonging to the Hp (1–1) type.

The observed frequencies are:

Hp (1–1)	148	(37·19 per cent)
Hp (1–2) normal	141	(35·43 per cent)
Hp (1–2) modified	44	(11·05 per cent)
Hp (2–2)	47	(11·81 per cent)
Special types	2	(0·50 per cent)
No haptoglobin detectable	16	(4·02 per cent)

The proportion of the sera in which no haptoglobin was detectable is very much lower in our results than that obtained by Allison *et al.*[2] and by Harris *et al.*[1]. In Gambia, Harris *et al.* found more than 40 per cent of such sera. On the other hand, Sutton *et al.*[4] did not specially seek the ahaptoglobinæmic types, but their figures suggest a low frequency, of the same order of magnitude as ours.

Sera which were weakly stained by the benzidine reagent were very frequent in the material we tested. Presumably, minor differences in the technique could have led us to classify them in the 'ahaptoglobinaemia' group. In such populations, if the size of this group is so largely dependent on the technique, it will be very difficult to make accurate comparisons from an anthropological point of view.

A more detailed report will be given elsewhere[6].

J. Moullec
J. M. Fine
Centre National de Transfusion Sanguine,
6 rue Alexandre-Cabanel,
Paris, 15.
J. Linhard
Hôpital Le Dantec,
Dakar.

---

[1] Harris, H., Robson, E. B., and Siniscalco, M., "Biochemistry of Human Genetics", Ciba Foundation Symposium (Churchill, London, 1959).

[2] Allison, A. C., Blumberg, B. S., and Rees, M., *Nature*, 181, 824 (1958).

[3] Moullec, J., and Fine, J. M., *Nature*, 184, 196 (1959).

[4] Laurell, C. B., *Scand. J. Clin. Lab. Invest.*, 11, 18 (1959).

[5] Sutton, H. E., Neel, J. V., Livingstone, F. B., Binson, G., Kunstadter, P., and Trombley, L. E., *Ann. Hum. Genet.*, 23, 175 (1959).

[6] Moullec, J., Fine, J. M., and Linhard, J., *Revue d'Hémat.* (to be published).

BIOLOGY

Translocation of Wild Animals as a Means of Game Control

A preliminary trial in the translocation of the herd of kob antelope (*Adenota kob thomasi*) at Lugari in Kenya was made in June of last year (Buechner, H. K., Harthoorn, A. M., and Luck, C. P., unpublished work). The herd in question numbers some 500 head, and is the only herd of kob in Kenya. Its existence in this number on the farm- and ranch-land of Lugari cannot be supported by the landowners. Moving part of the herd to other areas is the only alternative to destruction.

During the first eight days of the scheme early in March of this year, forty animals were darted, using one Capchur gun and Crockford syringes. Of this number 13 failed to go down; this was discovered to be due to a fault in loading, with resulting syringe blow-out between leaving the gun and entering the animal; three animals escaped on the first day due to faulty construction of the holding area; and three animals died during immobilization. Whereas deaths due to succinylcholine had not been reported previously in the course of immobilizing some sixty males, it appears that the female, possibly only the pregnant female, is more susceptible. After adding atropine to our succinylcholine solution, as is our routine practice with animals such as buffalo, no more deaths from this cause ensued. Among the first animals caught, two died from injuries caused by their efforts to break out of the stockade. Adequate thatching of the inner face of the perimeter stockade will possibly prevent this in the future, as will the presence of tame animals. Furthermore, these animals had not been tranquillized with 'Largactil'.

Twenty kob were ready at the end of the eight days for loading on to a truck to be moved to a game reserve 320 miles away. Of these, 18 were females, the greater number of whom were clearly pregnant; two were sub-adult males. The extreme tips of the young horns of the males were removed and the ends covered with strips of 'Elastoplast'. They were caught one by one by being driven into a crush, injected with 'Largactil' (chlorpromazine hydrochloride) and placed in the darkened truck interior. There they settled down immediately. The inner walls of the lorry had also been lined with grass.

The first attempt at moving these animals from the holding enclosure failed. The crush at that time opened into a small catching chamber where it was hoped to hold the animal by manual restraint while the injection was being made. This proved to be quite impracticable, and some injury was inflicted on the handlers. A modification whereby the animals ran through the crush into a specially constructed slatted box, where they could be tranquillized and afterwards moved to the truck, proved to be satisfactory. It was found convenient to drive the animals into the crush at dusk. Artificial lights were used to encourage the animal to move towards the slatted box. The animals were transported during the night to avoid overheating—an important factor in tropical climates.

In the first batch moved there were a dozen females and one male. All arrived safely at the new Meru Game Reserve, having travelled a distance of 320 miles.

The trial has indicated that the number of animals that can be caught by one gun or other projector, and moved per week, can be at least doubled with increased experience and improved equipment. This method of game control has now been shown possible. It is hoped that the principle of removing wild animals from contested areas will be used with increasing frequency instead of the destruction that has been practised up to date.

We wish to express our gratitude to the farmers in the Lugari area for their co-operation with us on this scheme. Equipment was supplied by the Kenya Game Department and the project has been assisted by a grant-in-aid from the Fauna Preservation Society, London. The succinylcholine chloride was kindly given by Messrs. Burroughs Wellcome (East Africa), Ltd., and the 'Largactil' by Messrs. May and Baker.

A. M. Harthoorn
J. A. Lock
Departments of Veterinary Physiology and
Medical Pharmacology,
University College of East Africa,
Kampala, Uganda.
J. MacKrand
(Warden)
Kenya Game Department.

Effect of Penicillin on the Maintenance of Rumen Oligotrich Protozoa

It has been shown previously[1,2] that sheep rumen *Entodinia* spp., principally *Entodinium caudatum*, could be grown *in vitro*, dividing every 48 hr. on a medium of salts, dried grass, rice starch, chloramphenicol and fresh or autoclaved rumen fluid, but that it was necessary to add fresh grass and rice starch to the medium every day. This communication describes the successful maintenance of these Protozoa in the presence of penicillin for periods up to 14 days without daily additions.

The substrate consisted of 3–4 ml. quantities of mineral salt solution *B* (see below) plus about 6 mgm. dried grass[1] and 0·2 ml. 10 per cent 'Difco' yeast-extract contained in cotton-plugged 7-ml. tubes (fitted with ground glass stoppers) and autoclaved at 10 lb./sq. in. for 20 min. Immediately after removal from the autoclave and cooling, the following additions were made aseptically: 0·2 ml. 1 per cent L-cysteine hydrochloride (neutralized with sodium hydroxide and Seitz-filtered just before use), 0·2 ml. 5 per cent sodium bicarbonate (Seitz-filtered), 0·25 ml. 6 per cent rice starch (British Drug Houses, Ltd., Poole, England; heated at 120° for 24 hr.), 0·8 ml. Protozoa-containing autoclaved rumen fluid and 0·4 ml. 25,000 U. penicillin *G*/ml. (sterile). The tubes were then inoculated, completely filled with sterile mineral salt solution *B* and sealed with flamed glass stoppers, taking care to exclude all air. The cultures were incubated at 38° without further additions to the medium. The mineral salt solution *B* contained per 100 ml.: K_2HPO_4, 0·50 gm.; KH_2PO_4, 0·39 gm.; NaCl, 0·050 gm.; $MgSO_4.7H_2O$, 0·007 gm.; $CaCl_2.6H_2O$, 0·007 gm.; CH_3CH_2COONa, 0·375 gm. The Protozoa-containing autoclaved rumen fluid was prepared from the rumen contents of a hay-fed Clun Forest sheep by straining through two layers of muslin and autoclaving under 95 per cent nitrogen + 5 per cent carbon dioxide in sealed McCartney bottles for 20 min. at 10 lb./sq. in.

The Protozoa (more than 90 per cent *Entodinium caudatum*) for inoculation were prepared from cultures which were growing in the presence of rice starch, grass, chloramphenicol and autoclaved rumen fluid under the condition *C2*[2] and which had been last diluted 48 hr. previously. Under these conditions the Protozoa formed a layer at the bottom of the tube, and the grass formed a scum on the surface. This surface scum was removed and then the residual medium plus the Protozoa centrifuged at 400*g* for 1 min. on an angle-head centrifuge, the organisms washed twice on the centrifuge in 10 ml. of sterile mineral salt solution containing 0·03 per cent L-cysteine and inoculated. The initial number of Protozoa was usually 3,000–20,000/ml.

Rough viable counts on the number of bacteria present in the protozoal cultures were made by carrying out serial tenfold dilutions in cotton-plugged test-tubes containing 10-ml. quantities of the following medium: mineral salt solution[1] without the sodium acetate containing 0·5 per cent 'Difco' yeast extract, 0·5 per cent glucose, 0·5 per cent 'Difco Bacto-tryptose', 0·35 per cent sodium lactate and 4·0 per cent Protozoa-containing autoclaved rumen fluid (centrifuged to remove the solid matter), autoclaved at 10 lb./sq. in. for 20 min. The cultures were incubated aerobically at 38° until no further growth was observed (about 4 days); the addition of 0·05 per cent L-cysteine and incubation in anaerobe jars under 95 per cent hydrogen + 5 per cent carbon dioxide (without catalyst) did not increase the number of viable bacteria found in penicillin-treated cultures.

Under the cultural conditions described the number of Protozoa increased for 3–7 days (Fig. 1), and the omission of the yeast extract or Protozoa-containing autoclaved rumen fluid reduced or prevented the growth of the Protozoa although they remained alive for up to 7 days. Similar results with a doubling in the number of Protozoa in 3–7 days were obtained from inocula of 2,000–40,000 Protozoa/ml. and in the best experiments fivefold increases were obtained in 3 days. From the third–seventh day onwards, depending on the experiment, the number of Protozoa declined steadily until they were usually dead by the twelfth–fourteenth day, although some occasionally persisted for 16–17 days.

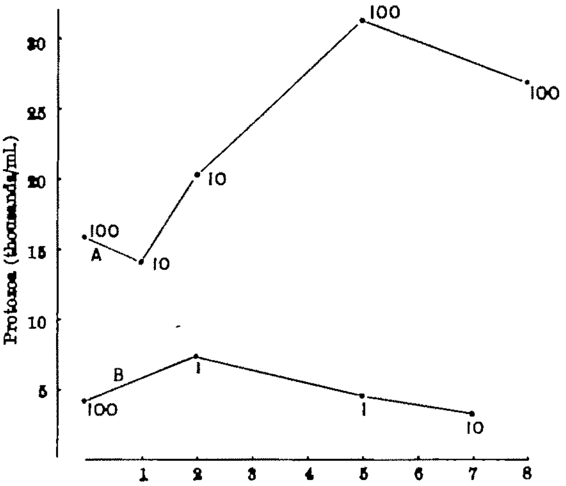


Fig. 1. Maintenance of *Entodinia* spp. in the presence of penicillin, without daily additions, under the conditions described using two levels of inoculum. The figures at each point indicate in thousands the approximate number of bacteria per ml. in the complete culture

Fig. 1 shows that the number of viable bacteria present in the complete protozoal culture containing the Protozoa was 10^3–10^5/ml., but in approximately half the experiments the number of bacteria present during protozoal growth was 10^6–10^7/ml. However, in almost all experiments the rice starch was metabolized only slowly and remained as a white deposit on the bottom of the tube throughout. This is in contrast to the results reported previously[2] for growth in the presence of chloramphenicol, where all the starch disappeared within 24 hr. and the number of viable bacteria was 10^7/ml. (as determined by the above viable count method); it shows that the number of viable bacteria could be reduced to 1 per cent or less. Nevertheless, since the Protozoa were not broken before the viable counts were carried out, it is possible that, in experiment *A* (Fig. 1) at least, the Protozoa contained many bacteria. It seems probable that in the present experiments the penicillin inhibited the growth of the starch-digesting bacteria, and that the starch remained for the Protozoa to engulf and metabolize. The numbers of viable bacteria reported are not necessarily an accurate estimate of the number actually present, but since there is no one medium which will grow all rumen bacteria, the results may be taken to indicate that the numbers of some of the more easily grown bacteria can be markedly reduced without affecting protozoal growth. Further experiments are in progress in an attempt to reduce the numbers of viable bacteria to still lower levels and to obtain Protozoa that contain no bacteria.

An effect of fresh rumen fluid on the Protozoa was shown in the following experiment. A protozoal culture which was declining in numbers was diluted with an equal volume of fresh complete medium and divided between two tubes. One drop of fresh rumen fluid[1], from which the Protozoa had been removed, was added to one tube; growth of the Protozoa was resumed in that tube but not in the other. In the presence of the fresh rumen fluid the Protozoa divided once or twice in three days without any daily additions, whereas in its absence the numbers declined by 50 per cent in three days.

I wish to thank Miss J. M. How for technical assistance.

G. S. COLEMAN

Biochemistry Department,
Agricultural Research Council
Institute of Animal Physiology,
Babraham,
Cambridge.

[1] Coleman, G. S., *Nature*, 182, 1104 (1958).

[2] Coleman, G. S., *J. Gen. Microbiol.*, 22, 555 (1960).

Protandry and Self-Fertilization in the Calyptraeidae

ORTON[1] suggested that protandrous animals might be self-fertilizing and that this would be advantageous for the spread of a species. He concluded that *Crepidula fornicata* was self-fertilizing because he found an isolated female guarding veliger larvæ. I have kept single *Crepidula* in aquaria and they have laid fertilized spawn two to three months later. Chipperfield[2] found no unfertilized eggs but he examined only unbroken chains from a densely populated area. Wilczynski[3] has recently said that the typical chains are feeding communities, not breeding associations and that copulation is effected with additional or visiting males. In *Calyptraea chinensis* (L.) males and females begin to associate seven months before spawn is laid[4]. Females probably store foreign sperms for long periods. Evidence for self-fertilization in *Crepidula* is therefore still lacking.

Calyptraea chinensis is a protandrous hermaphrodite and might be self-fertilizing as sperms and ova are found together in the gonad. However, many functional females guard unfertilized eggs. These eggs are more orange than the normal 1–8 cell embryos (stage 1) (ref. 4), lack a definite shape and fertilization membrane and are very fragile. When kept in the laboratory in finger bowls of sea water, these eggs slowly disintegrated into masses of yellow globules whereas normal stage-1 embryos developed so far as the veliger stage. Unfertilized eggs left undisturbed beneath the parent on glass did not develop.

The percentage of unfertilized spawn varied in different years. There was an inverse relationship between association of males with females and the percentage of unfertilized spawn laid the following summer (Table 1). The total number of associated females was undoubtedly higher than that shown, especially in the winter of 1953–54. The period of association was sometimes as short as overnight in laboratory experiments although many associations last for several months in the laboratory and in the Yealm Estuary. I never saw copulation, nor can I find an account of it. The possibility of small numbers of self-fertilizing animals is not excluded. Table 1 shows the percentage of females guarding unfertilized eggs. Females were found which guarded both embryos and unfertilized eggs, even in the same capsule. These were classed as fertile spawn even when only one embryo was found. The total number of unfertilized eggs is therefore greater than Table 1 suggests.

Table 1. ASSOCIATION OF *Calyptraea chinensis* AND SUBSEQUENT PERCENTAGE OF UNFERTILIZED EGGS IN THE YEALM ESTUARY

Percentage of functional females associated in the winter		Percentage of functional females with spawn, guarding unfertilized eggs	
1952–53	unknown	summer 1953	7
1953–54	24	summer 1954	30
1954–55	<5	summer 1955	70

C. chinensis has no free-swimming veliger larva and the hatched animals do not move far. Each male seeks a female and, after association with her, departs to find a smooth surface for his own permanent settlement and change of sex. The surface may be a stone, shell or glass; the only rough surface on which I have found an animal was the ribbed outer shell of *Cardium edule*. The number of suitable surfaces is limited and the stone already occupied by a female must be suitable for a male after association. The number of stones with two or more animals might be greater than that expected by chance. Gregariousness would increase the chance of association and the number of fertile spawnings.

Three samples collected in July, August and September before the main period of association were examined. The numbers of animals on each stone (Table 2) showed no evidence of gregariousness when compared with the expected Poisson distribution.

Table 2. NUMBERS OF *Calyptraea chinensis* FOUND ON STONES IN THE YEALM ESTUARY

No. of associated females	No. of animals not associated	Nos. of stones bearing unassociated animals									
		1	2	3	4	5	6	7	8	9	Total
21	1,168	762	110	40	7	2	2	1	0	1	925

Calyptraea chinensis in the Yealm Estuary was neither self-fertilizing nor gregarious. It is doubtful whether the protandrous Calyptraeidae are self-fertilizing, and if some animals are, the number of embryos so produced is probably small.

H. V. WYATT

Department of Bacteriology,
The Medical School,
Leeds, 2.

[1] Orton, J. H., *Nature*, 169, 279 (1952).

[2] Chipperfield, P. N. J., *J. Mar. Biol. Assoc. U.K.*, 30, 49 (1951).

[3] Wilczynski, J. Z., *Bull. Biol.*, 109, 353 (1955); *J. Exp. Biol.*, 36, 34 (1959).

[4] Wyatt, H. V., *Ann. Mag. Nat. Hist.* (in the press).

Suppression of Cytoplasmic Division in *Amoeba proteus*

CYTOPLASMIC division in *Amoeba proteus* can be suppressed by the application of strong light during the division process[1]. The same can be achieved as follows. Division is allowed to proceed undisturbed until nuclear division is complete. When the cell becomes elongated and the division furrow appears, slight pressure with a glass needle is applied for short intervals alternately on each one of them, thus shifting parts of the liquid endoplasm back and forth from one prospective daughter cell into the other. After about 7–10 min. of such treatment, without having completed the cleavage the cell resumed its normal interphase appearance. The surface, which had been covered with blebs, becomes smooth, pseudopodia are formed, and the cleavage furrow gradually disappears. Pressure applied for the same length of time before the completion of nuclear division does not prevent either nuclear or cytoplasmic division. Once the furrowing process is suppressed no cytoplasmic division occurs before the next full cell division about 20–28 hr. later.

The observation that the prevention of cytoplasmic division by pressure applied for a minimum time of 7–10 min. is sufficient to postpone it for one full cellular cycle suggests that the completion of chromosome duplication has itself a reversing influence upon the factors involved in cytoplasmic division. The minimum time which this influence requires to become effective is provided in the experiment by the artificial retardation of the furrowing process. If the initiation of both nuclear and cytoplasmic division were controlled by the ratio between utilization and production of chemically bound energy[2-4], the increased rate of energy-utilizing macromolecular synthesis after mitosis[5-7] could be the mechanism for this reversal.

EDMUND GUTTES
SOPHIE GUTTES

Department of Biology,
Brown University,
Providence 12,
Rhode Island.

[1] Prescott, D. M., "Rhythmic and Synthetic Processes in Growth", edit. by Rudnick, D., 59 (Princeton University Press, 1957).
[2] Plesner, P. E., *Biochim. Biophys. Acta*, 29, 462 (1958).
[3] Swann, M. M., *Cancer Res.*, 17, 727 (1958).
[4] Guttes, E., and Guttes, S., *Science*, 129, 1483 (1959).
[5] Prescott, D. M., *Exp. Cell Res.*, 9, 328 (1955).
[6] Mitchison, J. M., *Exp. Cell Res.*, 13, 244 (1957).
[7] Mitchison, J. M., *Exp. Cell Res.*, 15, 214 (1958).

Albinism in an American Population of the Shore Crab, *Carcinus maenas* (L.)

THE common shore or green crab, *Carcinus maenas* (L.), is a widely distributed predator in inshore areas on both sides of the Atlantic. The ecological importance of the green crab, its status as a predator on commercial shellfish, and its extensive use in laboratory studies warrant a preliminary report on a recently noted abnormality found in a population of this species near Woods Hole, Massachusetts.

Two female *Carcinus maenas* with abnormal coloration were discovered by me in the summer of 1958 at Menemsha Creek, Martha's Vineyard Island, Massachusetts. In one specimen the right cheliped was entirely lacking pigment, appearing chalky white. The second specimen was similarly affected in all segments of a walking leg. The crabs, which had mated prior to capture, were isolated in running sea water at the Massachusetts State Lobster Hatchery and Research Station, and in November of 1958 they both became ovigerous. The white-clawed individual lost all her eggs during confinement; but the last of these were well developed by the time they became unattached. The second crab retained a part of the egg mass to the hatching stage. During March 20–30, 1959, slightly more than 700 eggs hatched from this female, 15 of them yielding larvæ totally lacking pigment except for the eyes. This group, slightly less than 2 per cent, were completely transparent and very readily separable from their siblings. Had they survived they probably would have become totally white adults. Relatively small amounts of white such as present on the parent crab would have been indistinguishable in the larval stages, and thus it is possible that some of the 'normal' larvæ also would have exhibited some albinism had they attained the adult form.

An attempt was made to rear all the larvæ but *Artemia* nauplii provided as food were apparently too large for the larvæ to utilize and other foods were not available at the time. Within 23 days of initial hatching all larvæ had died from starvation or other adverse cultural conditions, but there was no apparent tendency for albino larvæ to succumb more quickly than the others.

Discovery of several additional albino adults in the tidal creeks near the Lobster Hatchery some 10 miles from Menemsha indicated that the anomaly was not restricted to a single locality. Indeed, John Ropes of the Narragansett Marine Laboratory has since found partially albino green crabs in Rhode Island waters and even in Plum Island Sound, Massachusetts, north of Cape Cod.

To determine the frequency of occurrence of this abnormality in a natural population a trapping survey was undertaken during the summer months of 1959, near the Lobster Hatchery. The traps used were of 1-in. chicken wire mesh, and very young crabs were not retained. The results, therefore, are based only on adults and large juveniles. Prior to May 26, 1959, a total of 5 albino crabs had been captured in Martha's Vineyard waters. Between May 26 and July 31, 1959, a total of 1,595 green crabs was trapped of which 45, or 2·9 per cent, were partial albinos. The degree of albinism exhibited varied considerably. Thirty-one specimens had only one dactyl affected, whereas some specimens had several entire appendages white. In two specimens a white maxilliped was found, and several individuals had white sternal plates. At least two specimens were irregularly mottled on the carapace and other portions of the body. Specimens which moulted in captivity showed the same degree of albinism after moulting as before. There was no indication that the abnormal coloration was the result of injury or regeneration.

The incidence of 3 per cent reported here for an adult population may be lower than the frequency for the population as a whole, for trapped animals often had one or more appendages missing which would tend to reduce apparent incidence. If selective predation tends to eliminate those individuals showing large white areas, the adult incidence is probably less than in a juvenile population.

The wide variation in degree of albinism suggests more than one gene may be responsible for inheritance and/or exhibition of the character, but controlled laboratory matings will be necessary to study the inheritance of this condition in more detail.

At the time the data were collected I was employed by the U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Milford, Connecticut. I wish to thank Dr. V. L. Loosanoff, director of the Milford Laboratory, for permission to undertake this study.

ANTHONY J. PROVENZANO, JUN.

Marine Laboratory,
1 Rickenbacker Causeway,
Miami 49,
Florida.

Chordotonal Organs in Crustacea

THERE is a series of proprioceptor organs in the joints of the walking legs of decapod Crustacea, each consisting of a strand of elastic connective tissue with which are associated bipolar sensory nerve cells. These organs have been mentioned by Alexandrowicz and Whitear[1] and by Alexandrowicz[2]; work on their physiology has been published by Burke[3], Wiersma and Boettiger[4] and by Wiersma[5]. An electron microscope study of these organs in *Carcinus maenas* has now shown that they are chordotonal organs; the distal processes of the sensory cells are associated with scolopales.

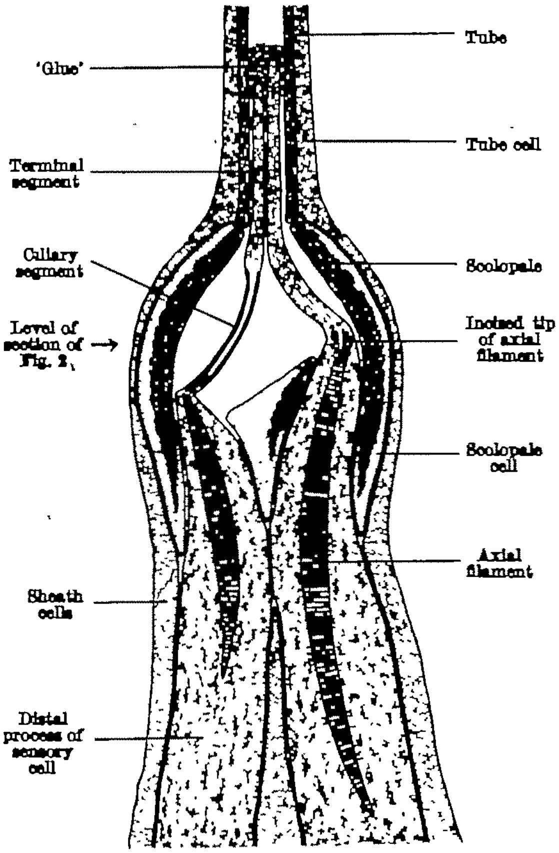


Fig. 1. Diagrammatic longitudinal section of a heterodynal scolopidium of the propodite-dactylopodite chordotonal organ, not to scale

In the organ spanning the propodite-dactylopodite joint each scolopidium receives the distal processes of two sensory cells; these are dissimilar in their fine structure. Following Debauche[6], who described scolopidia with paired sensory cells in certain insect chordotonal organs, such a scolopidium may be described as *heterodynal*. The structure is illustrated diagrammatically in Fig. 1. All the parts shown are embedded in the connective tissue of the strand; the nerve cell bodies may lie within the strand, or alongside it. Proximally, the distal processes of the sensory cells are wrapped in sheath cells which separate them from the connective tissue of the strand. Where a pair of distal processes become associated they are separated by a sheath cell, but after a certain distance this withdraws from between them, so that the cell membranes of the two sensory cells are in apposition, separated only by a 200–300 Å. gap. The two processes then enter the base of the scolopale, and become separated again by an intrusive projection of the scolopale cell. The scolopale itself is an intracellular organ consisting of an agglomeration of fibrous material which is markedly electron-dense. The scolopale cell encloses a space, 2–5μ across, which is presumably filled with fluid during life. Within the scolopale, the distal processes of the sensory cells narrow, and at first lie against the wall. They then change their structure and pass across the scolopale cavity to enter a tube, the lumen of which is continuous with the scolopale space. This tube, which corresponds to the 'terminal bundle' or 'terminal fibre' of classical descriptions of scolopidia, is an extracellular organ, presumably formed by a pair of cells which lie on either side of it. The walls of the tube consist of an amorphous substance which is vacuolated at intervals. The tube continues distally some way beyond the ends of the distal processes of the sensory cells, but eventually ends within the connective tissue strand; it does not reach so far as the exoskeleton.

As the distal processes of the sensory cells approach and enter the scolopale, each contains an *axial filament*, which is a rod about 0·5μ in diameter, tapering at the ends. It has transverse striations with a total interval of about 800 Å. Distally the axial filament ends where the sensory cell process leaves the wall of the scolopale; mitochondria occur in the cytoplasm of the cell process up to this point, but not beyond it. One of the two dissimilar sensory cell processes (that on the left in the diagram) as it passes into the lumen of the scolopale acquires a fine structure somewhat like that of a cilium, with nine peripheral microfilaments; there are, however, no central microfilaments. This part of the sensory cell process, the *ciliary segment*, is about 0·3μ in diameter. Before leaving the scolopale, the distal process thickens and loses the ciliary structure; instead of nine peripheral filaments it contains numerous microtubules, each about 200 Å. across. This part of a sensory cell process may be called the *terminal segment*. In the second sensory cell process (on the right in the diagram) the axial filament is longer than in the first cell, and extends somewhat farther up the scolopale wall, often partially wrapped by a ridge of the scolopale. At its distal end this axial filament becomes incised and vacuolated, so that in transverse section its extreme tip appears as an annulus with radiating buttresses. The ciliary segment as such is lacking, although in some cases there are indications of a ninefold structure immediately beyond the tip of the axial filament. As it crosses the lumen of the scolopale, the cell process has the structure of a terminal segment, with microtubules.

Fig. 2 is an electronmicrograph of a transverse section of a heterodynal scolopale showing the ciliary segment of one cell process and the incised tip of the axial filament of the other.

Both terminal segments run for a certain distance into the tube. Near their ends they become surrounded by an ill-defined substance which in Fig. 1 is referred to as 'glue', in consequence of its supposed function of fastening the terminal segments into the tube. One of the distal processes generally extends slightly farther than the other, but they both end within the 'glue'; more distally the tube appears empty.

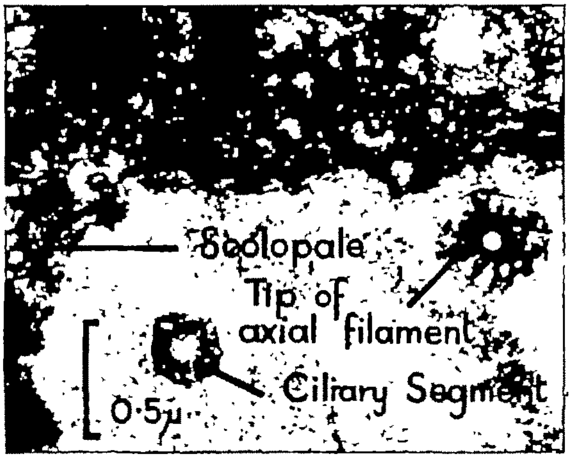


Fig. 2. Electronmicrograph of a transverse section of part of a scolopale of the propodite-dactylopodite organ; the level of the section is indicated in Fig. 1. Specimen fixed in osmium tetroxide, stained with phosphotungstic acid, and embedded in 'Araldite' epoxy-resin

All the scolopidia seen in the propodite-dactylopodite chordotonal organ have been heterodynal. According to Wiersma and Boettiger[4], the distal cells are 'position' and the proximal cells 'movement' receptors; no morphological differences between the scolopidia in the two positions have been detected, except in the size of the cell bodies.

There are two chordotonal organs associated with the carpopodite-propodite joint; *CP* 1 does not cross the joint, *CP* 2 does. All the scolopidia seen in *CP* 1 have been heterodynal, wherever situated. In *CP* 2, on the other hand, all the scolopidia seen have had associated with them only one sensory cell; it is proposed to refer to scolopidia of this type as *monodynal*. In all the cases seen, the distal process has been of the type with a ciliary segment. Apart from the lack of a second cell process, the structure of a monodynal scolopidium is as described above.

The organs in the meropodite have not yet been investigated with the electron microscope. The organ of the coxo-basipodite joint, *CB*, has scolopidia with paired distal processes, which are similar to one another, both being of the type with a ciliary segment. Following Debauche[6], such scolopidia are *isodynal*. Their structure otherwise resembles that of the heterodynal scolopidia.

Many of the structures described in these crustacean scolopidia, for example, the scolopale, axial filament and ciliary segment, may be compared directly with those in the scolopidia of the auditory organs of *Locusta migratoria*, recently described by Gray[7].

Any discussion of the functions of the types of scolopidia described above is speculative. So far as the propodite-dactylopodite and carpopodite-propodite organs are concerned, it would not be inconsistent with the results of Wiersma and Boettiger[4] and of Wiersma[5] to suppose that, in the heterodynal scolopidia, one sensory cell responds to stretching of the terminal segment, and the other to its slackening. The apposition of the two distal processes, proximal to the scolopale, suggests that they are capable of interacting in some way, perhaps of modifying one another's response. The presence of monodynal scolopidia in *CP* 2 would be consistent with Wiersma's report that the response of this organ is commonly to movement in one direction only. There are no published results on the responses of the coxo-basipodite organ, so that nothing can be said about the functions of isodynal scolopidia; it should be noted, however, that this is the only chordotonal organ of the series investigated which is not attached to a muscle tendon.

Various anomalies have been seen, particularly in the structure of non-ciliary processes of the heterodynal scolopidia, for which no explanation can be given as yet. The receptor organs at the bases of the legs of decapods, described by Alexandrowicz and Whitear[1] and by Alexandrowicz[2], are also being investigated by electron microscopy. It need only be mentioned at present that the muscular receptor organ and the innervated elastic strands are not chordotonal organs, and show none of the elaborations of structure described here.

MARY WHITEAR

Department of Zoology,
University College, London.

[1] Alexandrowicz, J. S., and Whitear, M., *J. Mar. Biol. Assoc. U.K.*, **36**, 603 (1957).

[2] Alexandrowicz, J. S., *J. Mar. Biol. Assoc. U.K.*, **37**, 379 (1958).

[3] Burke, W., *J. Exp. Biol.*, **31**, 127 (1954).

[4] Wiersma, C. A. G., and Boettiger, E. G., *J. Exp. Biol.*, **36**, 102 (1959).

[5] Wiersma, C. A. G., *J. Mar. Biol. Assoc. U.K.*, **38**, 143 (1959).

[6] Debauche, H., *Cellule*, **44**, 45 (1935).

[7] Gray, E. G., *Phil. Trans.*, B. (in the press).

Effects of Light and Darkness on the Rhythm of Output of Carbon Dioxide of Excised *Bryophyllum* Leaves

IT has been shown by Wilkins[1,2] that if excised leaves of the succulent plant *B. fedtschenkoi* are maintained in darkness, at a constant temperature of 26° C. and in an air-stream initially free of carbon dioxide they exhibit a 22·4-hr. rhythm in their rate of output of carbon dioxide. Furthermore, it was found that continuous illumination inhibited the rhythm, which recommenced when darkness was restored. A more detailed investigation of the light inhibition of the rhythm has been made by illuminating leaves for a few hours at various positions in the cycle.

If leaves are illuminated for 3 (Fig. 1*A*) or 6 hr. at an intensity of 3,000 lux between the peaks the phase is reset so that the first post-treatment peak occurs approximately 19 hr. after the end of the treatment. The degree of phase shift is therefore determined not by the duration of the treatment but by the time at which it terminates. Illumination for 1 hr., even at an intensity as high as 20,000 lux, has little or no effect upon the phase. On the other hand, up to 5 hr. illumination at an intensity of 3,000 lux applied at the crest of a peak did not reset the phase (Fig. 1*B*). Thus, the phase of a rhythm persisting in leaves in darkness varies in its sensitivity to a 3-hr. light treatment; it is reset by a treatment applied between, but not at the crests of, the peaks.

Over the range 8–3,000 lux, the intensity of illumination during a 6-hr. light treatment applied between the peaks has no effect on the efficiency with which that treatment resets the phase; the phase delay is determined by the time at which darkness is restored. At an intensity of 2 lux, however, the phase delay is equal to the duration of the treatment.

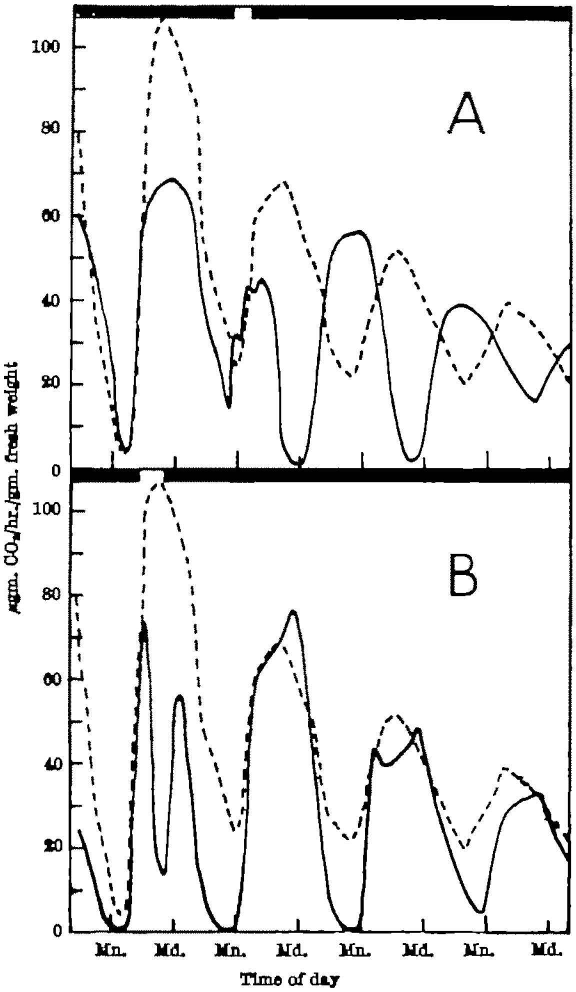


Fig. 1, *A*. Showing that 3-hr. illumination at an intensity of 3,000 lux, applied between the peaks, resets the phase of a rhythm persisting in darkness and at 26° C. *B*, showing that 6-hr. illumination at 3,000 lux applied at the crest of the peak does not reset the phase Illumination programme shown by the bar above each figure. Ordinates: μgm. carbon dioxide/hr./gm. fresh weight. Abscissae: Time of day, Mn. = midnight, Md. = noon. Control experiment in continuous darkness throughout shown by the broken lines

Wave-lengths of light greater than 565 mμ are responsible for inducing a phase shift. A 6-hr. red light treatment at an intensity of 850 ergs/cm.^{2}/sec. applied between the peaks resets the phase in a manner similar to a 3,000-lux white light treatment, whereas 6-hr. illumination with blue light (below 525 mμ) at an intensity of 10,860 ergs/cm.^{2}/sec. has no effect upon the phase. Moreover, continuous red light completely inhibits the rhythm, which recommences in blue light.

Clearly, whether or not a light treatment resets the phase of the rhythm depends on its wave-length, duration and intensity, and the time in the cycle at which it is administered.

It was previously observed that continuous illumination strongly inhibits the rhythm; but experiments carried out to determine the effect of changing the intensity of light to which leaves were exposed revealed that a rhythm is initiated in illuminated leaves if the intensity is reduced, either suddenly or gradually, by at least 80 per cent. The effect of a given intensity on the rhythm depends, therefore, on the intensity by which it is immediately preceded. For example, exposing leaves to an intensity of 500 lux inhibits a rhythm which was previously persisting in darkness (Fig. 2*A*), but initiates a rhythm in leaves which had previously been exposed to the higher intensity of 2,500 lux (Fig. 2*B*). A rhythm induced in this way in illuminated leaves will persist so long as a rhythm in darkened leaves and its phase is determined by the time at which the intensity is reduced. Over the range 0–500 lux, the period is unaffected by the intensity of white light to which the leaves are exposed.

Further experiments were carried out to determine whether or not the phase of a rhythm persisting in illuminated leaves was reset by interrupting the illumination with a few hours darkness and, if this was so, whether it was equally responsive to a short dark treatment applied at different positions in the cycle. A rhythm was initiated by illuminating leaves at an intensity of 3,000 lux for 13 hr. and then reduc-

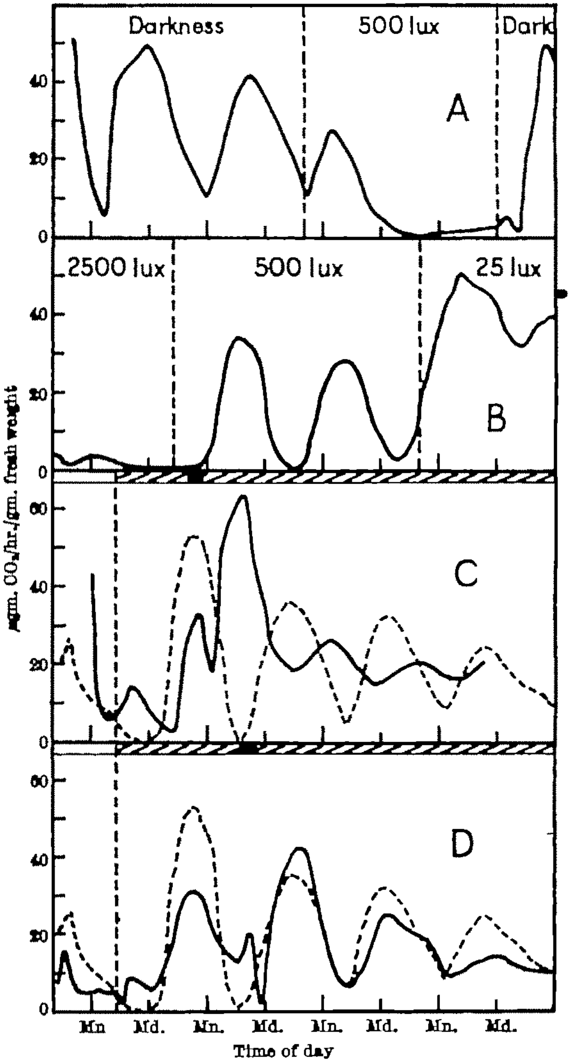


Fig. 2, *A* and *B*. Showing effect on the rhythm of changing the intensity of illumination to which the leaves are exposed. An intensity of 500 lux inhibits a rhythm in leaves previously exposed to darkness (*A*), but initiates a rhythm in leaves which were previously exposed to an intensity of 2,500 lux (*B*). *C* and *D*, showing that the phase of a rhythm in leaves illuminated at an intensity of 100 lux (hatched area in the illumination programme bar) is reset by 3 hr. darkness applied at the crest of a peak (*C*) but not between the peaks (*D*). Control experiment in 100 lux throughout shown by the broken lines. Unshaded area of illumination bar indicates that leaves were exposed to an intensity of 3,000 lux ing the intensity to 100 lux (broken curves in Figs. 2C and 2D). The phase is reset by darkening leaves for 3 (Fig. 2C), 6 or 9 hr. at the crest of a peak. The amount of phase shift is determined by the duration of the treatment, increasing to a maximum with 9-hr. darkness. On the other hand, the phase is unaffected by darkening leaves for 3 (Fig. 2D) or 6 hr. between the peaks. The phase of a rhythm persisting in illuminated leaves varies in its sensitivity to a 3-hr. dark treatment, being reset by a treatment applied at the crests of, but not between, the peaks. This variation is in the opposite sense to that of the phase of a rhythm in darkened leaves to a 3-hr. light treatment.

The phase of a rhythm in illuminated leaves is, however, reset when the light is permanently extinguished at a point between, or at the crests of, the peaks. Thus, while 6-hr. darkness applied between the peaks does not affect the phase, continuous darkness commencing at a similar time induces a phase shift.

The effects of light and darkness on the rhythm differ in two respects. If leaves having a rhythm persisting in light are exposed to continuous darkness only the phase is shifted, the rhythm is not inhibited as it is when leaves which have been kept in darkness are exposed to continuous light. Further, the minimum duration of light treatment required to induce maximum phase shift in a rhythm persisting in darkness is less than 3 hr., whereas more than 6-hr. darkness is required to induce maximum phase shift in leaves having a rhythm persisting in light.

In general, the reactions of the endogenous rhythm in *Bryophyllum* to changes in conditions of illumination closely resemble those of the rhythm of luminescence in *Gonyaulax polyedra*[3]. A more complete description of this work and a detailed comparison of the results with those of other authors will be published elsewhere.

MALCOLM B. WILKINS

Botany Department,
King's College,
University of London,
68 Half Moon Lane,
S.E.24. March 21.

[1] Wilkins, M. B., Ph.D. thesis, University of London (1958).

[2] Wilkins, M. B., *J. Exp. Bot.*, 10, 377 (1959).

[3] Hastings, J. W., and Sweeney, B. M., *Biol. Bull.*, 115, 440 (1958).

ENTOMOLOGY

Recognition of Nulliparous Mosquitoes without Dissection

DURING the age-grading of female mosquitoes it frequently happens that a large proportion of the dissecting time is devoted to the recognition of those that are nulliparous, when it is usually only the parous ones which require detailed examination. Such a difficulty is encountered to a marked degree in large samples of forest mosquitoes in Uganda, of which more than 95 per cent may be nulliparous. It is therefore desirable to establish means whereby as many nullipars as possible can be recognized without dissection. The use of two external characters for age-grading mosquitoes has been suggested previously[1,2], but only recently have techniques become available[3] whereby their reliability can be adequately checked. The work reported here was undertaken to determine whether these and two other external characters could be used with confidence to distinguish nullipars of certain African mosquitoes. The condition of each mosquito was checked by dissection of the ovaries[4]. Results show that in certain species the use of these characters can enable up to 90 per cent of nullipars to be recognized, thereby effecting a great economy in the age-grading of samples.

External wear. Variation in external wear was suggested as a means of age-grouping by Perry[1]. This character can be valuable if its use is restricted to recognizing only those females so fresh as to be certainly nulliparous. Once the minimum amount of wear associated with the first oviposition has been assessed, thereafter all individuals showing less wear can be classified as nulliparous. To establish the appropriate level of minimum wear in *Mansonia* (*Coquillettidia*) *metallica* Theo. and *M.* (*C.*) *fraseri* Theo. about 500 females of each species were first examined and dissected, and then reliability trials were conducted. Subsequent errors were extremely small. Of those classified as 'nulliparous', 8/938 (0·9 per cent) of *M.* (*C.*) *metallica* and 1/946 (0·1 per cent) of *M.* (*C.*) *fraseri* were parous; whereas among those classified as 'doubtful' 97/225 (43·1 per cent) and 60/143 (42·0 per cent) were parous, respectively. It has been found, moreover, that by adopting a slightly more severe criterion of minimum wear and achieving a greater familiarity with the species concerned, these errors can be reduced still further. In these samples the number of nulliparous mosquitoes dissected unnecessarily was reduced from 93 to 10 per cent. The amount and type of wear that is critical must be assessed independently for each species. Denuding of the abdominal sternites is the best guide in *Mansonia* (*Coquillettidia*), whereas wing fray is more reliable in *Mansonia* (*Mansonioides*) *africana* Theo., *M.* (*M.*) *uniformis* Theo. and *Aëdes*.

Parasitic mites. Gillett[5] suggested that hydrachnid mites could be used to age-grade swamp-breeding mosquitoes. Subsequent attempts to determine their reliability by dissection[5,6] have shown that, although the great majority of infested females are nulliparous, mites occasionally occur on parous ones also. In the present work it has been found that, although in some species more than 30 per cent of parous mosquitoes may carry mites, in nearly every case the latter are either dead or else not hydrachnids. Female mosquitoes which bear living hydrachnids are almost always nulliparous (Table 1). It is considered likely that the few exceptions recorded in Table 1 were due to initial failure to recognize those mites which were dead. In *M.* (*C.*) *fuscopennata* Theo., for example, hydrachnid mites die on at least 5 per cent of infested females before their first oviposition, and thereafter

Table 1. INFESTATION OF MOSQUITOES WITH LIVING HYDRACHNID MITES

Species	Nulliparous		Parous	
	Total examined	Percentage bearing hydrachnids	Total examined	Percentage bearing hydrachnids
M. africana	266	65·8	179	2·8
M. fuscopennata	1,594	52·1	676	2·5
M. uniformis	39	43·6	36	2·8
C. annulioris	366	14·2	330	0·3
M. metallica	3,904	10·4	384	—
M. aurites gp.	198	8·6	35	—
M. fraseri	4,944	8·3	410	—
M. maculipennis	197	4·6	20	—
M. pseudoconopas	1,666	2·2	54	—

remain attached to the host. The percentage of mites dying on the host varies according to the species of mite and mosquito, but has so far proved to be highest in *M.* (*C.*) *fuscopennata*. Such characters as shape, pattern, colour, site of attachment and associated scars indicate the kind of mite, whereas its shape and colour can show whether it is alive or dead. If these reservations are observed, hydrachnid mites can provide a valuable means of recognizing nulliparous mosquitoes.

Colour of integument. In *M.* (*C.*) *pseudoconopas* Theo. the colour of the thoracic pleura changes during adult life from apple-green to brownish yellow. If three progressive colour grades are recognized, it is found that all females in the first are nulliparous. The proportion of parous individuals encountered in each colour grade during trials were: green 0/606 (0 per cent); pale green 10/564 (1·8 per cent); and yellow 34/123 (27·6 per cent). Only about 20 per cent of parous females remain in the second colour grade after having laid eggs once. It has been found that most nullipars in the second grade can be recognized on abdominal wear, and that this often leaves only about 10 per cent of a sample to be dissected. In this species the existence of a colour sequence enables non-hydrachnid mites to be used as an additional guide to age, since these are small at the beginning of each gonotrophic cycle but large at the end of it. Thus their size can often make certain an otherwise doubtful diagnosis. About 36 per cent of *M.* (*C.*) *pseudoconopas*, nulliparous and parous, bear this kind of mite. Colour changes similar to, though less obvious than, those found in *M.* (*C.*) *pseudoconopas* occur in other mosquitoes. In some (for example, *Anopheles* (*Anopheles*) *implexus* Theo., *M.* (*C.*) *maculipennis* Theo. and *Culex* (*Lutzia*) *tigripes* Grp. and C.) the change takes longer and is not completed before the first oviposition, but in others (for example, *M.* (*C.*) *metallica*, *M.* (*C.*) *fuscopennata*, *M.* (*C.*) *aurites* Theo. gp., *M.* (*C.*) *fraseri* and *C.* (*Culex*) *annulioris* Theo.) females with greenish areas on thorax or abdomen are invariably nulliparous. In *M.* (*C.*) *metallica* up to 26 per cent of nullipars can be recognized in this way.

Presence of meconium. In younger nullipars of certain species with a pale abdominal integument (for example, *Coquillettidia* spp.) the meconium is clearly visible in abdominal segments 4 and 5. In catches of resting mosquitoes, up to 34 per cent of nulliparous *M.* (*C.*) *fraseri* may still retain it.

Other characters. If nulliparous females have to be dissected, they can often be classified quickly on two other characters. The first is the degree of resilience of the abdomen, which can differ markedly in nulliparous and parous individuals. The second is the presence of 15–30 discrete disks of fat in the abdominal cavity, as found in *Toxorhynchites*, *Coquillettidia* and *Eretmapodites*. These disks disintegrate during the first gonotrophic cycle, and in *Coquillettidia* usually before the first blood meal.

It is intended to publish a full account of this work elsewhere.

PHILIP S. CORBET

East African Virus Research Institute,
Entebbe, Uganda.

[1] Perry, R. L., *Paludism*, 2, 32 (1912).

[2] Gillett, J. D., *Ann. Trop. Med. Parasit.*, 51, 151 (1957).

[3] Detinova, T. S., WHO Course in Advanced Entomological Techniques (London, 1959) (Roneotyped).

[4] Corbet, P. S., *Trans. Roy. Soc. Trop. Med. Hyg.*, 53, 297 (1959).

[5] Wharton, R. H., *Nature*, 184, 830 (1959).

Ovarioles as a Meristic Character in Coleoptera

INSECT ovaries are bilateral structures (except in certain aphids) which contain 1–3,000 egg tubes or ovarioles. In Coleoptera, the ovarioles are polytrophic and acrotrophic in the sub-orders Adephaga and Polyphaga, respectively (see, however, Bonhag[1]). As the meristic nature of the beetle ovary has not been particularly studied, and because of the possible importance of the ovariole number as an aid to systematics, a study was undertaken.

The ovaries were removed by vivisection, placed on depression slides containing 0·8 per cent saline, and examined with a dissecting microscope. A list of the ovariole numbers in some families, arranged in the order of Leng[2], is given in Table 1.

Table 1. OVARIOLE NUMBERS (ONE OVARY) IN COLEOPTERA*

	Mean	Range	Species	Genera
Cicindelidae	10	9–12	3	1
Carabidae	10	4–21	33	14
Dytiscidae	15	14–40	6	6
Hydrophilidae	15	13–20	7	6
Silphidae	20	12–40	5	2
Staphylinidae	7	3–10	16	12
Lampyridae	20	8–27	4	4
Meloidae	86	12–200	5	4
Elateridae	19	4–33	9	6
Cucujidae	3	2–8	12	5
Coccinellidae	17	2–51	55	26
Tenebrionidae	20	4–52	6	5
Scarabaeidae	6	5–7	14	12
Cerambycidae	30	27–33	3	3
Chrysomelidae	13	5–25	20	16
Curculionidae	2	1–2	36	25
Scolytidae	2	2–2	14	10

* A partial listing of work on 45 families or 287 species, 106 of which have been determined by me.

A wide range of 1–200 ovarioles occurs within the Coleoptera. There is, however, relatively little intrafamilial variation in ovarioles (usual number in parentheses) in the Staphylinidae (5), Cucujidae (3), Scarabeidae (6), Curculionidae and Scolytidae (2). While similar values occur in other families they are part of an extensive interspecific range in ovariole number. Thus the Silphidae, Lampyridae, Elateridae, and Tenebrionidae, which average close to 20 ovarioles, contain large interspecific differences (2–52). The highest values are found in the Meloidae and Cerambycidae, which have 86 and 30 respectively. The Cerambycidae show a narrow range (27–33), but in the Meloidae it is very great (12–200). Prominent differences can often be observed between subfamilies and between tribes. The Coccinellidae and Coccinellinae and Epilachninae average 16 and 27, respectively; within Coccinellinae, the Hyperaspini, Scymnini, Psylloborini and Coccinellini have values of 7, 6, 13 and 21, in that order.

While many species contain a constant number of ovarioles just as many show an intraspecific variation. For example, *Harpalus pennsylvanicus* DeG. and *Chauliognathus pennsylvanicus* DeG. have means of 10 ± 1·8 and 47 ± 11·9, respectively. Where species were sampled from two localities different values were obtained. Thus *C. pennsylvanicus* from Penn Park, Pa., have 34 ± 15·5 ovarioles, whereas 47 ± 11·9 obtain at Ottawa, Ontario. Within individuals a difference in ovariole number between left and right ovaries was often noted; *Plagiodera versicolor* Laich. and *Coccinella novemnotata novemnotata* Hbst. are examples. In *Drosophila melanogaster* Meig. it is thought that this asymmetry results from disturbance of embryonic processes that precede ovariole development[3].

A detailed report on the numbers of ovarioles and their structure is being prepared for publication. I am indebted to Mr. W. J. Brown of this Institute for identification of species and assistance with problems of synonymy.

J. G. ROBERTSON

Entomology Research Institute,
Canada Department of Agriculture,
The K. W. Neatby Building,
Ottawa,
Ontario.

---

[1] Bonhag, P. F., "Ann. Rev. Entomol.", 3, 137, 143 (1958).

[2] Leng, C. W., "Catalogue of the Coleoptera of North America, North of Mexico" (Cosmos Press, 1920).

[3] Robertson, F. W., *J. Genet.*, 55, 410 (1957).

Nutritive Values of Carbohydrates for the Silkworm, *Bombyx mori*

NUTRITIONAL requirements for carbohydrates in insects have been widely studied[1], but not enough in the leaf-eating forms. This is mainly due to the fact that there are difficulties which must be solved before the determination of their nutritional requirements, namely, in devising a suitable test diet. In the silkworm, *Bombyx mori*, the nutritive value of the mulberry leaves has hitherto been discussed on the basis of the analytical data of leaf components as well as of the rearing experiments of larvæ. Though many efforts have been made to formulate a chemically defined diet for this insect, no suitable one has so far been made available. I have recently tried to determine the nutritive values of carbohydrates for the silkworm by means of oral administration of them.

Newly moulted, unfed fifth instar larvæ were used. All substances were supplied in the form of either a solution or a suspension and no leaf was offered to the larvæ[2]. A hypodermic needle mounted on a syringe was inserted from the mouth opening into the gut lumen and a known volume of such a solution (10 per cent, w/v) was administered once a day. The larvæ were kept at room temperature and weighed every day until death. Ten larvæ were used for one substance in each experiment. Data on survival tests have been calculated as the number of days that the larvæ remained alive, in other words, days to 100 per cent mortality. The mean was obtained by dividing the summation of days for each larva in one group by ten, as summarized in Table 1.

Table 1. SURVIVAL OF SILKWORM LARVÆ ADMINISTERED WITH VARIOUS CARBOHYDRATES

Carbohydrate	Mean length of survival (days)		
	Experiment 1	Experiment 2	Experiment 3
Pentoses			
L-Arabinose	3·3	3·3	4·1
L-Rhamnose	3·2	2·9	4·0
D-Ribose	4·0	4·4	5·5
D-Xylose	5·9	7·8	9·8
Hexoses			
D-Fructose	6·1	5·6	7·7
D-Galactose	5·1	5·5	5·7
L-Sorbose	2·3	3·0	3·4
D-Glucose	6·8	7·1	7·9
D-Mannose	6·9	7·8	7·7
Disaccharides			
Sucrose	6·8	7·1	8·2
Maltose	5·9	6·9	6·2
Lactose	5·8	7·9	8·5
Cellobiose	7·2	8·7	8·3
Trehalose	6·9	6·3	8·2
Melibiose	6·2	7·3	8·4
Trisaccharides			
Raffinose	7·5	7·8	7·7
Melezitose	8·6	8·2	8·6
Glycosides			
α-Methylglucoside	3·5	3·2	4·3
α-Methylmannoside	2·7	2·8	3·6
Sugar alcohols			
Inositol	—	5·3	6·2
Mannitol	—	—	8·3
Dulcitol	—	2·6	3·8
Sorbitol	6·2	8·3	9·7
Polysaccharides			
Dextrin	—	6·0	9·6
Starch	—	—	5·4
Water	3·1	2·8	3·5
Starved	3·1	3·4	4·4

Any carbohydrate which increases survival beyond that of the control larvæ supplied with water alone can be assumed to be of nutritive value. Control larvæ usually survived for three days or a little longer and died somewhat sooner than those starved.

Among four pentoses tested, only xylose is utilized and arabinose and rhamnose are of little or no value. Ribose is slightly better than those two. Of the hexoses, glucose, fructose and mannose are good; galactose is of moderate value, while sorbose is exceptionally bad. The disaccharides are uniformly good. The trisaccharides raffinose and melezitose are well utilized. Both glycosides tested are scarcely utilized. Among alcohols, sorbitol and mannitol are utilized, but inositol is intermediate, and dulcitol is of no value. Dextrin is also good and much better than starch.

The results on the increase in body-weight also supported that on survival tests; carbohydrates increasing the length of life resulted in an increase in body-weight, while those not increasing survival were generally of no effect on the weight or rather often inhibitory. Thus, it is of interest that the nutritional requirements for carbohydrates by the silkworm are in good agreement with those of many other insects in many ways, even though there are great differences between insect species in the survival value of certain compounds.

Preferences for sugars have also been studied with this insect[3], and it is concluded that there is no correspondence between the nutritive value of various sugars and preference for them. Sugars which are preferred most and are of high nutritive value are sucrose, fructose and raffinose.

TOSHIO ITO

Sericultural Experiment Station,
Suginami-ku, Tokyo.

Feb. 4.

---

[1] Trager, W., in "Insect Physiology", 350, edit. by Roeder, K. D. (John Wiley and Sons, Inc., New York, 1953). Lipke, H., and Fraenkel, G., "Ann. Rev. Entomol.", 1, 17 (1956). Friend, W. G., "Ann. Rev. Entomol.", 3, 57 (1958).

[2] Ito, T., and Tanaka, M., *Bull. Seric. Exp. Sta.*, 15, 353 (1959).

[3] Ito, T., *J. Insect Physiol.* (in the press).

GENETICS

Autogenous Necrosis in an *Antirrhinum* Species Hybrid

HERITABLE plant tumours have been found in interspecific hybrids of *Nicotiana*[1,2], particularly in the hybrids of *N. glauca* × *N. langsdorffii*. Seldom, however, have they been found in any other plant material; an inbred line of clover[3] and interspecific hybrids of *Datura*[4] being possible extensions of the

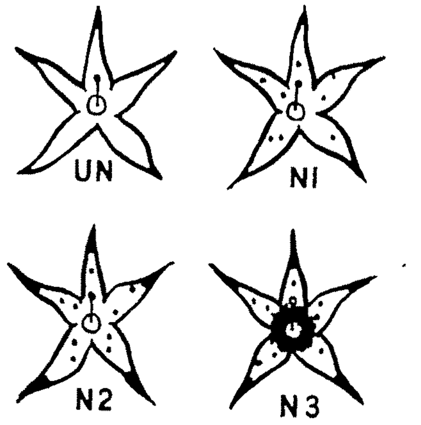


Fig. 1. Degrees of necrotic spotting on the calyces of *A. orontium* × *A. meonanthum* hybrids

phenomenon. Autogenous necrosis, also an infrequent pathological condition but perhaps genetically analogous to some cases of tumour formation, has been observed and analysed in hybrids of *Lycopersicon* species and wheat varieties[5,6]. The results presented here have many similarities with the variable production of necrosis in some wheat hybrids, but the sterility of the *Antirrhinum* material prevented further analysis.

The necrosis in *Antirrhinum orontium* × *A. meonanthum* appears as excrudescent, corky spots on the stems, leaves and calyces, together with occasional lesions on the stems. The degree and position of these effects varied according to the origin of the parent plants (see Table 1 and Fig. 1). The hybrid was also found to be sterile, no chromosome-pairing occurring at meiosis, and it could only be produced when the self-fertile *orontium* species was the female parent and the self-incompatible *meonanthum* the male[7]. Many interspecific hybrids have been made within the genus, but only the *orontium* × *meonanthum* hybrid has shown this abnormal pathological condition.

Table 1

A. orontium ♀	*A. meonanthum* ♂			
	Penacova origin		Coimbra origin	
	Cross-compatible plants *A*	*B*	Cross-compatible plants *A*	*B*
Kew origin	*L* *N2*	*LL* *N3*	*UL* *UN*	*UL* *UN*
Sacavem origin	*L* *N1*	*LL* *N1*	*UL* *UN*	*UL* *UN*
Var. *parviflorum*	—	*LL* *N3*	*UL* *UN*	*UL* *UN*

UL, Unaffected by lesions on stem; *L*, lesions on stem; *LL*, severe lesions; *UN*, unaffected by necrotic spots; *N1*, necrotic spots on stems, leaves and calyces; *N2*, necrotic spots on stems, leaves and calyces and on all tips of calyces; *N3*, like *N2*, but centre of calyces badly affected by necrosis.

Although no phenotypic differences can be seen between *orontium* plants obtained from Kew and those from Sacavem (Portugal), the F_1's of these with *meonanthum* show different expressions of necrosis. Likewise, in *meonanthum*, no phenotypic differences could be seen between the Portuguese (Penacova and Coimbra) lines but, even when cross-compatible plants within the Penacova line were tested, the associated, although not necessarily correlated, differences in genetic constitution were sufficient to influence the expression of stem-lesions and necrosis in the hybrid. Hybrids involving the Coimbra *meonanthum* never showed any lesions or necrosis; these hybrids, moreover, although still sterile, were much more vigorous and germinated better than the hybrids incorporating the Penacova line.

Crosses of *orontium* (Kew) with the *meonanthum* cross, Penacova × Coimbra, and reciprocal, segregated for affected and unaffected plants irrespective of the way the *meonanthum* cross was made. No necrosis was transmitted across the union when grafts were made between affected and unaffected plants. This strongly indicates that the cause is nuclear-genetic, perhaps similar to that of the wheat necrosis[6], rather than cytoplasmic or of virus origin. Tetraploid *orontium* (Kew) showed a few slight stem-lesions but no necrotic spots. No necrosis or lesions were observed in any of the tetraploid *meonanthum* material.

From Table 1 it can be seen that the production of lesions and necrotic spotting varies characteristically among the different *orontium* × *meonanthum* crosses. As there is a characteristic siting of necrosis, according to the cross, the condition cannot be attributed to haphazard breakdown of tissue; the differential siting and degree of breakdown would seem to be an expression of associations of complementary genes variously carried in some populations that have, in these hybrids, come together in unbalanced genomes. Different degrees of additional gross unfitness in a wide cross may, therefore, result from latent complementary genetic differences between parents that only show in particular F_1's and which can be variously contributed by either male or female parent. Such genes could be carried in populations without any rigorous erosion as they are apparently expressed only in this very rare cross which, being sterile, has no mating continuum.

B. J. Harrison

John Innes Horticultural Institution,
Bayfordbury, Hertford,
Herts.

March 16.

[1] Kostoff, D., "Cytogenetics of the Genus *Nicotiana*" (State Printing House, Sofia, 1941–1943).
[2] Kehr, A. E., and Smith, H. H., Brookhaven Symp. Biol., No. 6, 55 (1954).
[3] Littau, V. C., and Black, L. M., *Amer. J. Bot.*, 39, 191 (1952).
[4] Satina, S., Rappaport, J., and Blakeslee, A. F., *Amer. J. Bot.*, 37, 576 (1951).
[5] Langford, A. N., *Canad. J. Res.*, 26, 35 (1948).
[6] Hermsen, J. G. Th., *Euphytica*, 9, 37 (1960).
[7] Harrison, B. J., and Darby, L. A., *Nature*, 176, 982 (1955).

Frequency of Quadrivalents in Autotetraploid Plants

The cytological examination of chromosomes at meiosis in autotetraploid plants is an important part of the study of chromosome behaviour. Cytological studies have varied in intensity from casual observations at meiosis to meticulous analyses of all configurations observable, including an estimate of the frequency of quadrivalent formation. It is a common belief that the number of quadrivalents formed is governed by: (1) the size of the chromosomes; (2) the chiasma frequency; (3) the existence of

Table 1. ASSOCIATION OF CHROMOSOMES AT FIRST METAPHASE IN SOME AUTOTETRAPLOIDS

Species	No. of chromosomes	No. of cells	Univalents	Bivalents	Trivalents	Quadrivalents	Percentage of chromosomes in quadrivalents
Plants with large chromosomes							
Lilium, garden hybrid	48	50	< 0·1	5·0 (0–10)	< 0·1	9·4 (7–12)	78·3
Triticum durum	56	100	1·2	8·9 (2–18)	0·5	8·8 (6–13)	62·8
Avena strigosa	28	50	< 0·1	5·9 (0–10)	< 0·1	4·0 (1–7)	57·1
Medium to small chromosomes							
Asparagus officinalis	40	25	0·7	5·2 (0–10)	0·4	6·9 (4–10)	69·0
Petunia hybrida	28	10	0·1	4·6 (2–8)	0·1	4·6 (2–6)	65·7
Small chromosomes							
Ageratum houstonianum	40	10	—	7·4 (4–10)	—	6·3 (5–8)	63·0
Lycopersicum esculentum	48	25	< 0·1	9·9 (4–14)	< 0·1	7·0 (5–10)	58·3
Raphanus sativus	36	10	—	5·2 (2–12)	—	6·4 (2–8)	71·1
Antirrhinum majus	32	25	0·1	2·7 (0–8)	0·1	6·5 (4–8)	81·2
Kalanchoe blossfeldiana	68	25	< 0·1	12·5 (8–18)	< 0·1	10·7 (8–13)	62·9
						Mean	66·9

localized rather than random chiasmata; (4) an excess number of chromosomes, within a cell, which prevents the physical process of pairing; and (5) genetical control. Several of these factors have been discussed under different aspects, sometimes with a slight change in meaning. For example, the cause of low quadrivalent formation has been related to the paucity of 'pairing blocks', the position of the centromeres in chromosomes, and chiasma interference across the centromere[1].

We recently completed a study of meiosis in seven autotetraploid cereals and grasses in which we were not able to demonstrate major differences between the species in regard to the number of quadrivalents that were formed[2]. All strains or species had $4x = 28$ chromosomes and a mean of 4·3 quadrivalents. That is, about two-thirds of the chromosomes were united as quadrivalents. Similar proportions of chromosomes were associated as quadrivalents in autotetraploid flax ($4x = 60$) and corn ($4x = 40$). Both these species have small chromosomes. A further test with a wider range of material was immediately suggested because our results obviously did not conform to current concepts of quadrivalent formation in autotetraploids.

Meiosis was studied in ten different autotetraploids, representing a wide range in plant types, chromosome number and size. The species (Table 1) have been arranged in decreasing order of nuclear size (see also Fig. 1). It is immediately evident that in plants with small chromosomes as many quadrivalents are formed as in plants with large chromosomes. The results also support our hypothesis that in all autotetraploids, approximately two-thirds of the chromosomes form quadrivalents.

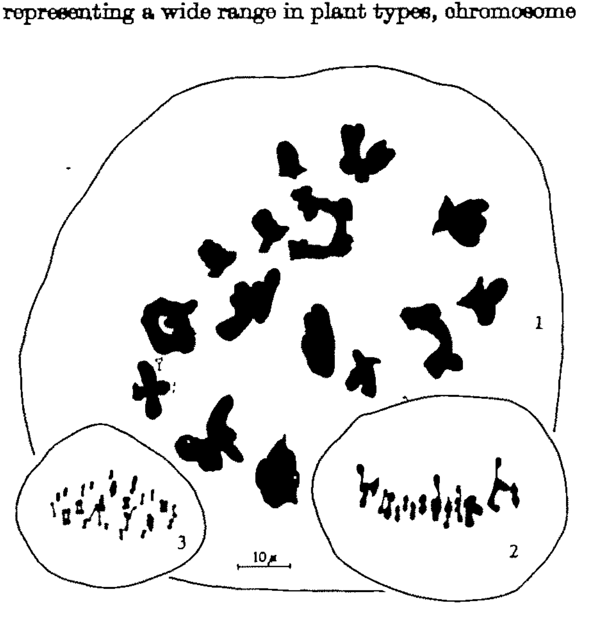


Fig. 1. Cells at first metaphase of meiosis. 1, *Lilium* $6^{II}9^{IV}$; 2, *Asparagus* $8^{II}6^{IV}$ (4 large, 2 small); 3, *Kalanchoe* $14^{II}10^{IV}$

Table 2. ASSOCIATION OF THE FOUR SMALL AND THE SIX LARGE CHROMOSOMES OF *Asparagus officinalis* IN 25 POLLEN MOTHER CELLS

Associations	Small chromosomes		Large chromosomes	
	Average number	Percentage of total possible	Average number	Percentage of total possible
Univalents	0·3	1·8	0·4	1·6
Bivalents	2·4	31·0	2·8	23·3
Trivalents	0·1	1·8	0·3	3·7
Quadrivalents	2·6	65·0	4·3	71·6

Several examples in plants[3] and in animals[4] have been cited to show that within an organism the larger chromosomes form more quadrivalents than the smaller. We found that in the tetraploid *Asparagus* the small chromosomes formed as many quadrivalents as the large ones (Table 2). Our results for *Asparagus* do not nullify previous reports. But when this evidence is considered in conjunction with the fact that in very small chromosomes of *Kalanchoe*—so small in fact that chiasmata cannot be estimated—there is no restriction of quadrivalent formation, then it seems reasonable to suppose that size alone does not limit the formation of quadrivalents: the shortest chromosomes are long enough to undergo the reactions necessary to produce quadrivalents. Because our results do not uphold the assumption that plants with small chromosomes have fewer quadrivalents than plants with large chromosomes we therefore disagree with the conclusions of Kostoff[3] and see no reason why autotetraploids with small chromosomes should be more suitable for plant breeding than those with large chromosomes.

If only one chiasma is formed between two chromosomes in a bivalent then, under our present concepts of chromosome behaviour, no quadrivalents would be possible in a homologous set of four chromosomes. It follows that if a species had a low chiasma frequency per bivalent, fewer quadrivalents would be formed. To be of any value in clarifying the problem a chiasma count would have to be made at the actual time of union or crossing-over. With present-day techniques this is not feasible and the later stages, diakinesis or metaphase, are used. Chiasma number of the diploid *Lilium* has been estimated at 3–5 per bivalent, in *Triticum* and *Avena* at 2–3, in *Lycopersicum* at 1–2 and a similar low figure for other small chromosomes. It is quite impractical to estimate chiasma number for small chromosomes and counts given for some can be viewed with considerable circumspection. We found a fairly uniform number of quadrivalents for all the species and so conclude that either the present-day estimates of chiasmata are out of line or else frequency has no effect on the number of quadrivalents formed.

Localization is difficult to detect by cytological methods and is often assumed to be the rule in organisms when terminalization does not occur. It is undetectable in cytological preparations of small chromosomes and therefore our results do not add much evidence. If localization is a true phenomenon and not an artefact arising from our inability to trace chiasmata in cytological preparations, then, coupled with low frequency of the event, it would probably restrict quadrivalent formation. However, because it holds only for special species and is not constant under all conditions, it should not be regarded as exercising major control over quadrivalent formation.

The implication that physical interference could restrict quadrivalent formation is a direct one relating comparative nuclear volume to the number of chromosomes within that nucleus. The diameters of the nuclei at pachytene varied from 45μ in *Lilium* to less than 15μ for *Lycopersicum* and *Kalanchoe*. The chromosome numbers ranged from 28 to 68. Yet, in none of the species studied was there any indication that crowding of the chromosomes had restricted quadrivalent frequency.

Some cytologists still support the theory that a trend towards 'bivalency' occurs in autotetraploids. We do not, because in advanced generations of many different induced autotetraploids we did not find any reduction in quadrivalent frequency. Further, in the natural autotetraploids *Hordeum bulbosum*, *Hordeum violaceum*, and *Arrhenatherum elatius* we found no evidence for an increase in the number of bivalents[3]. In this study of ten autotetraploids, representing different families and orders, approximately two-thirds of the chromosomes formed quadrivalents. This does not deny the existence of a gene which could control quadrivalent frequency, but it does give some warning against the acceptance as autotetraploids of those plants with twice the expected number of chromosomes in which no quadrivalents are found, for example, in the supposedly clear-cut case of autopolyploidy, *Galax aphylla*[6]. Our results, then, show no evidence of gene control over quadrivalent frequency and support the hypothesis that the behaviour is similar for all species.

J. W. MORRISON
T. RAJHATHY

Genetics and Plant Breeding Research Institute,
Research Branch,
Canada Department of Agriculture,
Ottawa.

---

[1] Current concepts of quadrivalent formation can be traced to the original publications of C. D. Darlington *et al.* For references, see "Recent Advances in Cytology" (Churchill, London, 1937) or "Evolution of Genetic Systems" (Oliver and Boyd, London, 1958).

[2] Morrison, J. W., and Rajhathy, T., *Chromosoma* (in the press)

[3] Klingstedt, H., *Mem. Soc. Fauna Flora Fenn.*, 12, 104 (1936).

[4] White, M. J. D., "Animal Cytology and Evolution" (Cambridge University Press, 1954).

[5] Kostoff, D., *J. Heredity*, 31, 33 (1940).

[6] Swanson, C. P., "Cytology and Cytogenetics" (Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1957).

OCEANOGRAPHY

Southern Atmospheric Cyclones and the Whale Feeding Grounds in the Antarctic

KNOWLEDGE of the distribution of the stocks of commercial fishes and whales is of no less interest than knowledge of their numbers. N. A. Mackintosh[1] suggested that "it may be that since Blue and Fin whales tend to concentrate in much the same regions in the Antarctic [where the Humpbacks concentrate —C. W. B.], they too, although they do not crowd into temperate coastal waters, are still loosely influenced by the southern land-masses, and that it is subsidiary features of their distribution that are controlled by their immediate environment" (p. 259). This communication gives a possible explanation of this "loose influence".

After their arrival in the Antarctic the whalebone whales start seeking their food (mainly krill, *Euphausia superba*) at random. Nevertheless, in spite of their random movements, the whales are grouped in separate areas, approximately 20–60° long. from each other. These areas correspond to the well-known whaling grounds situated one in each of the whaling sectors, outside the former sanctuary[1]. The uneven distribution of the whales is an obvious result of the uneven distribution of the krill (see maps). The krill itself is influenced by the atmospheric cyclones in a following way[4].

Due to atmospheric cyclones, the Antarctic Divergence is not continuous but is formed of areas where the water rises very intensively in the centres of the cyclones and of areas where it sinks in their peripheries[4]. The longer the cyclone stays in a given place the more intensive upwelling it induces near its centre. In the zone of the Antarctic Divergence in the centres of cyclones the upwelling is easily noticeable by the increased area between the isotherms 1·5° C. and

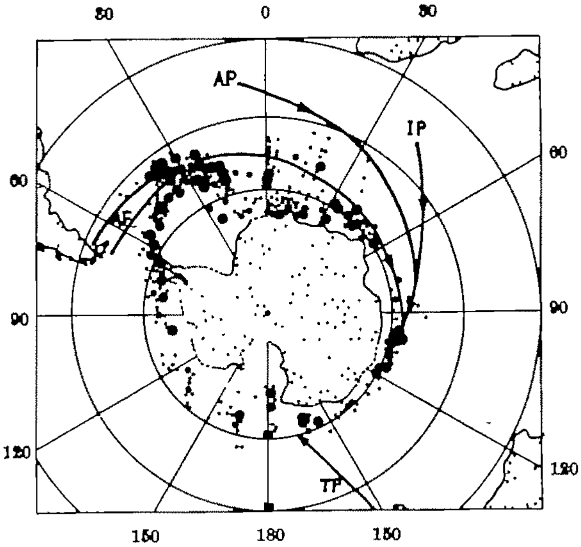


Fig. 1. Krill and cyclones distribution in the Antarctic (combined from Marr (ref. 2), Tauber (ref. 10) and Schmitt (ref. 12). with modifications). Arrows, tracks of cyclones in January; *AP*, cyclones of the Atlantic polar front; *IP*, cyclones of the Indian polar front; *TP*, cyclones of the Tasman polar front; *AF*, cyclones of the Antarctic front; circles, quantity of *Euphausia superba* not less than 20 mm. long, based on the catches of 1 m diameter stramin nets towed on the surface during the pelagic whaling season, January–February–March. ·, 1–100; ●, 100–1,000; ●, 1,000–10,000; ○, 10,000–100,000

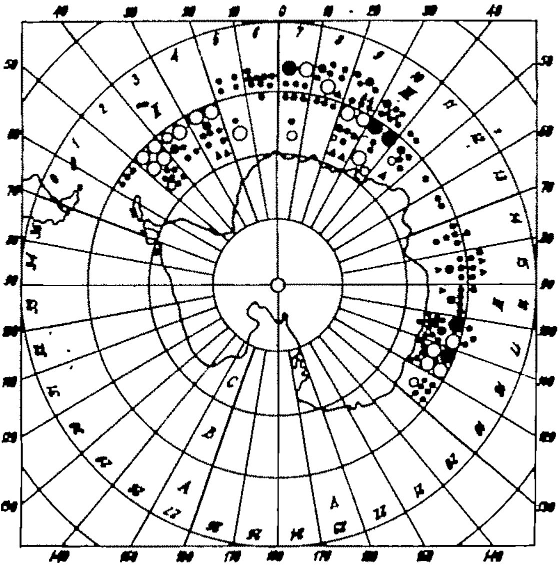


Fig. 2. Number of whales killed during the pelagic season 1937–38 (after Zenkovich (ref. 3)). Black circles, blue whales; open circles, fin whales (large circles, 1,000; medium circles, 500; small circles, 100); open triangles, humpbacks (100). In different years the maxima of whales are not situated exactly at the same places

2·0° C. in the layer of maximal temperatures[4]. The barren upwelled 'new water' carries along the phytoplankton cells to the peripheral region of the cyclone, thus forming a 'clearing' in the diatom bloom. At the same time the upwelling adds to the rise to the surface of the later *Furcilia* larvæ and young adolescent krill[4] which lives in its earlier stages in the intermediate warm water layer[7]. A similar distribution pattern of phytoplankton and euphausiids (*Euphausia pacifica*) can be seen in the Monterey Bay (California) area[8], where a canyon acts as a fountainhead from which the cold waters rise and then spread out to other regions of the Bay. During the upwelled-water period there is a 'clearing' in the bloom over the canyon and tremendous swarms of *E. pacifica* have been observed at the surface in broad day-light there, though normally this species is found near California coasts at depths of 100–400 m.[8], in the intermediate water layer of sub-arctic origin[9]. (It must be remembered that the phytoplankton distribution is never operative in the distribution of krill and whales, but the 'clearings' are very characteristic features of the local upwelling areas and thus worth mentioning.)

In the eastern hemisphere the cyclones of the antarctic front have their maximal frequency between 0° and 70° E. Near the coasts of Antarctica the cyclones of the polar front have their maxima at 90–110° E., 140–170° E., and in the Ross Sea. The number of the cyclones diminishes eastward and is minimal in the southern Pacific[10] (Fig. 1).

The krill is more abundant, and there are more blue and humpback whales in regions where the cyclones are more frequent and stay longer. The centres of these regions are situated at 35° E., 95° E., and 175° W. The total amount of the krill and of the blue whales killed per annum (like the cyclones) diminish eastward and are minimal in the southern Pacific.

In the mean the feeding grounds of fin whales are situated more northerly than those of the blue whales, and therefore the former feed mainly on larger older developmental stages of the krill which are not so closely connected with the areas of the upwelling in the zone of the Antarctic Divergence as the small 'blue whale krill'[1,2,11]. The fin whales are more uniformly distributed in antarctic waters than the blue and humpback whales are and are more loosely connected with the atmospheric cyclones.

The cyclones of the polar front are formed in the sub-tropical zone in the regions of the hydrological fronts between the warm and cold currents to the east of the southern parts of America, Africa and Australia. From these regions they migrate to the south-east and enter the antarctic zone[10,12]. In consequence there are more polar-front cyclones where the continents lie more closely to each other, that is, in the Atlantic and Indian sectors. The position of individual regions rich in krill and whales is largely determined not only by the local antarctic conditions but also by the tracks of the polar front cyclones as well. Thus the distribution of the most important pelagic animals in the Antarctic is influenced by the general distribution of sea and land in the southern hemisphere. The cyclones of the polar front promote the spreading of the influence of sub-tropical land-masses in the antarctic zone.

C. W. Beklemishev

Institute of Oceanography,
U.S.S.R. Academy of Sciences,
Moscow.

[1] Mackintosh, N. A., "Discovery" Rep., 22, 197 (1942).
[2] Marr, J. W. S., *Norsk hvalfangsttidende, Arg.*, 45, No. 3 (1956).
[3] Zenkovich, B. A., *Tr. Vniro*, 33, 5 (1957).
[4] Beklemishev, C. W., *Izvestia U.S.S.R. Acad. Sci.*, Ser. Geogr., No. 6 (1959).
[5] Ivanov, J. A., and Tareev, B. A., *Izvestia U.S.S.R. Acad. Sci.*, Ser. Geogr., No. 6 (1959).
[6] Beklemishev, C. W., *C.R. (Doklady) U.S.S.R. Acad. Sci.*, 119, No. 4 (1958).
[7] Fraser, F. C., "Discovery" Rep., 14, 1 (1936).
[8] Barham, E. G., Hopkins Marine Station Tech. Rep., No. 1 (1957).
[9] Beklemishev, C. W., and Parin, N. V., *Trans. Inst. Oceanog.*, 41 (1960).
[10] Tauber, G. M., "Antarctica", Pt. 1 (Hydrometeoizdat, Leningrad (1956).
[11] Nemoto, T., Rep. Whales Res. Institute, No. 14 (1959).
[12] Schmitt, W., "Synoptic Meteorology of the Antarctic", "Meteorology of the Antarctic", edit. by van Rooy, M. P., Chap. 11 (Pretoria, 1957).

PSYCHOLOGY

Time Uncertainty and Choice Reaction Time

The duration of the foreperiod, that is, the interval between some warning signal and the stimulus, has long since been known as one of the main factors which influence the length of simple reaction time[1–4]. Klemmer[1] has recently shown that reaction time is shorter with brief (0·25 sec.) constant foreperiods than with either longer constant foreperiods or variable ones. He suggested that the critical factor is 'time uncertainty', that is, uncertainty as to the moment of occurrence of the stimulus. This uncertainty would result from the length of the foreperiod as well as from its objective variability, due to the inaccuracy of internal time estimation processes. Speed of reaction clearly depends on the possibility for some transitory state of preparation to be reached at the right time.

In the case of simple reactions, the only limit to speed comes from time uncertainty. In the case of choice reactions, there is also uncertainty as to the nature of the stimulus to come and consequently of the response to be given. We were interested to know whether the usual effects of time uncertainty can then still be observed. An answer to this question could throw some additional light on the nature of 'preparation', by telling whether it is a completely selective process, linked to a particular stimulus-response pair. If preparation is completely selective, it is of no use to be able to anticipate the moment of occurrence of the signal if one does not know which it shall be. Then choice reaction time, provided the series of signals is non-redundant, must be independent of foreperiod variability. If it is not, some degree of non-specific preparation must be possible.

The exploratory experiment to be reported consisted of measuring both simple and choice reaction time under conditions (*a*) of constant short foreperiods of 0·50 sec., (*b*) of variable foreperiods, 8 intervals ranging by roughly equal steps from 0·25 to 5·50 sec. appearing in random order with equal frequencies. A neon bulb provided the warning signal. On every trial, it was lighted for 2·5 sec. The foreperiod started when it went off. The stimulus itself was provided by a cold cathode indicator tube, with figure-shaped coils (a 'Nixie' tube, manufactured by the Burrough Corp.). For the choice reactions, the stimuli were a 4 or a 3, and two relays served as response keys, which the subjects pressed with both index fingers. For the simple reactions, the stimulus was a 3 and the subject responded with the right index. 5 per cent of catch-tests were interspersed, to discourage premature reactions. The duration of the foreperiod was controlled by a capacitance-resistance circuit. Reaction times were measured to the nearest 0·01 sec. with a chronoscope.

Four subjects participated in 14 sessions—6 practice and 8 experimental. One session consisted of 200 trials. During the experimental sessions, the four conditions were alternated in balanced order, two conditions being given on each session. For each condition, we have thus 4 series of 100 measurements. The first 20 in each series were discarded.

The average reaction times per subject and per condition are given in Table 1. The differences between related means for constant and variable foreperiods were tested, using the t test. For simple reaction times, 3 subjects respond faster with constant foreperiods, as expected. Subject 4 paradoxically gives the inverse result. In the last 4 practice sessions, however, this subject gave shorter reaction times ($m = 236$ m.sec.) with constant than with variable ($m = 267$ m.sec.) foreperiods; but later, for some unknown reason, responded considerably more slowly in the constant foreperiod condition.

Table 1

Condition	Reaction	Foreperiods	Score	Subjects			
				1	2	3	4
1	Simple	Constant	*R.T.* (m.sec.)	212	240	201	254
2	Simple	Variable	*R.T.* (m.sec.)	260	282	241	248
			t (2 − 1)	16·7†	14·5†	18·8†	−2·9*
3	Choice	Constant	*R.T.* (m.sec.)	361	360	350	334
4	Choice	Variable	*R.T.* (m.sec.)	381	422	382	368
			t (4 − 3)	5·7†	12·5†	6·2†	9·8†
3	Choice	Constant	errors (per cent)	1·2	1·6	1·2	1·9
4	Choice	Variable	errors (per cent)	2·2	2·5	0·9	1·8

* $P < 0·01$. †, $P < 0·001$. *R.T.*, reaction time.

The main result, however, is that, for each subject, variable foreperiods give rise to considerably longer choice reaction times than constant ones. Some efficient preparation can still be done when the nature of the response to be given is unknown. It seems thus that preparation is not a completely selective process.

In this experiment, time uncertainty in the variable foreperiod conditions can be a result of longer average foreperiod as well as of variability. A more extensive experiment is being carried out, where both parameters are varied separately, and will be reported later.

PAUL BERTELSON
JEAN-PAUL BOONS

Laboratoire de Psychologie,
Université Libre de Bruxelles.

[1] Klemmer, E. T., *J. Exp. Psychol.*, 51, 179 (1956).
[2] Woodrow, H., *Psychol. Monogr.*, 17 (5) (1914).
[3] Woodworth, R. S., and Schlosberg, H., "Experimental Psychology" (Holt, New York, 1954).
[4] Wundt, W., "Éléments de Psychologie physiologique" (Alcan, Paris, 1886).

The Relativity of 'Meaning'

IT is now widely accepted that the information content of a message is not intrinsic to the message: it depends on the set of messages from which the message comes. Not so generally accepted is the postulate that the meaning of a message also depends on the set that the message comes from. The following example, though imaginary and seeming flippant, shows decisively that the presence of another message may grossly affect the meaning of what is transmitted, though the other message is in fact not sent.

The story is told that Mr. and Mrs. A, while on holiday, decided to send a greeting back to the wife's mother. The telegraph company offered a set of standardized messages (actually only two), which were:

Message 1: "How we wish you were here!"
Message 2: "The weather is fine."

In fact they sent message 1 to express a simple and friendly meaning.

Suppose, however, that the company had also offered:

Message 3: "Do come and join us!"

In its presence, the message "How we wish you were here" becomes merely ironic; for to send it is equivalent to a refusal to send the invitation.

Thus, in this example at least, the 'meaning' of message 1 is not intrinsic to the actual words sent: it is a function of the whole set. Passing from the message to the meaning thus resembles such functional operations as taking the average, or the maximal value. According to this view, the 'meaning', on the reception of message i from the set $\{1, 2, \ldots, i, \ldots\}$ is not to be identified with the element i but with forming the i-th function over the set of messages. Applied to the brain (as a dynamic system the behaviour or activity of which forms some function of its input) this view suggests that we should relate the 'meaning' not to the message that comes to it as input but to the particular behaviour or output with which the brain responds.

W. ROSS ASHBY

Burden Neurological Institute,
Bristol.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned.

Physicist (honours graduate), for work concerning dosimetry and related problems in the clinical use of high energy radiation from isotope beam units and, in the near future, a linear accelerator—The Assistant Secretary, Westminster Hospital, London, S.W.1 (August 10).

Hospital Physicist, Basic or Senior grade (with an appropriate science degree), in the Regional Physics Unit, for work concerned with the uses of radiation and radio-isotopes in the diagnosis and treatment of disease and includes co-operation with the medical staff on physical and instrumental problems—The Secretary, Leeds Regional Hospital Board, Park Parade, Harrogate (August 12).

Lecturer (with an honours degree and preferably teaching and/or industrial experience) in the Department of Physics and Mathematics, College of Technology, Byrom Street, Liverpool, to teach, to graduate level, in either mathematics or physics and to intermediate standard in other subjects—The Director of Education, 14 Sir Thomas Street, Liverpool 1 (August 12).

Biochemist (Basic grade)—The Administrator and Secretary, University College Hospital, Gower Street, London, W.C.1 (August 13).

Biochemist, Basic grade (with an honours degree in chemistry, biochemistry or physiology, or Associate or Graduate Member of the Royal Institute of Chemistry) in the Department of Chemical Pathology—The Secretary, The United Liverpool Hospitals, 80 Rodney Street, Liverpool 1 (August 13).

Principal Lecturer (with a high academic or professional qualification, and specialized in one of the following: concrete technology, materials of construction or services) in Applied Science (Building and Civil Engineering)—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "B" (August 13).

Research Fellows in Polymer Chemistry or Polymer Technology, Combustion or High Temperature Materials; Research Fellows and Research Assistants in Physical or Industrial Metallurgy; and a Research Fellow and Research Assistants in Fluctuation, Shot Noise and Flicker Effect, Electron Space Charges, Information Theory Wave Optics or Nuclear Emulsion Studies—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "D" (August 13).

Research Officers (with the research outlook and a degree level knowledge of statistical mathematics) in Operational Research—The Director of Establishment, British Transport Commission, 222 Marylebone Road, London, N.W.1 (August 13).

Lecturers in Physical and in Organic Chemistry at the University of Melbourne—The Registrar, University of Melbourne, Parkville, N.2, Victoria, Australia (August 15).

Research Fellow, to undertake original work in the mathematical fairing of ship lines; and a Research Assistant to prepare and run programmes for routine ship calculations—The Secretary of University Court, The University, Glasgow (August 15).

Senior Physicist (with good general experience of hospital physics) in the Radiotherapeutic Centre—The Secretary, Addenbrooke's Hospital, Cambridge (August 15).

Technician (with experience in metallurgy and elementary workshop practice), to be responsible for work in the metallurgical laboratories and workshop—The Principal, Coventry Technical College, Butts, Coventry (August 15).

Senior Lecturer or Lecturer (honours graduate in electrical engineering or physics and suitable research and teaching experience in electronics and radio communication) in Electrical Engineering—Joint Clerk to the University Court, Queen's College (University of St. Andrews), Dundee (August 20).

Research Chemist (with experience of research work in physical chemistry or chemical engineering, and preferably with a higher degree in one of these subjects), to continue a programme of measurements of the heat capacities and Joule-Thompson coefficients of vapours under the terms of a contract between the University and the D.S.I.R.—The Registrar (Room 22, O.R.B.), The University, Reading (August 22).

Rheumatism Research Fellow (with qualifications or special interests in physiology, or physics, or physical chemistry), for research on tissue elasticity—The Registrar, The University, Leeds 2 (August 22).

Principal Scientific Officer or Senior Scientific Officer (with a first- or second-class honours degree in science with chemistry or physics as the main subject, or equivalent, and at least three years postgraduate or other approved experience, and research experience in the field of organic or physical chemistry) at the British Museum, London, W.C.1, to supervise research in the examination and conservation of antiques and archæological material—The Civil Service Commission, 17 North Audley Street, London, W.1, quoting S/5177/60 (August 23).

Assistant Lecturer in the Department of Physics—The Secretary, Medical College of St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (August 25).

Research Physicist (honours graduate in physics (or equivalent qualifications) and some years postgraduate research experience) at the Irrigation Research Station, Commonwealth Scientific and Industrial Research Organization, Griffith, New South Wales, Australia, to investigate the response of plants to changes in their environment, particularly the phenomena associated with the sudden change of incoming radiation and other energy factors—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 500/119 (August 27).

Experimental Officer (with a qualification in electronics, electrical engineering or a relevant branch of physics or chemistry) in the Chemistry Department, to be responsible for the supervision and maintenance of electronic instruments in the Department, especially infra-red and ultra-violet spectrometers—The Registrar, The University, Southampton (August 31).

Research Fellow (Microbiologist, with postgraduate research experience, and preferably experience in microbial genetics) in Microbiology, to join a research team of chemists and microbiologists concerned with fundamental studies on biosynthesis—The Registrar, University College, Singleton Park, Swansea (August 31).

Senior Lecturer and a Lecturer in Botany, and Lecturers (2) in Geography at the University of Melbourne—The Registrar, University of Melbourne, Parkville, N.2, Victoria, Australia (August 31).

Senior Lecturer in Applied Mathematics at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 31).

Senior Lecturer in Educational Psychology at the University of Natal, Durban, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, August 31).

Assistant Lecturer (graduate, with special interests in either igneous petrology or sedimentary petrology and palæozoic stratigraphy) in Geology—The Registrar, The University, Exeter (September 10).

Lecturer (with medical qualifications or higher degree in physiology) in the Department of Physiology, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, September 15).

Principal of the National College of Agricultural Engineering, Silsoe, Bedfordshire—National College of Agricultural Engineering, c/o Ministry of Education, FE(IV)A, Curzon Street, London, W.1 (September 16).

Biochemist (graduate in chemistry, biochemistry or physiology) in the Pathology Department, for work concerned with biochemical investigations on patients—The Group Secretary or Consultant Pathologist, Dulwich Hospital, East Dulwich Grove, London, S.E.22.

Biochemist or Immunologist (preferably with a Ph.D.), for research on the thyroid gland, with particular reference to thyroid auto-immunity—Dr. I. M. Roitt, Middlesex Hospital Medical School, London, W.1.

Biochemist (with an appropriate science degree or the A.R.I.C.) to work under the direction of the Chemical Pathologist at the City Hospital—The Group Secretary, Nottingham No. 2 Hospital Management Committee, Sherwood Hospital, Hucknall Road, Nottingham

Chief Technician I (F.I.M.L.T., or equivalent qualification) in the Department of Histopathology, to maintain the efficient running of the Department and to train Junior Staff—The Secretary, Royal Free Hospital, Gray's Inn Road, London, W.C.1

Experimental Officers and Assistant Experimental Officers (with H.S.C. or G.C.E. or equivalent, or H.N.C. or university degree) in Mathematics, Physics, Meteorology, Chemistry, Metallurgy, Biological Sciences, Engineering, Miscellaneous (Geology, Library and Technical Information Services)—The Civil Service Commission, 17 North Audley Street, London, W.1, quoting S/94-96/60.

Geneticist, Principal Scientific Officer/Senior Scientific Officer (with a Ph.D. or good honours degree, and at least two years postgraduate research experience in microbiology), to take over the Genetics Section—The Secretary, Research Institute (Animal Virus Diseases), Pirbright, Surrey.

Laboratory Technician (preferably with experience in animal keeping) for Biology at L.C.C. Furzedown College—The Secretary, Furzedown College, Welham Road, London, S.W.17, quoting (Estab. 7/N/1952/7).

Lecturer (chemical or mechanical engineer, or metallurgist) in the Department of Metallurgy, to teach basic engineering aspects of extraction metallurgy, including effects of heat, mass and momentum transfer on the design and operation of processes—Prof. F. D. Richardson, Department of Metallurgy, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

Medical Laboratory Technician (with experience in biological, immunological or microchemical assays)—Dr. R. G. Macfarlane, Blood Coagulation Research Unit, Churchill Hospital, Oxford.

Power Station Chemists (qualified and experienced chemists), for the Power Stations of the Electricity Supply Commission in the Transvaal and Orange Free States, South Africa—The London Representative, Electricity Supply Commission, 723/737 The Adelphi, John Adam Street, London, W.C.2, quoting Ref. E/263/4

Research Assistant (with a first- or second-class honours degree in biochemistry), to assist with investigations into disturbances of calcium metabolism in man—The Director, Metabolic Disturbances in Surgery Research Unit, The General Infirmary, Leeds.

Scientific Director (with three years postdoctoral research experience in nuclear reactions) of the Nuclear Physics Laboratory of the Institute of Physics and Mathematics, to lead research around an operating 800 kV. Cockcroft–Walton accelerator and to lecture on experimental and theoretical nuclear physics at the School of Physics of the University of Chile—Director, Instituto de Fisica y Matematicas, Universidad de Chile, Casilla 2777, Santiago, Chile

Scientific Officer (honours graduate in chemistry or biochemistry) in the Radiobiochemistry Department, for biochemical research involving the use of radioactive isotopes and in particular C^{14} and tritium—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 60/3.

Senior Scientific Officers/Scientific Officers (with a first- or second-class honours degree or equivalent in an appropriate subject), in the Traffic and Safety Division, Road Research Laboratory, Langley, Bucks, to carry out theoretical and experimental research on traffic flow and road safety, including psychological aspects, physics of friction and impact problems, and the relationship between vehicle design and injuries sustained in road accidents—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.286/0A.

Soil Physicist (with training in modern techniques and preferably with experience of the irrigation of heavy clays) with the Kafue Pilot Polder Trust in Northern Rhodesia—The Personnel Officer, Rhodesian Selection Trust, P.O. Box 1479, Salisbury, Southern Rhodesia.

Visiting Assistant Professor–Research Associate, to give some lectures in general chemistry and in an advanced course in inorganic chemistry, help with the supervision of laboratory work and engage in research in inorganic chemical synthesis or reactions—Louis J. Bircher, Box 1550, Vanderbilt University, Nashville 5, Tennessee, U.S.A.

ZOOLOGIST (ENTOMOLOGY) (with a degree in general biology, biology or entomology) with the Government of Kenya, to work in the laboratory or field principally on insect vectors and possibly other parasitic diseases of animals—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.67/7/010.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Institution of Professional Civil Servants. Annual Report for the year 1959. Pp. 64. (London: Institution of Professional Civil Servants, 1960.) [126

Science Masters' Association. Science Teaching in Secondary Modern Schools. (A Survey of Conditions and Staffing carried out by the Science Masters' Association, Secondary Modern Schools' Committee.) Pp. 12. (Swavesey, Cambridge: Mr. D. M. Chillingworth, Science Masters' Association, The Village College, 1960.) 1*s*. [185

Library Association Pamphlet No. 20: The Reproduction of Catalogue Cards. By Philip S. Pargeter. Pp. 48. (London: Library Association, 1960.) 8*s*. 8*d*. (L. A. Members, 6*s*. 6*d*.) [135

International Journal of Mechanical Sciences, Vol. 1, No. 1 (January, 1960). Pp. 144. Published bi-monthly. Subscription rates (including postage): (A) For libraries, government departments or industrial establishments, £6 (U.S.A. 17 dollars) per volume; (B) for subscribers who write directly to the publisher certifying that the journal is for their personal use £3 10*s* (U.S.A. 10 dollars) per annum. Single issues £2 10*s*. (U.S.A. 5 dollars) each. (London and New York: Pergamon Press, 1960.) [185

Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization. Reference to Scientific Literature on Fire, Part X, 1956. By Miss H. M. Shakeshaft and Mrs. B. F. W. Rogowski. Pp. 107. (Library Bibliography No. 5, Part X.) (Boreham Wood, Herts: Fire Research Station, 1960.) [135

Living Animal Material for Biological Research: Proceedings of a Symposium organized by the International Committee on Laboratory Animals, under the auspices of UNESCO, held at Gif-sur-Yvette, Seine-et-Oise, 6–9, October 1958. Edited by W. Lane-Petter. Pp. iii+100. (Carshalton, Surrey: International Committee on Laboratory Animals, M.R.C. Laboratories, Woodmansterne Road, 1960.) 20*s*.; 3 dollars. [165

Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act, 1954, for 1959. West Midland and Southern Division. By F. S. Pollard. Pp. iv+37+6 plates. (London: H.M. Stationery Office, 1960.) 3*s*. 6*d*. net. [165

The Royal College of Science and Technology, Glasgow. Annual Report on the One Hundred and Sixty-third Session, 1958–1959. Pp. 64. Report on Research, Session, 1958–1959. Pp. 38. (Glasgow: Royal College of Science and Technology, 1959.) [165

Freshwater Biological Association. Scientific Publication No. 18: A Key to the British Freshwater Cyclopid and Calanoid Copepods, with Ecological Notes. By Dr. J. P. Harding and W. A. Smith. Pp. 54. (Ambleside: Freshwater Biological Association, 1960.) [165

Bibliographical Citation. By Cyril C. Barnard. Second edition. (Reprinted, with revision, from *The Librarian*, May, July and August, 1950.) Pp. ii+20. (London: James Clarke and Co., Ltd., 1960.) 2*s*. 6*d*. net. [165

University College of Wales, Aberystwyth. Report of the Welsh Plant Breeding Station for 1959. Pp. 119. (Aberystwyth: Welsh Plant Breeding Station, University College of Wales, 1960.) 10*s*. [165

Department of Scientific and Industrial Research: National Physical Laboratory. Report for the year 1959. Pp. viii+140. (London: H.M. Stationery Office, 1960.) 8*s*. net. [185

The Institution of Mining and Metallurgy. Progress in Mining Geology: Training, Research and Employment. By Dr. David Williams. (Presidential Address delivered at the Annual General Meeting, Thursday, 19th May, 1960.) Pp. 16. (London: Institution of Mining and Metallurgy, 1960.) [185

Fuel Abstracts and Current Titles, Vol. 1, No. 1 (May, 1960). Pp. 107. Published monthly. Subscription: £12 12*s*. (36 dollars) per year (including index and postage). Single issues 25*s*. (3.50 dollars). (London: Institute of Fuel, 1960.) [185

Institution of Electrical Engineers. Annual Report for 1959–60. Pp. 26. (London: Institution of Electrical Engineers, 1960.) [185

Associated Electrical Industries, Ltd. Research Laboratory, Harlow. Pp. 28. (London: Associated Electrical Industries, Ltd., 1960.) [235

Proceedings of the University of Durham Philosophical Society. Vol. 13, Series A (Science), No. 12: The Development of Qualitative Analysis from 1750 to 1850, Part 1. By W. E. Campbell and C. H. Mallen. Pp. 108–118. Vol. 13, Series A (Science), No. 13: On Some of the More General Aspects of Insect Metamorphosis. By G. W. Heslop-Harrison. Pp. 119–132. (Durham: University of Durham Philosophical Society, 1959.) [235

Poisons and T.S.A. Guide for Pharmacists in Retail and Hospital Practice. (A Guide to the Pharmacy and Poisons Act, 1933; the Poisons Rules; the Pharmacy and Medicines Act, 1941; the Dangerous Drugs Act, 1951 and Regulations; and the Therapeutic Substances Act, 1956 (Part 2), with an Extended Poisons List.) Sixth edition. Pp. 75. (London: The Pharmaceutical Press, 1960.) 7*s*. 6*d*. [235

Air Ministry: Meteorological Office. Geophysical Memoirs, No. 102: Average Water-Vapour Content of the Air. By J. K. Bannon and L. P. Steele. Pp. ii+38. (M.O. 631b.) (London: H.M. Stationery Office, 1960.) 8*s*. 6*d*. net. [235

The British Hydromechanics Research Association. 12th Annual Report, October, 1958, to September, 1959. Pp. 40. (Harlow: The British Hydromechanics Research Association, 1960.) [235

Sunningdale Nurseries. Rhododendrons at Sunningdale. Compiled by James Russell. (A descriptive and illustrated account of the species and the new and old varieties of the vast family of Rhododendrons and Azaleas grown on this nursery, with notes on their history, cultivation and uses.) Pp. iv+103+12 plates. (Windlesham, Surrey: Sunningdale Nurseries, 1960.) 3*s*. [235

Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act 1954, for 1959. South Western Division. By C. Leigh. Pp. iv+25+2 plates. (London: H.M. Stationery Office, 1960.) 2*s*. 6*d*. net. [235

Other Countries

Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Bulletin 56: Contributions to Canadian Palynology, No. 2. Part 1: A Palynological Study of Post-Glacial Deposits in the St. Lawrence Lowlands. Part 2: A Palynological Study of Pleistocene Interglacial Beds at Toronto, Ontario. By J. Terasmae. Pp. xii+41+6 plates. (Ottawa: Queen's Printer, 1960.) 50 cents. [125

National Academy of Sciences—National Research Council. The Biological Effects of Atomic Radiation: Summary Reports from a Study by the National Academy of Sciences. Pp. xi+90. A Report to the Public on the Biological Effects of Atomic Radiation based on the 1960 Summary Reports of the National Academy of Sciences, Committee on the Biological Effects of Atomic Radiation. Pp. iii+19. (Washington, D.C.: National Academy of Sciences—National Research Council, 1960.) [125

Conseil International des Unions Scientifiques. Union Geodesique et Geophysique Internationale. Association de Séismologie et de Physique de l'Intérieur de la Terre. Publications du Bureau Central Séismologique International. Série A, Travaux Scientifiques, Fascicule 20. Pp. 442. (Toulouse: Édouard Privat et Cie, Librairie-Éditeur, 14 Rue des Arts, 1959.) [165

Laboratoire d'Astronomie de Lille. Astronomical News Letter, No. 90. Pp. ii+52. (Lille: Laboratoire d'Astronomie, 1960.) [165

Science Council of Japan: National Committee for the International Geophysical Year. Preliminary Report of the Remarkable Events Observed in Japan during the International Geophysical Year. No. 1: July–December, 1957. Pp. i+30. No. 2: January–June, 1958. Pp. i+44. Japanese Contribution to the International Geophysical Year, 1957/58. Pp. ii+178. (Tokyo: Science Council of Japan, 1958 and 1959.) [165

Organization for European Economic Co-operation. Fertilizers: Production—Consumption—Prices and Trade in Europe and U.S.A. (9th Study, 1957–1960). Pp. 107. (Paris: Organization for European Economic Co-operation; London: H.M. Stationery Office, 1960.) 5 NF, 7*s*. 6*d*.; 1.25 dollars; 5 Swiss francs. [165

Fiskeridirektoratets Skrifter. Serie Havundersøkelser. (Reports on Norwegian Fishery and Marine Investigations.) Vol. 12, No. 6: Investigations on Zooplankton in Norwegian Waters and in the Norwegian Sea during 1957–58. By Kristian Fredrik Wiborg. Pp. 19. Vol. 12, No. 7: Investigations on Eggs and Larvae of Commercial Fishes in Norwegian Coastal and Offshore Waters in 1957–58. By Kristian Fredrik Wiborg. Pp. 27. Vol. 12, No. 8: Investigations on Pelagic Fry of Cod and Haddock in Coastal and Offshore Areas of Northern Norway in July–August, 1957. By Kristian Fredrik Wiborg. Pp. 18. (Bergen: A. S. John Griegs Boktrykkeri, 1960.) [165

East Africa High Commission. East African Fisheries Research Organization. Annual Report 1959. Pp. ii+46. (Jinja: East African Fisheries Research Organization, 1960.) [165

Companhia de Diamantes de Angola (DIAMANG). Serviços Culturais Dundo–Lunda–Angola. Publicações Culturais No. 44: Subsídios para o Conhecimento do Clima da Lunda. Resultados das Observações Meteorologicas (Area das Explorações da Companhia), Anos de 1953 a 1957. Elaborados por Tomaz Rebelo do Espirito Santo. Prefácio do Professor Amorim Ferreira. Terceiro Volume: Apuramentos mensais dos Postos Climatológicos. Pp. 285. (Lisboa: Companhia de Diamantes de Angola, 1958.) [165

East Africa High Commission. East African Virus Research Institute. Report, July 1958–June, 1959. Pp. ii+49. (Nairobi: Government Printer, 1960.) Sh. 5. [185

Council of Scientific and Industrial Research, New Delhi. Indian Scientific and Technical Publications Exhibition 1960: a Bibliography. Compiled by the National Library, Calcutta. Pp. xii+195. (New Delhi: Council of Scientific and Industrial Research, 1960.) [185

Commonwealth Scientific and Industrial Research Organization, Australia. Animal Research Laboratories Technical Paper No. 3: The Biology of the Fleece. By A. S. Fraser and B. F. Short. Pp. 108+5 plates. Division of Fisheries and Oceanography Technical Paper No. 8: Surface Circulation in the Coral and Tasman Seas. By K. Wyrtki. Pp. 44. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1960.) [185

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2.
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

MANAGERIAL RESOURCES: AN INTERNATIONAL SURVEY

SOME reasons for Britain's continuing difficulties with her balance-of-payment problems have been revealed in three recently published works. An American book presents an international picture of management in a number of industrialized countries[1]. A British book deals particularly with the management scene in Britain[2]. The third is a comparative study by an American don who has looked critically at American and Russian industry and, after a year as a Fulbright Scholar in Britain, has produced a book which points to the inescapable conclusion that British industry will remain hamstrung until there is a marked improvement all round in the quality of her executives.

The seesaw of import–export figures with every other year producing too little to cover long-term overseas investments has been with us since the War. Exhortation for more productivity to give us more exports has led up to the fourth balance-of-payments crisis during the past decade and has once more caused the Chancellor of the Exchequer to apply the brakes to industrial investment. The overall result has been a slow rise in British productivity which has been insufficient to pay for our imports, the improved standard of living which should accompany productivity, and to leave enough for essential overseas investment. The tragedy for Britain is that other European countries have been able to steer clear of balance-of-payment difficulties. An authority like Colin Clark has confirmed that increases in productivity of most industrialized countries have exceeded those of the United Kingdom[4]. The rise over the past year has still not been enough to prevent the Chancellor calling a halt to expansion.

Many of our difficulties lie, of course, within the political, economic and social fields. But from Harbison and Myers's analysis of management in the industrial world, a considerable part of our trouble is bound up with the quality and distribution of men occupying top and middle management positions in our industrial organizations.

Harbison and Myers first define the bases on which their comparisons of management are made, and then, with expert help from various countries, go on to examine the nature of management as an economic resource, as a system of authority and as a class, as well as the development of managerial resources in different industrialized countries.

Compared with countries like India, Egypt, Chile and Israel, which are less developed industrially, Britain, in common with other advanced industrial nations like Japan, Germany, Sweden, the U.S.S.R. and the United States, possesses reserves of actual and potential management talent which helps them to maintain their industrial supremacy. That this position is not likely to go without challenge is shown by Egypt, where institutions for the generation of high-talent man-power are quite advanced. In contrast to France, Italy and many of the newly developing countries, Egypt's industrial progress is not retarded by a conservative patrimonial *élite* and its managers . . . "are receptive to new ideas". Despite the warnings and forebodings of British politicians, for example, in 1958 the all-Egyptian management of the Suez Canal Authority was handling 25 per cent more ship traffic than "its predecessor foreign management handled before 1956. At the same time, the total number of white-collar, technical, professional and managerial positions has been reduced by 23 per cent". In Israel, a vigorous, young and aggressive managerial class has sprung up with growing social prestige.

For Britain, management comparisons with other advanced industrial countries are more revealing. In Japan, concentration of industrial power in the hands of the *zaibatsu* has led to the remarkable development of human resources in general and high-talent man-power in particular. The vast industrial empires of the *zaibatsu*, motivated by a nationalistic patriotism, have been successful in building managements which are imbued with the spirit of hard work, perseverance and unfaltering loyalty both to the organization and the dynasty which controls it. In the larger firms there is an almost feverish interest in new techniques, and to-day Japan is probably one of the few countries which could easily export high-level man-power resources without straining its economy; entry into the ranks of professional management is based primarily upon formal education.

The West German achievement is well known; there is no adequate parallel to the transformation of West Germany since the War. Between 1950 and 1957 the gross national product was more than doubled; the British increased slightly.

Like his counterparts in the United States, the U.S.S.R. and Japan, on the solid basis of prestige, power and wealth, the German manager vies for prominence among the members of other high-status groups. A significant difference between the German system and the British is that, in Germany, the top-level man, the *Unternehmer*, has real authority and direct interest in the business he controls, and is so free from day-to-day executive activities that he is able to forecast, plan and direct the policy of the company. Few boards of directors in Britain are able to function in this way, although our system of having a good sprinkling of executive directors has much to commend it.

The great difference between German, Russian and American management and that of the United Kingdom lies in the educational background of the men and women who become managers. In 1955, for example, at least 31 per cent of German top management had university degrees; the largest single group consisted of graduates from the *Technische Hochschulen*. The position is much the same in the United States and the U.S.S.R. In the U.S.S.R. the change has been from a peasant, agrarian economy to a high level of industrial achievement since the introduction of the first five-year plan three decades ago. This has not entirely been due to the extreme use of totalitarian methods, concentration on heavy industry and the sacrifice of short-run consumption to facilitate the investment needed for long-term development. The main emphasis in the Soviet Union during the period has been on the development of well-qualified management[4]; the economic results are well known. If nothing else, the Soviet experience provides strong support for the belief that industrialization requires that access to important managerial positions be based on objective standards of competence rather than 'connexions'. Even in their doldrum days of the '30's, the Soviet leaders showed their long-sightedness in insisting that the British, German and American 'foreigners' should be used for training their own men for the future rather than producing results at the time.

The American position needs little underlining; the proportion of personnel of high talent among American management is the highest in the world. In contrast to much of British industry, competence and performance on the job have become the tests by which men are judged, although these reflect not only innate capacities but also prior education; between 50 and 60 per cent of executives have university degrees; and, because of the status which management enjoys in social and economic life, the recruitment of talented young men destined for managerial positions is easier than in most countries. A major difference between American and most other industrialized countries is in the emphasis she has given to the teaching of management subjects in her business-administration schools. Formerly, these were mainly concerned with provision for undergraduates. Since the Second World War, fifty colleges and universities have developed full-time postgraduate courses for industrial executives. Although some of the work done in these postgraduate schools might be rated as shoddy, Prof. Norman Hunt, of the University of Edinburgh, has written that "work of the highest quality both in research and teaching is being undertaken: much of it would stand up to the scrutiny of the most critical of us". The fine work being done in business-training schools is complemented by executive development programmes inside industrial organizations themselves. There is little doubt that American managers are, at present, the best trained in the world. Has this some connexion with productivity?

The British position has been admirably described by McGivering, Matthews and Scott[5], and, although their conclusions must be treated with some reserve, the impression they create does not lead to the belief that Britain can hope, in the near future, to match the examples of Japan, West Germany, the U.S.S.R. and the United States in their drives for productivity.

There are a number of reasons for British weaknesses and difficulties. It is now well established, for example, that the higher the degree of mechanization and the more sophisticated the environment in an industrial organization, the higher will be the ratio of managers required. This is necessarily accompanied by increasing specialization without automatically increasing the overall size of the organization; as Joan Woodward has indicated, "*specialization* technology rather than size *per se* is most important in promoting specialization within management"[6]. Because they find it difficult to see the place of the specialist and because they fear his challenge in the struggle for promotion, many senior executives have done their utmost to resist specialization albeit to the detriment of their companies.

Other factors tend to maintain centralized authority and control. "Firms which are owned by families, or in which the major share-holding interest is held by some other single group, are notoriously loth to expand", if this would lead to any loss of control or delegation of authority. Delegation, too, with all its advantages, can be achieved with greater confidence when adequate measures of the delegates' performance exists. "British management . . . is backward in the employment of techniques of work measurement, cost accountancy and budgetary control." There is also a deep-rooted belief among many senior executives that the higher management skills and especially those which go with 'leadership' are qualities which they possess but are denied to their subordinates; they are believed to accompany a public school education.

There are also factors to indicate that British industry continues to suffer because of social distinctions. Evidence is accumulating that "the rank order of advantageous categories . . . shows the superiority of an Arts degree (Oxon. or Cantab.) or major public school education over an Arts degree (Redbrick) or lesser public school or grammar school attendance". One investigation has shown that there is a direct correlation between social origin and salary; consciousness of social handicaps appear to be more prevalent in family firms and in firms recruiting largely from universities.

A major weakness is in the attitude of many managers towards productivity itself. In Great Britain productivity has frequently been interpreted as low-cost production to yield high returns on a steady market. American companies with manufacturing units in Europe have been quick to exploit their national habit of driving existing plants to achieve greater output without sacrificing quality or increasing costs; Britain has been slow to copy them.

Unfortunately, too, and this may be bound up with the social class background of many British senior executives, the trade unions are still regarded as enemies who must always be fought; the trade unions have responded to the attack, and the joint enterprise of American management and labour for increased productivity with sharing of rewards has not been repeated to the same extent in Britain.

How, then, can Britain hope to achieve a standard of productivity which will enable her to sell exports increasingly in direct competition with other advanced industrialized nations? The quality of management must be raised by increasing the standard of the recruits. Graduates must be used, and more scientists and technologists must command influential positions in the board room. Standards must be set against which performance can be judged. Men must be selected for their competence and not for their social background; there is little doubt that the talents of Great Britain are not being fully used, and perpetuation of the existing class system could lead to national disaster. Training schemes in firms must be developed to produce executives capable of making decisions as well as technicians and craftsmen to support them. Active trade unions should be encouraged to help in the drive for productivity. Above all, the supply of scientists and technologists must be stepped up; a heavy burden rests upon the Ministry of Education and local authorities.

All this will be vitiated, however, unless public opinion outside and inside industry drops its complacency and builds up a climate of opinion in which young men of talent can be given opportunities for making an attempt to raise productivity to standards not yet contemplated. Until this occurs, we can expect to have balance-of-payment difficulties with continuing regularity.

---

[1] Management in the Industrial World: an International Analysis by Frederick Harbison and Charles S. Myers (McGraw-Hill, London, 1959).

[2] Management in Britain: a General Characterization, by I. McGivering, D. G. J. Matthews and W. H. Scott (Liverpool University Press, 1960).

[3] The Red Executive, by David Granick (Macmillan and Co., Ltd., London, 1960).

[4] The Conditions of Economic Progress, by Colin Clark (Macmillan and Co., Ltd., London, 1957).

[5] Engineering Education in Russia, by S. P. Timoshenko (McGraw-Hill, London, 1959).

[6] Management and Technology (H.M.S.O., 1958).

NEWTON'S CORRESPONDENCE

The Correspondence of Isaac Newton

Edited by Prof. H. W. Turnbull. Vol. 1: 1661–1675. Pp. xxxvii+468+7 plates. (Cambridge: At the University Press, 1959. Published for the Royal Society.) 147*s.* net.

THE publication of the first volume of a critical edition of Newton's correspondence is an important event in the domain of history of science. Few periods in the development of human culture offer a more instructive and fascinating field of study than that which saw the birth of modern science. The basic data for such a study, in the form of letters and manuscripts as well as printed books and papers, exist in great abundance, and allow one—especially the letters, with their more personal and intimate communications—to form a vivid picture of the pioneers' adventurous exploration of Nature and of their struggle for the vindication of rational thinking and the establishment of proper methods of scientific analysis. Much of this material has long been available to scholars, above all in the monumental editions of the works and correspondence of Galilei, Descartes and Huygens. In this connexion, the insufficiency of the existing edition of Leibniz's scientific papers, but still more the lack of any coherent publication of Newton's works, has always been felt as a most serious inconvenience, which is still to this day hampering a really exhaustive investigation of some of the most critical phases in this momentous development.

On the Continent, the task of editing the works of great men is regarded as an undertaking of national concern, deserving the support of the Government as well as that of private bodies and institutions. The traditional aloofness of the British Government with respect to cultural matters has had no small part in the long neglect suffered by the Newton papers; but, without unkindness to a venerable institution, it must be said that the Royal Society was also very late in awakening to its responsibility. Prof. E. N. da C. Andrade's introduction to the present volume, in reciting the story of the Society's handling of the matter over many years, has a sad tale to tell of procrastination and inefficiency. Even now, when a most auspicious start has at last been made, our satisfaction is tempered by the disappointing confession that the Society does not feel able to undertake more than the publication of the correspondence; for a critical edition of Newton's great books and of his numerous and still incompletely surveyed manuscript notes and papers, scholars with the necessary leisure and competence, according to Prof. Andrade, are not to be found. In making this excuse he seems to lose sight of the vigorous growth of the modern school of scientific historians; anyhow, it is happily belied by the fact that at this moment, in the United States, two distinguished historians are actually preparing a critical edition of the "Principia", while the study of Newton's unpublished papers is also being actively pursued.

The time is not for incrimination, however, when we are presented with such a splendid achievement as this publication of Newton's correspondence; if the further volumes keep the same high standard, a monument of scholarship rivalling those recalled above will have been raised to Newton's memory. In fact, we are given more than just the letters: partly to atone for the renunciation to edit all the manuscripts, a selection of the latter, namely, those more closely connected with the correspondence, is also included. All texts are accompanied, in conformity with the exacting requirements of modern historical criticism, by the relevant information about their nature and provenance, and by abundant notes elucidating their contents. As regards the latter, some minor blemishes are inescapable—I hope to publish elsewhere a list of the corrections and additions which I noticed during the perusal of the volume—but on the whole the notes are excellent, especially on matters of mathematics and optics. The only serious shortcoming is the lack of accurate bibliographical descriptions of the books quoted (for example, in the form adopted in the Huygens edition); this desideratum could perhaps still be fulfilled in the future volumes. For the accuracy of the text, we must of course trust the editors, and we have certainly no reason not to do so: on internal evidence I have only detected two trifling textual errors (in French texts). The historians of science are indeed deeply indebted to Prof. H. W. Turnbull and his collaborators, the late Mr. W. H. Robinson and Dr. J. F.

Scott, for accomplishing their important task in such a painstaking and skilful fashion.

If we now turn to the contents of this first volume, which covers Newton's youth and his first creative period, during which most of the optical work was done and the new ideas about mathematical analysis and the theory of gravitation took shape, I cannot say that it discloses any striking novelty. Most of the letters and documents had already been published, and the fuller view we now gain by their more complete presentation can only increase our respect for the judgment of the Victorian scholars, Edleston, Rigaud, Brewster, who made the previous selections; it is comforting to realize, in particular, what careful and sagacious use good old Brewster, with all his oddities, could make of his sources. Nevertheless, renewed studies of these sources in their authentic and complete form cannot fail to reveal interesting new details, enlivening the picture of the times and deepening our understanding of the processes of discovery. Especially valuable in the latter respect is the publication of numerous documents illustrating the little-known relations between Newton and Gregory; it is the editor's great merit to have directed attention to them.

Reading such correspondence, in the chronological order in which it is presented, is like listening to a symphony the various themes of which successively appear and interlace, evoking the hero's growth and deeds against the background of his time and environment. In this respect, the comparison of the Huygens and Newton papers during the same span of their lives (three volumes to one!) illustrates in a most telling fashion the difference between the social classes to which they belonged and which supported and influenced their work. Of Newton's rustic youth scarcely any record remains, whereas there is a wealth of documents picturing all the stages of the opulent Huygens children's refined education and their development into sophisticated and slightly snobbish gentlemen. As soon as Huygens's precocious genius shot its first buds, he was admitted with demonstrative honour to the choicest circles of virtuosi; the poor Cambridge scholar had to be content with the less-glamorous, but perhaps more substantial esteem of plain people like himself, engrossed in the business of trade and administration, but compensating the lack of elegance in their intellectual demeanour by seriousness of purpose and a keen sense of reality.

It is highly instructive to watch how John Collins puts young Newton's mathematical skill to the test by proposing to him problems of annuities and related algebraic questions: of such obscure birth is modern analysis! The next theme, recurring through a great part of the volume, is the construction of a reflecting telescope; it is in this work as well as in their mathematical research that Newton and Gregory followed parallel ways, of which they became acquainted through their common correspondent, the always friendly, sometimes officious Collins.

Then comes the dominant feature of the period spanned by the volume under review, the great work on the theory of colours and the nature of light, which is here very fully documented. We may follow in minute detail the famous controversy to which Newton's investigations gave rise, so startling did his new method of reasoning by induction from experiment appear even to men like Huygens and Hooke. However, a careful reading of Hooke's objections, now for the first time available *in extenso* (I allude to the important new document No. 71), reveals that the latter had spotted a real weakness in Newton's argument, namely, his too rigid assertion of the permanent character of the homogeneous coloured rays. In this light, Newton's famous conciliatory letter to Hooke (No. 154), which has hitherto been presented as an example of generosity, cannot fail to strike one, on the contrary, as unpleasantly condescending and arrogant. Without denying Oldenburg's part in embittering the quarrel, one feels that Newton's own obstinacy and unwillingness or incapacity to understand Hooke's point are amply sufficient to account for it.

It is well known that the conception of universal gravitation goes back to the same period of Newton's life, when, as he will later declare, "I was in the prime of my age for invention". Yet, from this time we have only one document (No. 117) of extreme interest, recently brought to light by Dr. A. R. Hall: it is the first appearance of the mightiest theme in the Newtonian symphony, which will unfold itself throughout the further, eagerly awaited instalments of this magnificent publication. L. Rosenfeld

ASTROPHYSICS OF NON-STATIC SYSTEMS

Moving Envelopes of Stars

By Prof. V. V. Sobolev. Translated by Sergei Gaposchkin. Pp. xiv+106. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1960.) 38*s*. net.

THE astrophysicist trying to infer the development of astronomical systems from the available observations is generally like someone trying to imagine the story of a film from a few 'stills' shown outside a cinema. Most astrophysical theory is concerned with such an exercise. However, the astrophysicist is occasionally afforded the advantage of a 'trailer', when he actually sees some change occurring in the heavens as in a nova eruption or in cases of matter obviously streaming away from stars. But a trailer is usually concerned with the more colourful episodes in a story, and a special skill is needed for correctly imagining the whole film from it. The present book is concerned with the analogous exercise in astrophysical theory.

The contents of the book, however, are easy neither to describe nor to assess. This is mainly because, as Prof. Sobolev says, he leaves the general account of the subject to be found in text-books and here presents only his own results, seemingly in much the form in which they were originally published in Russian journals. At any rate, he states the purpose very clearly as "to give a theory of radiative equilibrium of a moving medium and to apply it to the moving envelopes of stars. Because of the breadth of the problem, only the basis of the theory and its most immediate applications are given here".

The account is concise and free from unnecessary complications. In fact, it is so concise that only someone currently working in the field is likely to be able to appreciate its full value. But even someone such as myself whose ventures into the field were some time ago, can realize that Prof. Sobolev has made important advances in the theory and its applications, and that Dr. Gaposchkin has done good service by making them better known by translating them into English. W. H. McCrea

SOUND TRANSMISSION IN THE OCEAN

Introduction to the Theory of Sound Transmission with Application to the Ocean

By C. B. Officer. (McGraw-Hill Series in the Geological Sciences.) Pp. viii+284. (London: McGraw-Hill Publishing Company, Ltd., 1958.) 77*s*. 6*d*.

THE author of this volume is associate professor in the Department of Geology, The Rice Institute, and associate in geophysics, Woods Hole Oceanographic Institution. These facts are mentioned to indicate that the book is of interest not only to physicists who are concerned with sound propagation in the sea, but also to geologists and geophysicists who are concerned with the wider aspects of the subject.

The propagation of sound in the ocean, in shallow seas, and in the Earth beneath the sea has important implications which concern a wide field of science, namely, physics, geophysics and oceanography.

In the preface the author directs attention to the fact that the preparation of the book has been sponsored ("encouraged and supported") by the Office of Naval Research and the U.S. Bureau of Ships, thus indicating its importance to those concerned with the applied aspects of a study of sound propagation in the ocean.

Reference is also made in the preface to many well-known American workers in this field, for example, J. B. Hersey, M. Ewing, J. L. Worzel and others.

The subject-matter of the book is divided into six chapters. The first of these deals with general wave theory for an elastic medium, including the cases of waves of finite amplitude and shock fronts. The second chapter is concerned with the 'ray' and 'normal-mode' theories of sound propagation, with refraction of a dispersive wave-train, and with prescribed boundary conditions. In Chapter 3, these considerations are applied to the case of transmission in shallow water where interference due to multiple surface and bottom images has to be taken into account. The fourth chapter deals with the case of deep oceanic water, where the bottom is not involved. In this case refraction due to temperature and pressure effects on sound-velocity is considered. Chapter 5 is concerned with 'reflectivity' of boundary layers, reflexion from three layers, and the interpretation of echo-sounding records and of geophysical reflexion and refraction profiles. The concluding chapter, "Attenuation", covers absorption in a viscous fluid, scattering and diffraction, and reception by a linear array.

Chapters 3 and 4, which deal respectively with the transmission in shallow water (inshore seas) and in deep water (the oceans), show the difficulties involved in attempting to arrive at a reliable theoretical solution of wave propagation in the sea. Consideration must ultimately be given to many factors, for example, the effects of depth and configuration of the sea-bed, the physical (acoustic) properties of the sea-bed material, the sound-velocity structure of the water (temperature- and pressure-gradients as they influence velocity of propagation), the shape of the sea-surface (waves and swell), the presence of sound-scatterers in the water, and so on. As the author very truly states, "A complete formulation with all possible variations of the above environmental conditions would be very difficult to obtain." The theoretical complications in shallow water transmission due to multiple reflexions between sea-surface and sea-bed are dealt with on both 'ray' and 'mode' theories, but there is clearly much more to be done to predict the sound-distribution in a shallow sea even under the most 'ideal' theoretical conditions of isothermal water and a flat bottom parallel to a flat sea surface.

The problem is a difficult one, and Prof. Officer has made a praiseworthy effort in presenting the theoretical aspect in a stimulating and readable fashion. As an introduction to the subject the book will serve a very useful purpose in arousing interest in physicists, geophysicists and oceanographers alike.

The book is well written, illustrated and produced and can be recommended to all those interested in this difficult but fascinating study of sound transmission in the sea.

A. B. WOOD

THEORY OF HIGH EXPLOSIVES

The Science of High Explosives

By Prof. Melvin A. Cook. (American Chemical Society Monograph Series, No. 139.) Pp. xv+440. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 180*s*. net.

THIS book is a valuable addition to the rather sparse literature on the subject of explosives. Its scope is wide; but, as the title suggests, it is concerned more with the basic physical and chemical principles underlying the behaviour of explosives than with practical applications. Nevertheless, there are parts that will be of general interest, in particular the chapters describing the modern explosives industry and the explosion properties and blasting action of high explosives.

Perhaps the heart of the book is formed by those chapters dealing with the mechanism of initiation and propagation of detonation and the accompanying phenomena. Particular attention is paid to the nature of the reaction zone in detonation waves, and the author considers that the classical treatments of Zeldovich, von Neumann, Doering, and others should be modified to include the notion of heat conduction. In addition to claiming that this modification gives a better explanation of the observed distribution of parameters in the reaction zone (for example, the evidence for the existence of a pressure 'spike' predicted by the original theories is inconclusive), he says that it explains what happens to the critical enthalpy that is necessary to initiate detonation. He considers that this enthalpy is contained within the reaction-zone and propagated as a heat pulse. The author claims to have obtained photographic evidence of a heat pulse during the growth to detonation of an initially non-reactive shock-wave in the liquid explosive nitromethane, but unfortunately the features in the original colour photographs to which he ascribes considerable significance do not show up well in the black-and-white reproductions. Also discussed in some detail are the respective theories of non-ideal detonation due to Jones and to Eyring and others. An alternative theory, called the geometrical model, is put forward which asserts that not only must lateral losses, which affect only the equations of continuity, be taken into account but also that only part of the reaction zone lies between the detonation front and the Chapman–Jouguet plane, so that not all the chemical energy released is available for supporting the detonation wave. As mentioned in the book, this theory is essentially the same as that proposed by different authors as long ago as 1928 but not then generally published.

There are useful chapters on the instrumentation used in modern explosives research and on the effects of air and ground blast waves, and considerable space is given to shaped charges and to the behaviour of solids under explosive attack. Perhaps the most disappointing parts of the book are those dealing with the blast waves produced in gases by detonating explosives; no mention is made of the modern approach based on the methods of fluid mechanics and the descriptions are derived from somewhat questionable qualitative assumptions.

The book is not easy to read; in the attempt to be comprehensive there is a tendency in places to deal too briefly with difficult physical concepts and this fault is aggravated by the widespread use of symbols as a shorthand method of writing. Even though the symbols are clearly defined in an appendix it is irritating to have to be continually referring to it. However, it may be said that this is a reference volume for the research worker rather than a textbook, and as such its wealth of detailed information and exhaustive lists of references make its appearance welcome. W. L. MURRAY

STORY OF CHEMICAL INDUSTRY IN BASLE

The Story of Chemical Industry in Basle

Pp. 234. (Published by CIBA Limited on the occasion of its 75th Anniversary.) (Basle: CIBA Limited, 1959.)

THE title of this work is far too modest. In 233 beautifully printed and illustrated pages the history of chemistry is set out in such a way as to give Basle its rightful place in the fields of drugs, plastics, textiles and dyeing. Although Ciba Ltd. are the publishers, full credit has been given to the firms of Sandoz, Geigy, and Hoffmann La Roche, as well as to other firms and individual scientists throughout the world, for their contributions to science and technology.

The first part describes the founding of the first Universities in Paris (by Bartholomew the Englishman in 1231), Oxford, Salerno and Montpellier. The influence of the Guilds is noted as is also the contribution to the Renaissance made by the monasteries. In the fourteenth century the Dominican monastery in Basle possessed works by Avicenna, commentaries on Aristotle, Latin translations of the works of Galen and the medical works of Albert the Great (usually referred to in English books as Albertus Magnus). In 1460 the University of Basle (modelled on those of Paris and Bologna) was founded and eight years later the printing of books commenced in Basle.

The University of Basle received a refreshing blast of fresh air in 1526 when Paracelsus occupied the chair of medicine for a few months. As every student of chemistry knows this rebel publicly burnt the works of Galen and Avicenna and scoffed at the alchemists, stating that medicine, not gold, was the true aim of alchemy.

The story continues to the eighteenth century, and the age of enlightenment. Voltaire, Diderot, Nicholas Leblanc, Edmund Cartwright, James Watt, Adam Smith, Montesquieu and Rousseau are just a few of the famous in all branches of philosophy who appear in the pages of this remarkable book. Next we read how refugees from the Reformation and the counter-Reformation transplanted luxury industries to Basle.

The second part of the book ("The Development of the Chemical Industry in Basle") commences by showing that chemical industry grew from the co-operation between the trade in crude drugs and colouring matters, the apothecaries' shop, and the gas works. In a short history of the ancient drug trade drugs which are also colouring matters (for example, saffron, buckthorn), are mentioned, as well as many others, some of which are illustrated in colour. Surprise is expressed that until the nineteenth century the whole drug was considered essential and no one thought of searching for pure 'active' principles. Extraction of 'principles' soon became commercially popular and in 1857 J. R. Geigy and U. Heusler built a plant in Basle to extract dye-woods. The silk ribbon industry in Basle naturally attracted dyers to the neighbourhood. In 1859, three years after Perkin's discovery of mauveine, Geigy switched his attention to the manufacture of synthetic dyes, starting with the preparation of fuchsine. Also in 1859, Clavel commenced the manufacture of fuchsine in Basle and his firm eventually became Ciba (a name formed from the initial letters of the Society for Chemical Industry in Basle).

The factors leading to the rapid growth in chemical industry in Basle are described. These are briefly (1) the ease with which coal-tar could be obtained from England, France and Germany, (2) the advantage of being able to dispose of waste products in the Rhine, (3) plenty of capital from the older industries, (4) the local market for dyes provided by the silk ribbon industry, (5) the socio-political freedom arising from the unification of the Swiss cantons into a federal State, and (6) the rapid rise in the population (and hence the labour supply) of Basle.

Dyestuffs are next dealt with in some detail, and I have space here only to mention such names as Liebig, Perkin, Hoffmann, Verquin, Graebe and Liebermann, Caro, Peter Griess, Martius, Walter, Baeyer, Sand-Meyer and Heumann.

The history of the scientific pharmaceutical industry commences in this book with the founding of the first institute for experimental pharmacology by Buckheim in Estonia in 1849. Then follows the bacteriological and antiseptic discoveries of Semmelweis, Pasteur, Lemaire, Lister and, last but not least, Socin in Basle, who in 1871 was using phenol for wounds. Then on to Robert Koch's *in vitro* cultivation of bacteria and the work of Ehrlich on the application of dyes and arsenicals to medicine. Among the newer bactericides we read how Prontosil (Domagk 1935) led to 'Cibazol' (Ciba—1938, better known to us as Sulphathiazole). In 1950 the La Roche group produced Isoniazide (for tuberculosis) and Ciba in 1958 introduced 'Ciba 1906' for leprosy.

Turning to drugs derived from natural precursors we are told the story of Nupercaine (Ciba 1929), Dolantin (1940) and Cliradon (Ciba 1949) and of Butazolidine (Geigy). (The latter derived from quinine in the mistaken belief that antipyrine is a quinoline derivative.)

Similar treatment is given for very many other organic medicaments: Ergotamine (Sandoz 1918), Coramine (Hartmann of Ciba, 1918), Priscol and Privine (Ciba 1939), and the isolation of Reserpine in 1952 (Ciba). Vitamin C was first synthesized by Reichstein in 1933 and within two years La Roche were manufacturing it. In the 'thirties Ciba helped to isolate progesterone and later worked with Reichstein on cortisone.

Part 2 finishes with a historical account of plastics, from ancient ceramic arts via gun-cotton (Schoenbein of the University of Basle in 1845), celluloid, the Chardonnet denitrification process, to the important modern epoxy resins of to-day such as Ciba's 'Araldite'.

The plain grey board covers of this book give no hint of the wealth of material within. Beautifully printed on high-quality paper with hundreds of illustrations, dozens of which are in beautiful colours, it stands in a class of its own.

I have noticed only one error of fact (p. 123). The dibromoanthraquinone which Graebe and Liebermann hydrolysed to alizarin was, in fact, the 2 : 3 dibromo compound and not the 1 : 2 as described, although this piece of 'research luck' was not discovered until several years after the event. A few expressions strike the English reader as unusual, for example, "in six years the price of quinine *dove* from 1·3 to 2·5 florins per oz.", "diazo dyestuffs" (we say 'azo dyes'), and the use of the word 'somnifacients' for what we (with perhaps less Latin and more Greek) call 'hypnotics'.

This work reflects great credit on Drs. Huber and Menzi, who wrote the text, on Drs. Wilhelm and Kappeli, who had the idea of thus celebrating Ciba's seventy-fifth anniversary, on the photographers and blockmakers, and on all those concerned with the book. All who are able to obtain a copy are indeed to be envied.

L. K. SHARP

QUANTUM CHEMISTRY

Quantum Chemistry

Methods and Applications. By R. Daudel, R. Lefebvre and C. Moser. Pp. xiii+572. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 14.50 dollars.

It is an interesting exercise to speculate on the probable contents of a new book on quantum chemistry. One can be fairly sure that there will be a discussion of the particle in the box, the hydrogen atom, the hydrogen molecule-ion, the hydrogen molecule itself and possibly methane, ethylene and benzene. But for the serious student of the subject it is the rest of the contents which will excite his main interest. The books entitled "Quantum Chemistry" which are already on the market differ very greatly in what their authors have seen fit to add to this rather pedestrian list of topics. The book by Eyring, Walter and Kimball makes much use of the theory of groups in the interpretation of spectra and is one of the best elementary sources for information about electromagnetic phenomena; on the other hand, in that book there is almost no discussion of the diverse and sophisticated facts of chemical reactivity. The book by Pitzer covers widely the basic principles of chemical physics, and lays considerable stress on statistical mechanics and molecular dynamics. Here again, however, there is virtually no discussion of chemical reactions in terms of molecular structure. The big book by Kauzmann is very largely devoted to atoms and the author never really crosses the border from physics into chemistry. Clearly, the word 'chemistry' means something quite different to these authors from what it means to the vast majority of chemists.

Now we have yet another book with the same title and a much braver effort. This new book, by Daudel, Lefebvre and Moser, represents a creditable attempt to set down in an orderly manner those developments which in recent years have made quantum chemistry a subject of real interest to the experimental worker. The centre of gravity of the book is the unsaturated hydrocarbons and their physical and chemical properties. This is not inappropriate, since until quite recently it would have been true to say that this particular field of study had yielded a greater crop of quantitative results than any other branch of theoretical chemistry. It is inevitable that a book of this sort should dwell on certain topics at the expense of others, and it would be easy to criticize the authors for having omitted any discussion of the recent striking advances in, for example, the theoretical chemistry of the transition elements. But this would be ungrateful, as the authors have obviously taken pains to include reference to the most important papers in the theory of conjugated molecules; the fact that their book is not as broad as its title suggests only bears witness to the great rate at which theoretical chemistry is now developing.

Turning to details, one is glad to have a clear account of the theory of antisymmetrized wave functions and the Hartree-Fock equations. Of less value is the short chapter on biochemical applications: we still know so little about the cell that it seems premature to attach any weight to a quantum mechanical theory of carcinogenesis. Again, the order of the chapters is perhaps a little odd; the two parts of the book are linked together by only a very tenuous thread, and it is strange to have a chapter on reaction-rates preceding one on chemical equilibria. Perhaps also in the second edition the authors might consider whether, for example, their long tables of bond angles are worthy of the space which they occupy in view of the very cursory discussion which is given to this set of data. But it is a fault on the right side to make too much reference to experimental results; it would indeed have helped the reader to appreciate the strength of the more sophisticated theory if more comparisons had been given between calculated and observed excitation energies in conjugated molecules.

Taken all in all, this book is certainly a useful addition to the literature.

H. C. LONGUET-HIGGINS

HIGH-PRESSURE TECHNOLOGY

The Design and Construction of High Pressure Chemical Plant

By Harold Tongue. Second edition, revised. Pp. xii+250. (London: Chapman and Hall, Ltd., 1959.) 84*s*. net.

Since the first edition of this book was published in 1934 there has been a widespread increase in the use of high pressures in the chemical industry, particularly in the field of petrochemicals. New processes such as the polymerization of ethylene and the synthesis of diamond have been developed which operate at pressures and temperatures far greater than those attainable twenty-five years ago; furthermore, the advent of nuclear power has necessitated a great increase in the size of pressure plant. In order to describe the many developments in high-pressure technology that have made this progress possible, the text has been added to and modified considerably, so that this edition may be regarded as a new book on the subject.

The chief aim of the author was to provide a practical guide to the design of industrial high-pressure plant; although the work is mainly concerned with equipment used in the chemical industry, the general background of high-pressure technology is broadened by frequent references to the techniques used in the design of nuclear power plant. The practical nature of the book is emphasized by the inclusion of an introductory chapter devoted to the various codes of practice, specifications and statutory requirements for the design and operation of pressure plant. It is unfortunate that the references to British Standard 1500 on "fusion welded pressure vessels for the chemical and allied industries" which occur throughout the book concern the provisional code issued in 1949 and not the extensively revised edition published in 1958.

Although the pressure vessel codes give detailed practical design procedures for vessels operating at pressures up to about 200 atmospheres, for higher pressures there are as yet no accepted codes and the chemical engineer must base his designs largely on first principles. It is with the principles governing the design, fabrication and choice of material of construction for highly stressed vessels that the first half of the book is concerned. The basic theory underlying the design of both monobloc and compound cylinders is supplemented by the detailed results of recent experimental work on the yield and rupture of thick-walled cylinders. In addition to the well-known methods of fabrication, such as hollow forging and fusion welding, the newer techniques of tape-winding and the multi-layer form of construction are described in detail. In view of the increasing use now being made of the autofrettage procedure for extending the elastic range and prolonging the fatigue life of thick-walled hollow cylinders, the chapter dealing with this subject is disappointing in that very little design information is given. The same criticism may also be made of the section concerned with the problems of creep at high temperatures; furthermore, no mention is made of the effect of fatigue on design. On the other hand, much useful information, not readily accessible in the literature, has been brought together in those sections of the book which deal with the low-temperature embrittlement of steels and with those corrosion problems peculiar to high-pressure plant.

The second part of the book, which is mainly concerned with ancillary equipment such as pumps, compressors and valves, provides the reader with well-illustrated and detailed descriptions of a large number of designs. Since the requirements of industrial processes are so diverse, the author has had to exercise careful judgment in selecting suitable examples to demonstrate the salient features of the various items of plant. In addition, much useful information is given concerning the techniques employed in a number of continuous high-pressure catalytic processes and the methods used for the preparation and purification of industrial gases.

Unhappily the author died earlier this year, soon after the publication of this edition of his first book. In compiling it, he has performed a valuable service to all those interested in the field of high-pressure technology. K. E. BETT

ANNUAL REVIEW OF ENTOMOLOGY

Annual Review of Entomology

Vol. 5. Edited by Edward A. Steinhaus and Ray F. Smith. Pp. vii+451. (Palo Alto, Calif.: Annual Reviews, Inc., 1960. Published in co-operation with the Entomological Society of America.) 7 dollars.

THE aim of this "Annual Review" is to cover the whole science of entomology, pure and applied; and since the insects provide at least five-sixths of all known species of animals, are exceedingly diverse in form and function, have a tremendous influence on the economy and health of man, and are being studied by a very large army of investigators—there is no shortage of material for annual review. The study of some subjects has only recently begun. It is still possible for all work on the fine structure of insects to be summarized in a single article (G. A. Edwards). Cytogenetics of insects has been studied for many years and the review by S. G. Smith covers only selected highlights from the recent literature. A few years, ago a review dealing with the biochemistry or neurophysiology of insects would have been a rather unsophisticated affair, from sheer lack of knowledge. But that is no longer so; the article on insect flight muscles and their physiology (E. G. Boettiger) shows that in both these fields new basic ideas are being worked out on insects. In the physiology of neurosecretion, which is well reviewed by W. G. Van de Kloot the insects have always led the way.

The editors of the "Annual Reviews" maintain a constant effort to persuade their authors to present a point of view and not just an annotated catalogue of references. They score a fair proportion of successes with their entomologists. In writing on host selection in phytophagous insects A. J. Thorsteinson contests the assumption made in an earlier review by Fraenkel and Lippe that only the adventitious flavours of plants are utilized in host selection, never the nutrients themselves. But if a point of view is put too strongly a review can degenerate into a polemic. In surveying once more the question of population control, H. G. Andrewartha and L. C. Birch make a serious effort to get away from the sterile theoretical arguments about density-dependent factors and to discuss some actual contributions to the study of insect abundance in Nature. Mechanisms of resistance are again reviewed, this time by A. W. A. Brown, who quotes 229 references; a number exceeded only by L. R. Jeppson and G. E. Parman, writing on insects and mites as pests of citrus, who have 240. That represents about half of the twenty articles in this volume. The range of subjects covered is so wide that every year there is plenty of material to choose from which really needs reviewing. The high standard of earlier volumes is maintained this year.

The print in these volumes is rather small, which reduces the impact of their content on the reader; but it is pleasant not to have them printed on the highly sized paper so much favoured in the United States. However, a substantial number of pages in the copy received for review showed the letterpress on the other side of the page so clearly as to be difficult to read. V. B. WIGGLESWORTH

THE LAND OF THE MARSUPIALS

Biogeography and Ecology in Australia
Edited by A. Keast, R. L. Crocker and C. S. Christian. (Monographiae Biologicae, Vol. 8.) Pp. iv+640+18 plates. (The Hague: Dr. W. Junk, 1959.) 65 guilders.

THE continent of Australia is about the same size as the United States or 25 times the area of the British Isles. Sydney was settled in 1788, but it was not until about 1825 that other coastal areas began to be developed. The 'gold rushes' brought a great increase of population in the mid-nineteenth century. It was not until a little more than a century ago that the dawn of scholarship came with the establishment of the Universities of Sydney and Melbourne.

In the pioneer era, the studies of the infant departments of biology were of necessity concerned largely with the description of local fauna and flora. In later years, however, the pendulum of interest swung remarkably so that the chief studies of a majority of senior academic zoologists were of problems that could be rather more efficiently attacked in London or New York. The wonder, then, is not that Australians know so little about the ecology, biogeography and physiology of their native fauna, but (as is shown by the present volume) that they know so much. It is significant that much of the new zoological knowledge is not due to the efforts of university workers, but to officers of the splendid Commonwealth Scientific and Industrial Research Organization.

"Biogeography and Ecology in Australia" will be valuable not only for ecologists but also as a general reference book for university teachers, senior students and biologists in general. (For example, how many know that there are only 11 fewer eutherians than marsupials in "the land of marsupials"?) The book brings together much of the available knowledge, as well as enabling us to see where the gaps are. The first essay deals with "The Uniqueness of Australia in Biology" (by F. S. Bodenheimer) and then follow thirty-six chapters on the ecology of primitive aboriginal man, contemporary human ecology, that of the vegetation, the extant chordate classes, some of the major invertebrate groups and other topics. Pleasing evidence that, largely under the impetus of a Swiss and an Englishman, Australians are at last beginning to study the biology of Australian mammals is found in the chapters by Main *et al.* and Sharman. Among the hitherto unsuspected physiological adaptations of certain pouched mammals is rumination. Delayed implantation, too, has been demonstrated in two species by Sharman and Ealey and others within the past few years. A. J. MARSHALL

CLIMATIC ATLAS OF THE CZECHOSLOVAK REPUBLIC

Atlas Podnebí Ceskoslovenské Republiky
Pp. 42+100 plates. (Praha: Ústřední Správa Geodesie a Kartografie, 1958.) Cena Kčs. 300.

THIS impressive book contains 89 charts of Czechoslovakia on the scale of 1 : 10^6 and eleven diagrams. The maps, which measure about 2 ft. 6 in. by 1 ft. 6 in., are beautifully printed in attractive systems of different colours for areas of different values of the elements concerned. East and West Germany are the only other countries to have produced a climatic atlas with maps of so large a scale.

Detailed descriptions of the contents are given in English, Russian, and French as well as Czech.

The first nine charts give the administrative areas, river basins, soil types, forest regions and climatic regions based on Končck's humidity index for the vegetation period.

Next there are thirty-one temperature charts which give mean monthly and annual isotherms of screen temperature (that is, not reduced to mean sea-level), mean numbers of days of maximum temperature over 25° C., of maximum below $-0 \cdot 1°$ C., etc., mean first and last frost days, and the mean duration of various periods such as the one of mean daily temperature 5° C. or more. The mean temperature of the day is defined as $(7)+(14)+2(21)/_4$, (7), denoting the temperature at seven hours, etc. In summer this probably gives a rather higher value than the customary British formula of average of maximum and minimum. As charts of mean values they are excellent, but for an area of such variable weather as Central Europe they much need to be supplemented by information on extremes. Extremes are not mentioned anywhere, yet other sources give the following table for Prague in January:

VALUES IN °F.

Average daily		Average highest in month	Average lowest in month	Absolute max.	Absolute min.
max.	min.				
34	25	45	8	55	−16

The information outlined on average monthly extremes and absolute extremes is the least information on variability which ought to be included for scientific and economic purposes.

The section on precipitation contains mean monthly and annual amounts, means for the vegetation and winter periods and the mean numbers of days with precipitation exceeding 1 and 10 mm., days of snowfall and snow cover, etc. Next there is a section with maps of wind-roses, averages of relative humidity in July and December, mean cloudiness in September, November and the year, annual numbers of days of fog, sunshine, and thunderstorms. These are standard features of most climatic atlases, but for a country of mixed terrain like this much is lost by giving only annual values of sunshine since it is well known that there is a marked seasonal difference between the relative sunshine distribution in mountains and plains.

Finally, there are twelve phenological charts (mean date of apple-blossoming, harvesting oats, etc.) and eleven charts of seasonal variations of soil temperature. The latter, with examples for a hot summer and a severe winter, are the only sections of the book to give any indication of extreme values.

The period of the observations used is mainly 1901–1950 but is 1926–1950 for some and 1946–1953 for wind-roses. The preface mentions that it is intended to publish a volume of tables but suggests that this will contain only the data used in drawing the isopleths of the work under review. It is much to be hoped that the tables will in fact contain some data on extremes of temperature and precipitation if it is not possible to go all the way and provide an airmass climatology similar to that published in 1958 for West Germany (*Ber. deutschen Wetterdienstes* No. 45. "Zur Klimatologie der Grosswetterlagen", by K. Bürger.) G. A. BULL

Physics and Chemistry of the Earth

Vol. 3. Edited by Prof. L. H. Ahrens, Frank Press, Kalervo Rankama and S. K. Runcorn. (Progress Series.) Pp. viii+464. (London and New York: Pergamon Press, 1959.) 100*s*. net; 15 dollars.

THIS volume contains admirably concise chapters by J. W. Durham on palæoclimates, by A. G. W. Cameron on the origin of the elements and by D. C. Tozer on the electrical properties of the Earth's interior. S. I. Tomkeieff, in "Geochemistry in the U.S.S.R. (1954–1956)" gives a partially annotated bibliography of about 1,200 titles which is an extremely useful list of Russian publications dealing with igneous, metamorphic and sedimentary rocks, geochemistry, cosmochemistry, mineralogy and natural waters. It is a sad reflexion on the state of scientific libraries in Britain that some of these publications are unobtainable anywhere in this country. The geochemistry of thorium and uranium is reviewed by J. A. S. Adams *et al.*, while in "Silicate Melt Systems" E. Roedder reproduces about sixty phase-diagrams dealing with various portions of the geologically important system K_2O—Na_2O—CaO—FeO—MgO—Fe_2O_3—Al_2O_3—SiO_2, and he gives a helpful summary of the experimental techniques used. Unfortunately there is no attempt to relate the diagrams to petrology in the way pioneered by N. Bowen more than thirty years ago.

Nearly half the book deals with geophysical investigations in the eastern Caribbean by C. B. Officer *et al.* and the continental margin of the east coast of North America, north of Cape Hatteras, by C. L. Drake *et al.* Much undigested detail quite unsuitable for a general review is contained in both these articles, and this has probably been the chief cause of the increased price (100*s*.) compared with either Vol. 1 (70*s*.) or Vol. 2 (63*s*). For example, the former article contains no less than 55 pages of seismic profiles and their interpretation while the latter contains 13 pages on 'significant' boreholes in eastern America and the important basement rocks encountered ('decomposed rock'; 'bedrock'; 'crystalline rock'), various figures and text, all of which fail to give the reader a picture of the basement.

B. E. LEAKE

The Measurement of Grassland Productivity

Proceedings of the University of Nottingham Sixth Easter School in Agricultural Science, 1959. Edited by Prof. J. D. Ivins. Pp. viii+217. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1959.) 35*s*.; 7 dollars.

FOR several years the University of Nottingham has organized an Easter School in a branch of agricultural science. At the 1959 School, on measuring grassland productivity, 20 papers were given, which are published in this book, together with summaries of the discussions.

Grass occupies two-thirds of British farmland, but current production from it is much less than would be possible if existing knowledge of improved varieties, fertilizers and techniques of management were fully applied. Lack of confidence in methods for measuring grassland productivity hinders these developments and this School was organized to review and discuss current methods.

In the opening session Dr. William Davies reviewed the history of methods of measuring grassland output; corresponding German work during the past twenty years was described by Prof. E. Klapp. T. E. Williams then gave a good account of the effect of leys on the productivity of arable crops grown after the leys were ploughed.

A second group of papers dealt with the growth characteristics of different herbage crops and the problems of assessing their relative merits. Herbage has no true value until it has been used by an animal, so the third group of three papers discussed methods of assessing how much grass is actually eaten by stock in grazing experiments. Eight papers dealt with assessments of animal production from grass, and with correlating estimates of pasture growth with the performance of animals using the herbage. Three of these papers discussed the digestibility of herbage in pasture experiments.

Two papers described farm-scale measurements. Work done by Imperial Chemical Industries, Ltd., on commercial farms showed that measurements of grassland production must be related to output from the whole farm business; single measurements of productivity, and particularly physical measurements, can be misleading. Mr. Rex Patterson showed how his farm records of grazing have been used to measure pasture productivity and also quality.

The papers cover the subject well although their quality varies; together they provide a good review and the book is recommended to those concerned with scientific work on grass.

G. W. COOKE

Handbook of Toxicology

Vol. 3: Insecticides: a Compendium. By William O. Negherbon. Prepared under the Direction of the Committee on the Handbook of Biological Data, Division of Biology and Agriculture, National Academy of Sciences—National Research Council. Pp. xxv+854. (Philadelphia and London: W. B. Saunders Company, 1959.) 98*s*. net.

THE insecticides volume of the "Handbook of Toxicology" is an impressive production which is well calculated to save an immense amount of time for anyone seeking the available information about the great range of chemicals that are in use as insecticides and synergists at the present time. The contents are arranged alphabetically under the preferred chemical names of the substances. But interspersed among these are general articles on such subjects as anti-metabolites, bees and insecticides, cytochrome oxidase (effect of insecticides on), resistance, temperature and insecticidal action and others. Some of these sections help to lighten the subject-matter, as do the introductory sections dealing with each insecticide or group of insecticides. Under a given substance will be found an account of its chemistry; toxicity for man and wild-life; toxicity for insects; factors influencing toxicity; entry and mode of action in the insect; formulations; resistance; all these subjects being illustrated by exhaustive compilations of tabulated data. An insecticide such as DDT on which a vast literature exists will have about 40 pages devoted to it. Original references are quoted for every piece of information; the reference list contains 3,404 titles. There are separate indexes to chemical compounds, and to the scientific and common names of insects.

This should prove a most valuable work of reference. The short general introductions to the various sections can be read with interest by anyone looking for a broad survey of the subject.

V. B. WIGGLESWORTH

NUCLEAR TRAINING FACILITIES AT THE ROYAL NAVAL COLLEGE, GREENWICH

By Prof. J. EDWARDS

THE Royal Navy, with one nuclear submarine, *Dreadnought*, well under construction, and another likely to follow, with a land-based prototype plant at Dounreay also well advanced, and a possible interest in nuclear surface ships, has an obvious need to ensure a continued output of officers fully trained in the theory, techniques and problems of nuclear propulsion systems to meet its specific requirements. To provide this, the Department of Nuclear Science and Technology was set up under me at the Royal Naval College at Greenwich in January 1959.

The responsibilities of this Department were to provide courses suitable for those officers responsible for the operation of the nuclear submarines and for the prototype at Dounreay, and also to provide an advanced course suitable for those technical officers and civilians who would go to the Design Departments of the Admiralty concerned with nuclear propulsion. At present all reactors under construction for these purposes are of the pressurized-water type, and the courses are therefore aimed at this system in particular and the small mobile reactor system in general rather than the large gas-cooled graphite-moderated reactors used in the land-based power station programme.

The course for the submarine officers and operators lasts six months and that for the designers one year; both are of high academic standard demanding good mathematical knowledge, and cover atomic and nuclear physics, chemistry and metallurgy, reactor physics and kinetics, shielding and heat transfer, servo-mechanisms and control systems, and detailed information on the actual plant systems and components to be installed in the submarines. In the case of submarine officers of H.M.S. *Dreadnought*, they, on successfully completing the course, proceed to the United States to undergo a period of practical training in sea-going nuclear submarines of the United States Navy. This facility will later be replaced by training on Great Britain's own prototype at Dounreay when this is commissioned. Those officers and civilians who successfully complete the six-months course and who stay on for the advanced course spend a further term in which the main emphasis is given to a detailed design study of a mobile reactor system, to additional experimental work, and to a series of lectures from experts from the Atomic Energy Authority and industry related to safety aspects, metallurgical topics including radiation damage and fuel element fabrication, steam generator design and steam cycles, radiochemistry, advanced mobile reactor systems, and more detailed reactor physics and core design studies, relating to flux flattening, burn-up, control problems and the use of burnable poisons, etc. The design studies, although at first concentrating on the pressurized-water systems, will gradually be extended to cover other systems of interest to marine propulsion, namely, boiling-water reactors, organic moderated reactors, high-temperature gas-cooled reactor systems and others. These lectures are supplemented by additional visits to centres of nuclear research, fabrication and construction.

The six months reactor course is necessarily predominantly theoretical but nearly a dozen basic physics experiments have been introduced to give the students familiarity with the detection and measurement of radiation, and basic health and safety precautions and monitoring instruments. These cover the normal Geiger counter experiments, the measurement of half-value thickness of various materials, calibration of scintillation spectrometers, measurement of beta absorption curves, and the back-scattering of beta particles. Some neutron transmission experiments have also been introduced in which neutron cross-sections, as well as diffusion and slowing-down lengths of neutrons, are measured. The neutrons for these experiments are provided by a neutron 'howitzer', essentially a carefully designed storage shield for a polonium–beryllium neutron source of about 1 c. The neutron howitzer consists basically of a steel drum containing a 10-in. thickness of paraffin surrounding the source. A number of vertical and horizontal ports or beam holes are provided for the experiments together with means for accurately positioning the source and the experimental equipment.

An important facility from the point of view of the reactor operators is the reactor simulator. This has been built by Vickers-Armstrongs (Aircraft) Ltd., and is largely based on their *Mk. II* design modified in certain aspects to meet the specific requirements of the Department. These machines are based on analogue computer principles, and by means of electronic circuits the equations relating to neutron flux, reactivity and time in a nuclear reactor are continuously solved. Various configurations of fuel and moderator with an associated range of prompt neutron life-times can be represented, and studies of the effectiveness of automatic control systems and the changes of reactivity due to fission product poisoning, temperature coefficient and thermal transient effects can be carried out. The control panel instrumentation provides most of the important indications given on the control desk of a full-sized reactor, including pen recording on logarithmic and linear power scales, a logarithmic power-level meter, and a doubling time or period meter. Automatic start-up is provided, as well as a 'demand-power' function generator with meter display. A temperature effect is also built in, using a temperature proportional to power, with a suitable time-lag, a temperature trip and a meter display of average coolant temperature. Safety simulation is obtained by the incorporation of various safety trips and interlocks to provide actual reactor safety trip responses. A large range of experiments can be undertaken with the aid of this machine, and include reactor start-up procedure, approach to maximum power-level, step changes in reactivity, doubling time and reactivity variations,

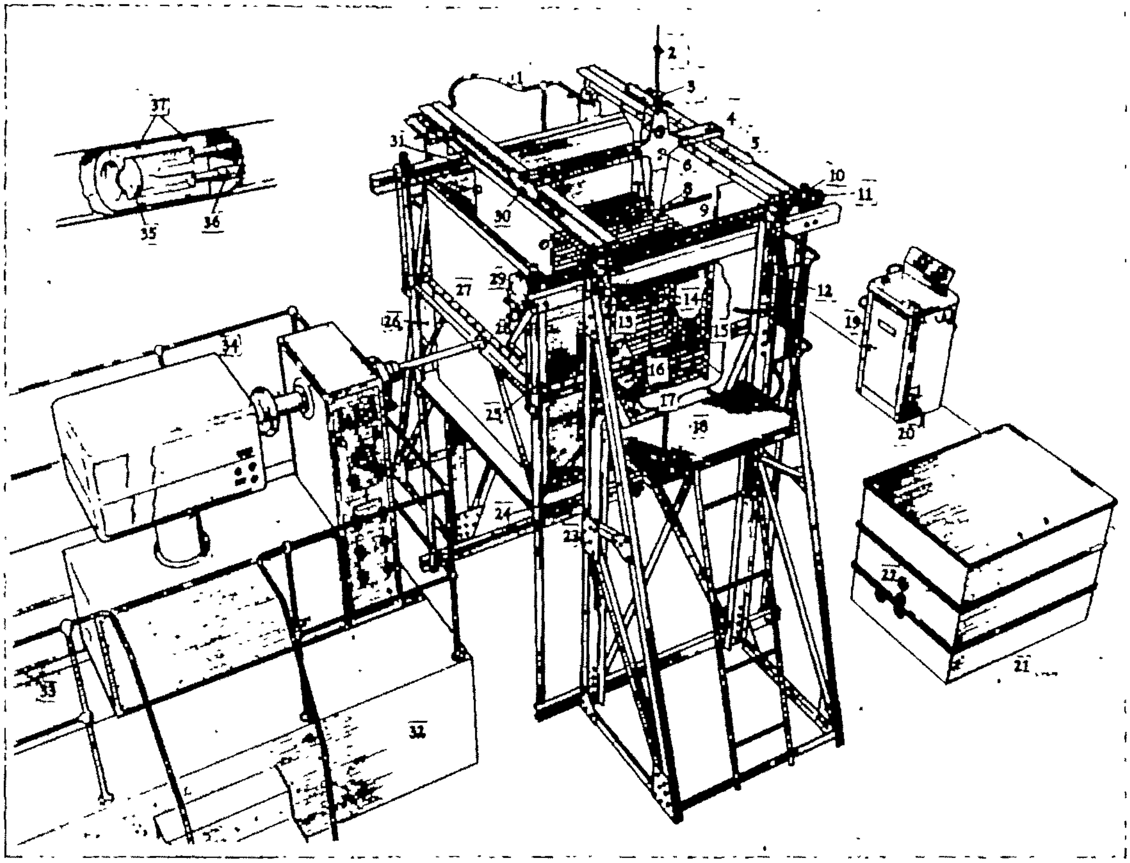


Fig. 1. Sub-critical reactor. Natural uranium light water moderated, pulsed neutron generator
1, handrail, 2, probe clamp, 3, probe adjuster; 4, indexed longitudinal beam; 5, indexed lateral angle; 6, ball lock; 7, probe locator; 8, probe guide wheels; 9, lattice plate spacer; 10, lateral movement hand wheel, 11, tank winch pulley; 12, jacking screw and hand wheel; 13, target (see detail), 14, alternative target holes; 15, lattice plate; 16, probe; 17, fuel elements; 18, operator's platform; 19, water purifier; 20, purifier drain; 21, small tank (unreflected system); 22, alternative target holes; 23, end frame assembly; 24, tank cradle locating peg, 25, tank winch cable tensioner; 26, tank cradle, 27, large tank; 28, winch handle and extractor; 29, tank winch gear-box; 30, ball lock; 31, lateral movement cable tensioner, 32, concrete plinth; 33, alignment rails, 34, particle accelerator. Details of target. 35, target, 36, cooling water pipes, 37, 'O'-type sealing rings

poisoning effects and simulation of 'accident conditions'. It therefore provides a comparatively inexpensive training device very suitable for experiments following on the theoretical teaching on reactor kinetics and control, and prior to actual power reactor operational training.

It is planned also to install shortly a sub-critical reactor in the Department (Fig. 1). This is being built by Miles-Hivolt and is largely based on a design evolved in the University of Birmingham, suitably modified to the Royal Naval College requirements to provide additional flexibility in the experiments to be carried out with this equipment. The facility is a light-water moderated, natural uranium assembly, using a small but powerful accelerator to produce neutrons. The latter can be used either as a continuous or pulsed source of mono-energetic neutrons, free of the γ-radiations emitted by most radioactive sources. It is easily transportable and can therefore be used independently for a variety of other nuclear physics experiments. The five tonnes of natural uranium rods are in the form of as-cast uranium rods canned in aluminium, 43½ in. long by 1·22 in. diameter. These are supported in two vertical lattice plates to form a horizontal array on a square pitch of 1·9 in. to an accuracy of better than 0·005 in. The assembly is supported in a space frame at a variable height and contained within one of two stainless steel moderator tanks which can be winched into position and provide either an unreflected system with one tank, or some 6 in. of water reflector with the other tank. A dump tank, pump, and water treatment plant are also provided. A platform around the structure provides easy access for the assembly and positioning of monitoring and counting equipment, and a special traversing mechanism is supplied to enable accurate positioning of such equipment in three dimensions to be carried out. A source tube 1 in. in diameter passes horizontally through the system and is coupled to the 150-kV. ion accelerator. The deuterium or tritium target for neutron production can be placed at any position in the tube, which in turn can be placed in any one of four alternative positions through the lattice. The accelerator, which requires a power supply of about 8 kV.amp. and a cooling water supply of 5 gallons per min., is capable of giving a maximum beam current between 0·75 and 1·00 m.amp. either with hydrogen or deuterium ions and can be operated continuously, or with a pulse repetition rate between 0·65 and 3 kc./sec. giving a neutron output between 10^9 and 10^{10} neutrons per sec. of either 3 or 14 MeV. energy, depending on the beam and type of target used. The advantages of using an accelerator as a neutron source instead of a powerful radioactive source are that one no longer needs extreme care in the shielding, handling and transport of the source; one can literally turn the neutrons on and off at the turn of a switch, and no expensive and time-wasting re-irradiation of the source is required. Some of the experiments which will be carried out to give the students an understanding of reactor core phenomena and essential design parameters include measurement of buckling, multiplication factor, thermal utilization factor, criticality measurements, neutron migration lengths, prompt neutron reactivity, time constants of the assembly and neutron lifetime studies for prompt and delayed neutrons. The equipment, however, due primarily to the pulsed neutron facility, will also provide adequate opportunities for research to be undertaken by the staff of the Department.

Other experimental rigs now being designed include two heat-transfer loops, for gas and liquid heat-transfer studies, and a large-scale shielding experiment to be used in conjunction with the accelerator. To provide some additional experience with an actual critical facility short training visits are being arranged with Hawker-Siddeley's Nuclear Power Co. at Slough, to enable students to become acquainted with operational procedures and experimental uses of the firm's 10-kW. Jason reactor. It is hoped to obtain a more advanced computer than the reactor simulator mentioned above.

The first full reactor course of six months has now just been completed, and a second six-month course is about half-way through its final term, as is the first advanced course. Results have been most encouraging, and it is evident that a firm foundation for training in nuclear propulsion systems has now been established. Additional and more general courses in nuclear science and technology lasting two weeks and six weeks respectively are to be instituted in the near future to cater for those concerned with other and broader aspects of nuclear propulsion.

The Department is situated in one of the historic and beautiful buildings designed by Wren of the Royal Naval College, and although this posed some problems in its internal conversion to nuclear laboratories, the building has been adapted surprisingly well. Two laboratories are provided, one on the third floor and one on the ground floor, each with its associated offices and instrumentation test facilities. That on the third floor, which is in close proximity to the main offices, lecture rooms, stores and electronic workshop of the Department, is used for the basic nuclear physics experiments involving, in the main, sources of only low activity, generally less than 1 mc. Facilities are also provided here for preparation of specific sources from radioactive liquids. The other laboratory is designed to provide storage and handling space for sources of several curies of activity as well as facilities for the storage of any accumulated solid and liquid active waste. This laboratory will house the larger and heavier experimental equipment such as the sub-critical reactor, heat-transfer loops and the large-scale shielding experiments referred to above. Consideration has also been given to the possibility of ultimately housing a low-power research and training reactor. Clean room, offices and adequate crane lifting capacity have been provided together with a dark room for the processing of film used in some experiments and for instruction in radiographic techniques. The conversion of this laboratory is now practically complete and the installation and commissioning of the sub-critical facility in which the advance course students will participate will begin towards the end of September.

Fig. 1 is a drawing of the sub-critical facility.

I wish to acknowledge with thanks the permission of the Admiralty to publish this article.

HUMAN AND OTHER ANIMAL CELLULOSE

By Dr. D. A. HALL and H. SAXL*

Department of Medicine, University of Leeds

PRIOR to the observations[1,2] that anisotropic fibres consisting partly of cellulose and partly of protein, exist as a minor but normal constituent of mammalian tissue, the only form of cellulose which could unequivocally be ascribed to the animal kingdom occurred in the tests of the tunicates. Evidence has also been advanced for the presence of cellulose in the outer layers of silk fibres from *Bombyx mori*[3], and other species of silkworm, but there is no evidence that this material is in any way oriented, nor is its identity proved beyond doubt[4].

We have therefore investigated the origin and comparative relationships of the cellulose-containing fibres of mammalian tissue. To do this, five different tissues have been examined, all rich in neutral polysaccharide, but differing markedly in site and function. These were: cotton fibres as representative of plant cellulose, anisotropic fibres from an affected area of the dermis of a case of scleredema adultorum of Buschke[5], a preparation from aged human aortic media, finely dispersed material from the basement membrane of pig kidney and the mid-portion of the test of the tunicate, *Ascidiella aspersa*.

Polarization and Electron Diffraction Observations

Polarization and electron diffraction results were correlated. It has been observed previously[6,7] that tunicin is composed of layers of interwoven anisotropic fibrils, and in addition it contains anisotropic fibres or lamellæ similar in all respects to those of mammalian tissue. Frozen sections of human aortic tissue also show the presence of the mammalian type of anisotropic fibre resembling presumably the anisotropic structures reported by Hass[8] as early as 1943. Aortic tissue preparations were also obtained by the fractionation of the pooled media of aged human aortas (50–70 years old) after removal of the collagen by exhaustive extraction with boiling dilute acetic acid[9]. Fractionation with boiling 40 per cent urea

---

* Ida Smedley MacLean International Fellow of the International Federation of University Women.

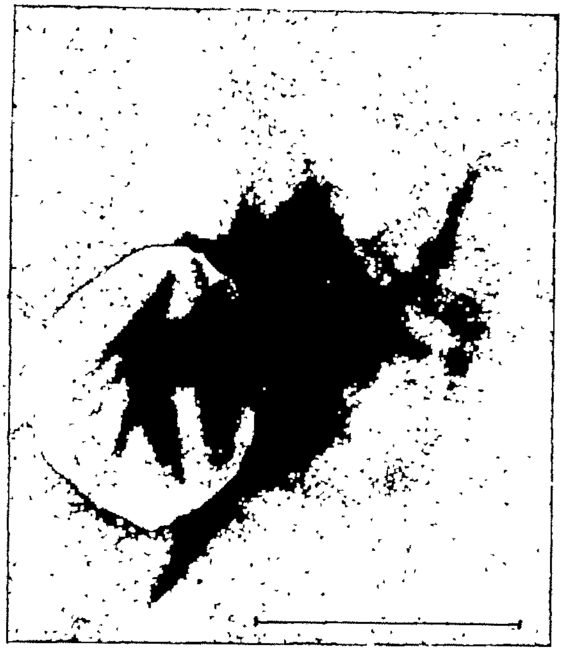


Fig. 1. Reticulin from the basement membrane of the kidney of a pig, exhibiting a laminated structure (ref. 11); isolated by cutting thick frozen sections (about 200μ) of the unfixed cortex from a region about 0·4 mm. internal to the capsule, followed by ultrasonic dispersion (for about 2 min. at 14,000 r.p.s.) (kidney obtained from freshly killed animals). The light area is that from which the electron diffraction pattern, demonstrated in Fig. 2, was obtained (the method has been reported in ref. 2) (× 24,000)

solution gave, after dialysis and filtration, a solution of pseudoelastin[10] which also contained small anisotropic particles (0·05–0·1 mm. in diameter). Particles of about similar size and having the same optical properties were observed in suspensions containing reticulin from basement membranes of pig kidney obtained by ultrasonic dispersion (Figs. 1 and 2); although reticulin in its native state is normally regarded as isotropic[11], it would appear possible that the ultrasonic dispersion has revealed some material which has a marked degree of anisotropy. Dermis from the lesion of Buschke's scleredema contained large numbers of anisotropic fibres of mammalian type.

Although X-ray diffraction studies give a fibre diagram for plant cellulose, this was not observed with electron diffraction studies[2], since the small number of micelles gave a Debye-Scherrer diagram, which is characteristic of amorphous or polycrystalline material. A fibre diagram was, however, observed for scleredema and tunicate cellulose with electron diffraction methods, indicating a greater degree of orientation at this level of organization. Classification was, however, also possible on the basis of the relative intensities of the reflexions. Electron diffraction patterns of the aortic pseudoelastin[10] and renal reticulin preparations included reflexions which were indistinguishable from those of cellulose as exemplified by fibres from human dermal tissue, cotton or tunicin. The intensities of the various reflexions differed considerably however. The heights of the peaks in the densitometer tracings are recorded in arbitrary units chosen to suit each plate. No direct comparison can therefore be made between the absolute values in different tracings. Relative values are, however, comparable. The main observation which can be made from the two sets of curves (Figs. 3 and 4) is that the manifestly fibrous forms (plant cellulose and that from human pathological dermis) are characterized by reflexions of considerable intensity from the 021 and 002 layers. Haphazardly oriented material, on the other hand, shows a more general spread of intensities over a number of different reflexions. Tunicin, although fibrillar, demonstrates a diffraction pattern similar in many respects to that of pseudoelastin and reticulin, and it is thought possible that this similarity may be related to the presence of a layered structure. However, the diffraction pattern of tunicin is characterized by the fact that the reflexions form arcs, indicating the type of orientation which Mark and Susich[12] ascribed to layers aligned at a constant angle. Similar arcs were observed in patterns from the fibres of scleroderma tissue, where cellulose sheets surround the protein template in layers.

Not only can the various polysaccharides be identified as having similar electron optical properties by the positions of the various reflexions, but also the human fibrous form can be shown to react in exactly the same fashion as the plant material to partial hydrolysis with hydrochloric acid[13], which is accompanied by changes in the crystal structure characterized by alterations in the diffraction pattern. The most obvious change under the conditions employed here is an intensification of the third-order reflexion from the 021 layer relative to the adjacent reflexion from the 002 layer. As can be seen from Fig. 3, this change occurs equally in both human and plant cellulose.

Biochemical, Histochemical and Electron Microscope Observations

These observations were made on the reticulin and the pseudoelastin fraction from aorta. Following intradermal injection of pectinase[14] into a guinea pig, microdissection of the reticulin layer of the dermal epidermal junction can be observed, and polysaccharide from this region is liberated into the tissue to form a broad band with positive periodic

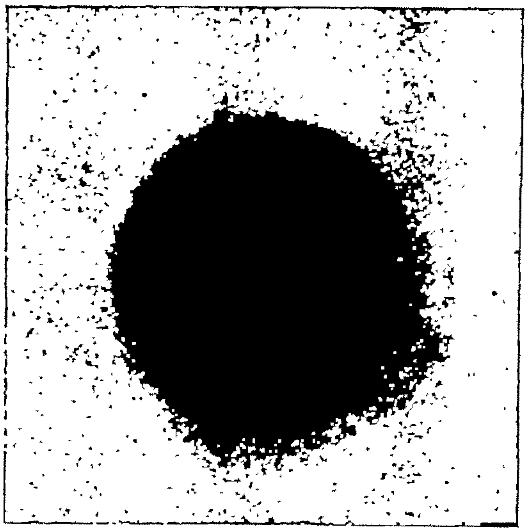


Fig. 2. Electron diffraction pattern from the area indicated in Fig. 1. The two most intense rings correspond to reflexions from the 101 and 021 layer lines of cellulose. The net plane indices of the other reflexions are indicated in the densitometer tracing in the upper section of Fig. 4. The broad diffuse band underlying the 021 ring represents the reflexion corresponding to the 2·86 Å. spacing of the haphazardly oriented array of collagen fibrils in the reticulin. Photographs taken with Elmiskop I

acid–Schiff reaction[13]. These observations could be related to the examination of bullous lesions of human dermis. *In vitro* studies demonstrated that the amount of polysaccharide liberated, following pectinase action, is much greater from sclerodermatous than from normal tissue. Electron microscope examination of the pathological dermis revealed how the formation of cellulose fibres from this polysaccharide might occur. It was suggested earlier[3] that the initial stage in the formation of anisotropic cellulose fibres in mammalian tissue may necessitate the presence of a protein template and that this might well consist of partially degraded collagen. In the case of reticulin, it appears that the template may in fact consist of a network of intact collagen fibrils. In pathological dermis, different stages in the transformation from reticulin-like fibrils to highly crystalline ones were observed. Cellulose micelles are preferentially adsorbed on to collagen in the regions of the a, b_1 and b_2 bands, thereby forming complexes which act as nuclei for the growth of cellulose crystallites.

High concentrations of neutral polysaccharide were also observed in the pseudoelastin preparations from arterial media. Total polysaccharide and uronic acid determinations made it possible to deduce that the neutral polysaccharide was firmly bound to a protein fraction, the so-called pseudoelastin which followed collagen but preceded elastin into solution in urea solution. This particular protein has the same amino-acid analysis as that reported for the protein fraction of anisotropic fibres in other tissues, and hydrolysis showed glucose to be the major sugar component. Not only was the solubility of old pseudoelastin (67 yr.) greater than that of a similar preparation from young tissue (20 yr.), but also the amount of cellulose-like neutral polysaccharide associated with it was increased. Apparently this was linked with an associated decrease in mucopolysaccharide content, since the total polysaccharide content was not greatly affected by age.

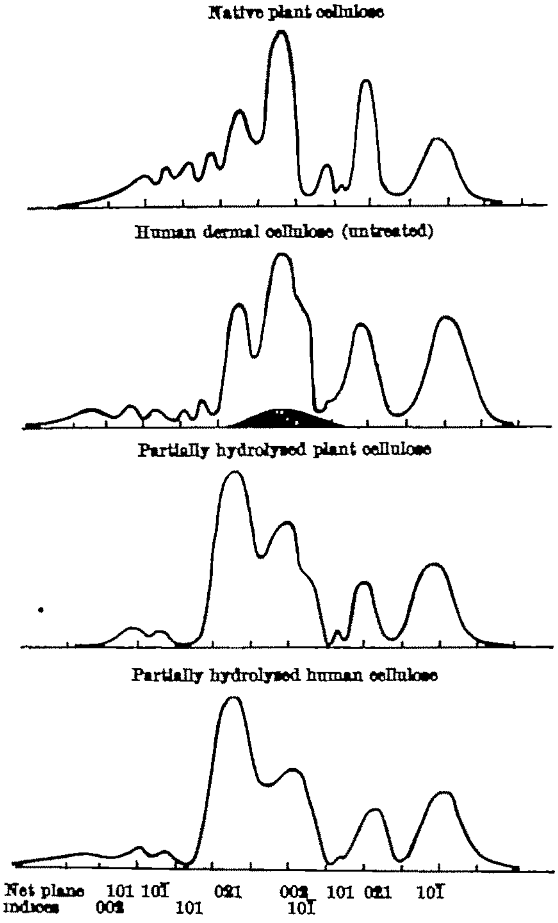


Fig. 3. Densitometer tracings of diffraction patterns from native plant and human cellulose (scleroderma dermis) and from similar material after partial hydrolysis following 5 hr. boiling under reflux with an azeotropic aqueous hydrochloric acid solution

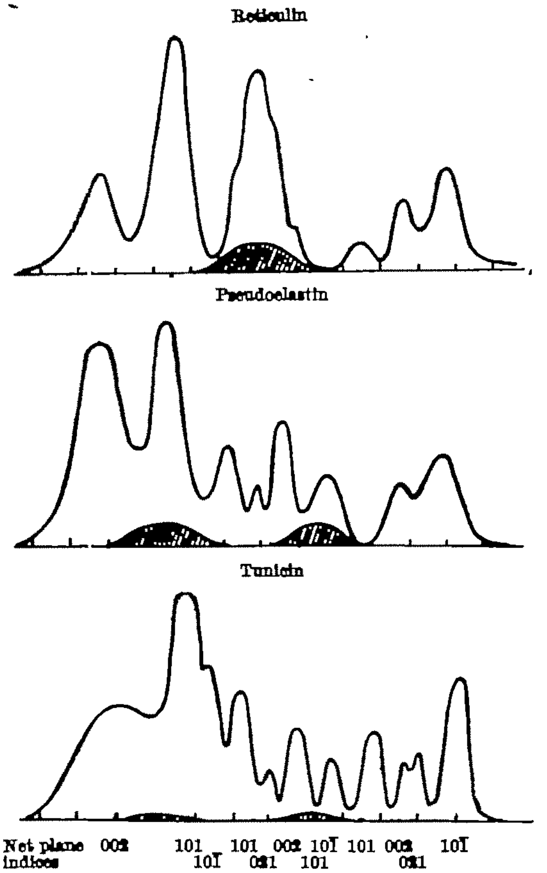


Fig. 4. Densitometer tracings of diffraction patterns from (*a*) pig kidney basement membrane (cf. Figs. 1 and 2), (*b*) a preparation (pseudoelastin) dissolved from human aortic media with boiling 40 per cent urea after the removal of collagen and ground substance with boiling 2 per cent acetic acid; and (*c*) a preparation of tunicin from the test of the tunicate *Ascidiella aspersa*. The shaded areas refer in (*a*) to the diffuse reflexions from the 2·86 Å. spacing in collagen, and in (*b*) and (*c*) to reflexions characteristic of the 2·0 and 4·4 Å. spacings of elastin

Frey Wyssling[14] has pointed out that interchain hydrogen bonds in the cellulose crystal lattice do not lie in the plane of the pyranose rings (the 002 plane) but in the diagonal 101, and to a less extent in 10Ī planes. The relative unimportance of the 002 spacing in preparations from reticulin, pseudoelastin and tunicin may therefore indicate that planar alignments of the cellulose chains are formed in these tissues, presumably due to the planar nature of the substrate on which they are deposited, as opposed to the three-dimensional crystal structure which results from deposition on a cylindrical template. Both reticulin and tunicin are known to be planar in arrangement, and it is to be expected that pseudoelastin, having been dried from solution, would crystallize in the simplest possible form. That such a simple structure is in fact in the form of a planar array has been demonstrated by Mukherjee, Sikorski and Woods[17] for mechanically or chemically dispersed plant cellulose microfibrils. It would appear therefore that, in the presence of a suitable substrate, hydrogen-bond formation in the 101 plane completely supersedes any interchain reactions in other planes, with the consequent formation of a layered cellulose structure. In all these cases, however, the presence of reflexions of low but finite intensity from the 002 plane must indicate that at least a portion of the polysaccharide has become associated with a template on which it is capable of forming a three-dimensional array and hence of producing a fibril. This deduction is in complete agreement with the observations of a limited number of anisotropic structures in these preparations.

The apparent similarity between the different protein polysaccharide complexes would appear to be of considerable significance. In all cases examined, the protein consists of either collagen or a degradation product of this, pseudoelastin. The nature of pseudoelastin has been discussed before[10]. The present work demonstrates that not only does pseudoelastin contain a basic amino-acid pattern but it also is a protein polysaccharide complex. Only in the case of tunicin and the mammalian dermal fibres has the polysaccharide been unequivocally identified as cellulose. The pseudoelastin fractions, by the nature of their method of preparation, cannot be identified as single compounds, but evidence from electron diffraction diagrams, examination in polarized light and chromatographic assessment of the sugar content of their acid hydrolysates would appear to indicate that the polysaccharide resembles cellulose, at least in so far as it consists in the main of β(D)-glucose molecules joined through 1 : 4 linkages. However, since similar anisotropic structures to those proved to contain cellulose can be observed in fibres containing chondroitin sulphate[3], it may not be necessary for all the linkages between the sugar residues to be 1 : 4.

That tunicates may represent the ancestors of the vertebrates has been discussed by several workers[18,19], and the similarity between the protein fractions to which mammalian and tunicate celluloses are attached may represent further evidence in support of this hypothesis. It does not appear inconceivable from the present observations that the polysaccharide–protein complex of reticulin may have been developed phylogenetically from the ancestral neutral polysaccharide–protein complex tunicin, on the pathway from tunicate to man, since only quantitative biochemical and biophysical changes would be required for such a development. Pontecorvo[20] has considered the possibility that evidence is available at a structural rather than a metabolic level for evolutionary development to be due either to changes in, or maintenance of, specific genetical characteristics. The appearance of increasing amounts of cellulose-like polysaccharide in combination with protein in ageing aortic tissue may indicate that similar genetical changes may occur during the ageing of an individual.

A fuller discussion of these results and their implications will be given elsewhere.

This work was mainly carried out while we were members of the Nuffield Gerontological Research Unit, University of Leeds. We thank Prof. R. E. Tunbridge, Dr. F. Happey and Prof. R. D. Preston for much critical discussion, and Prof. H. Magnus for the specimen of dermis from a case of scleroderma, and Dr. H. J. Woods for densitometer facilities.

[1] Hall, D. A., Lloyd, P. F., Saxl, H., and Happey, F., *Nature*, 181, 470 (1958).

[2] Hall, D. A., Happey, F., Lloyd, P. F., and Saxl, H., *Proc. Roy. Soc.*, B, 151, 497 (1960).

[3] Shimizu, M., *C.R. Soc. Biol.*, 149, 853 (1955).

[4] Buonocore, C., *Ann. Sper. Agraria*, 12, 681 (1958).

[5] Buschke, A., *Berl. Klin. Wochschr.*, 39, 955 (1902).

[6] Schmidt, W. J., "Die Bausteine des Tierkörpers im Polarisierten Licht", 236 (Bonn, 1924).

[7] Frey-Wyssling, A., and Frey, R., *Protoplasma*, 39, 656 (1950).

[8] Hass, G. M., *Arch. Path.*, 35, 29 (1943).

[9] Hall, D. A., *Biochem. J.*, 59, 459 (1955).

[10] Burton, D., Hall, D. A., Keech, M. K., Reed, R., Saxl, H., Tunbridge, R. E., and Wood, M. J., *Nature*, 176, 966 (1955).

[11] Robb-Smith, A. H. T., in "Connective Tissues", edit. by C. Ragan (Josiah Macy Jr. Foundation, New York, 1952).

[12] Mark, H., and v. Susich, G., *Z. phys. Chem.*, 4, 431 (1929).

[13] Immergut, E. H., and Rånby, B. G., *Indust. Eng. Chem.*, 48, 1183 (1956).

[14] McManus, J. F. A., and Saunders, J. C., *Science*, 111, 204 (1950).

[15] Stoughton, R. B., and Wells, G., *J. Invest. Dermatol.*, 14, 37 (1950).

[16] Frey-Wyssling, A., *Biochim. Biophys. Acta*, 18, 166 (1955).

[17] Mukherjee, S. M., Sikorski, J., and Woods, H. J., *Nature*, 167, 821 (1951).

[18] Berrill, N. J., "The Origin of the Vertebrates" (Clarendon Press, Oxford, 1955).

[19] Needham, J., Needham, D. M., Yudkin, J., and Baldwin, E., *Proc. Roy. Soc.*, B, 110, 260 (1932).

[20] Pontecorvo, G., "Trends in Genetic Analysis" (Columbia Univ. Press, New York, 1959).

COMPARISON OF FISSION PRODUCT AND BERYLLIUM-7 CONCENTRATIONS IN THE ATMOSPHERE

By W. ANDERSON, R. E. BENTLEY, R. P. PARKER, J. O. CROOKALL
and L. K. BURTON

Physics Department, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3

SCINTILLATION spectrometry provides a convenient method of following the levels of specific γ-ray-emitting nuclides, and, since May 1959, we have been measuring the γ-activity of atmospheric dust collected from surface air by an electrostatic precipitator at Sutton, Surrey[1]. Apart from one sample which contained material from the first French nuclear test[2], we have been unable to measure the relatively short-lived zirconium-95 plus niobium-95 in samples collected after December 1959. We have therefore considered the principal γ-emitting fission products of longer half-life[3], shown in Table 1. The 0·51 MeV. γ-line of rhodium-106 was thought to be particularly suitable for following current trends in concentrations of fall-out materials in the air. However, difficulties are encountered due to the presence of other nuclides with similar γ-energies.

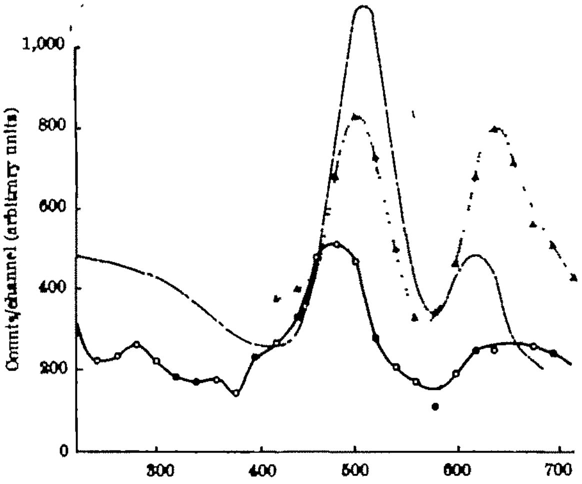


Fig. 1. Spectra of dust samples obtained with 3-in. crystal. - - -, May 1959; ——, December 1959; — — —, rhodium-106 reference standard

Fig. 1 shows the γ-spectra of two typical dust samples, one collected during May 1959 and the other during December 1959, measured with a 3 in. × 3 in. sodium iodide (thallium) crystal and 100-channel analyser. The spectrum of a rhodium-106 reference standard is also shown and it is found that the position of the principal peak in the spectrum of the May sample differs by not more than half a channel width from that of the standard. One channel width of our spectrometer corresponds to an energy difference of 0·020 MeV. In samples collected after December 1959 small but significant changes in the position of this photopeak were observed. Thus the position of the principal peak in the spectrum of the December sample is about 1·5 channels width from that of the standard, indicating an energy about 0·03 MeV. lower than the accepted value of 0·51 MeV. for rhodium-106[4]. This peak decayed initially with a half-life of about 70 days.

Detailed Analysis of 0·5 MeV. Peak

In order to determine more accurately the γ-energies contributing to the peak in the region of 0·5 MeV., the γ-spectra of several samples were measured using a 1-in. cube sodium iodide (thallium) crystal which has a lower efficiency than the 3-in. crystal previously employed but an improved energy resolution (8 per cent at 0·66 MeV.). Part of the spectrum of our mid-February 1960 sample is shown in Fig. 2 and it will be seen that the peak at about 0·5 MeV. is complex. One component appears to be at an energy slightly higher than 0·50 MeV. This is probably due to rhodium-106 since in addition we have observed a small peak in the spectrum at 0·62 MeV. (Table 1). If it is assumed that rhodium-106 is present, the intensity of the 0·62 MeV. line can be used to estimate the contribution of the 0·51 MeV. line to the composite peak, since the relative intensity of these two lines is known from the reference standard. The composite peak can then be resolved into three components with maxima at about 0·515 MeV., 0·476±0·005 MeV. and about 0·43 MeV. Each of these components was found experimentally to have the same resolution as a single photo-peak of corresponding energy, which suggests that there are only three main components. For the reasons given below, the 0·476 MeV. line has been attributed to beryllium-7 and the 0·43 MeV. line to antimony-125.

Identification of Antimony-125

Antimony-125 is known to occur as a fission product[5], and has been reported in soil samples taken near the site of a nuclear explosion[6]. Its possible occurrence in ryegrass has also been suggested[6].

Apart from the correspondence of the 0·43 MeV. peak (Fig. 2) with the energy of the principal γ-line of antimony-125, we have detected an X-ray line of 0·027 MeV. which would be expected from the tellurium-125m daughter of antimony-125. The additional γ-lines of antimony-125 at 0·60 MeV. and 0·17 MeV. were masked by γ-lines from other fission products (barium-137m, rhodium-106 and cerium-144).

Evidence for the chemical identity of the nuclide responsible for the 0·43 MeV. γ-line was provided by addition of antimony carrier to a dust sample, subsequent separation of the antimony fraction and examination of this by γ-spectrometry. It may be noted that the material thought to be antimony-125 remained associated with the insoluble fraction after evaporation of the sample with a series of concentrated and dilute acids (perchloric, hydrochloric, hydrofluoric and nitric). This marked insolubility suggests that the activity was incorporated in highly inert, probably fused, particles. The insoluble matter was fused at 600°–650° C. with a mixture of equal parts of potassium hydroxide, potassium carbonate and potassium nitrate, and with the addition of 10 mgm. each of silver, antimony, cerium and strontium as carriers. The melt was leached with water and the lixiviate was found to contain the activity suspected of being antimony-125. After acidification with hydrochloric acid, the Group 1 precipitate was centrifuged out and the antimony recovered from the supernatant as the sulphide. The γ-spectrum (Fig. 3) of this antimony sulphide was identical with that of an antimony-125 reference source.

Identification of Beryllium-7

Beryllium-7 is known to occur naturally[7], being produced in the atmosphere by the interaction of

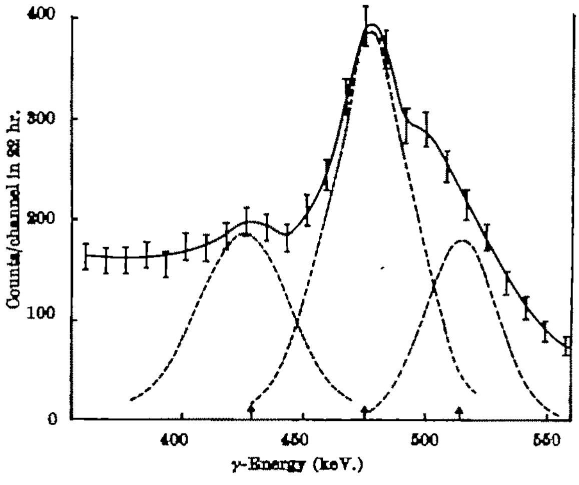


Fig. 2 Detailed analysis of 0·5 MeV. peak obtained with 1-in. crystal

Table 1. NUCLEAR DATA AND ATMOSPHERIC CONCENTRATIONS IN SURFACE AIR OF NON-GASEOUS NUCLIDES

Nuclides	Half-life of parent	Principal γ-lines		Maximum β-energy, MeV., principal mode of decay	Concentration in air February 1960	
		Energy MeV.	No. of transitions per 100 disintegrations of parent		c./litre	atoms/litre
Fission products						
^{106}Ru ↘	370 days			0·04	4×10^{-18}	7
^{106}Rh		0·513 0·621	21 10	3·5		
^{125}Sb ↘	2·4 yr.	0·175 0·427 0·595 0·027*	6 29 32 20	0·3	$2·5 \times 10^{-18}$	10
^{125m}Te						
^{137}Cs ↘	30 yr.			0·5	$\sim 10^{-18}$	~ 50
^{137m}Ba		0·662	83			
^{144}Ce ↘	285 days	0·134	8	0·3	7×10^{-18}	9
^{144}Pr				3·0		
^{95}Zr ↘	65 days	0·723 0·756	49 49	0·4	less than 10^{-18}	< 0·3
^{95}Nb		0·765	100	0·2		
Cosmic-ray produced nuclides						
^{7}Be	53 days	0·478	11	No. β's, 100 per cent electron capture	2×10^{-17}	5
^{22}Na	2·6 yr.	1·28	100	0·5 (β^+)	10^{-20}	0·04
^{32}P	14 days	—	—	1·7	5×10^{-19}	0·03
^{33}P	24 days	—	—	0·25	2×10^{-19}	0·02
^{35}S	87 days	—	—	0·17	10^{-18}	0·4

* X-ray line.

cosmic ray nucleons with nitrogen[8]. The energy of the main photopeak in the spectrum shown in Fig. 2 was found experimentally to correspond very closely with that of a beryllium-7 standard. However, a search of nuclear data tables[4] showed three other possible nuclides with principal γ-emissions in the energy-range of 0·46–0·49 MeV. and half-life between 10 and 100 days, namely tellurium-129m, hafnium-181, and curium-241. In view of the short half-lives (35–53 days) of all four nuclides it is unlikely that they would have been detectable if they had been products of nuclear explosions. It is improbable that beryllium-7 is produced in such explosions[9]. Moreover, the fact that beryllium-7 is continually produced in the atmosphere makes it the most probable of these four nuclides as being responsible for the 0·476 MeV. peak. The absence of additional γ- and X-ray energies which we would probably have detected from any of the other three nuclides adds weight to this view.

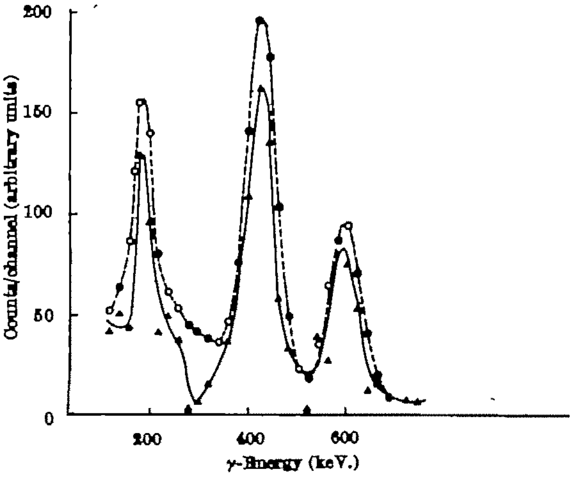


Fig. 3. Spectrum of antimony sulphide fraction (——) and reference standard of antimony-125 (- - - -)

We now turn to the chemical evidence for the identity of this material. An appropriate dust sample was digested with 50 per cent hydrochloric acid containing 10 mgm. of beryllium as carrier, and the 0·476 MeV. γ-line was found in the spectrum of the extract. The ready solubility of the activity is in marked contrast to that of antimony discussed above and accords with that to be expected from the mode of formation of beryllium-7, presumably as widely separated atoms. The solution was treated with an excess of ammonia to precipitate beryllium hydroxide and other hydroxides derived from elements such as aluminium and iron normally present in atmospheric dust[10]. The mixed hydroxides were extracted with 2·5 *N* sodium hydroxide to dissolve the beryllium and aluminium, leaving various hydroxides, notably that of iron, as an insoluble residue. The alkaline extract was next scavenged with hafnium by acidification, addition of hafnyl chloride and precipitation of hafnium hydroxide with excess alkali. Antimony and tellurium were removed together from the alkaline beryllium solution by successive acidification, addition of tellurium carrier, and precipitation of the sulphide. The beryllium was recovered from solution by precipitation with excess ammonia. A further scavenge, analagous to that with hafnium, was carried out using cerium. The hydroxide scavenges should have removed any curium that might be present.

In order to obtain the beryllium as a small source for β- and γ-counting, and to provide further purification, it was next separated from the associated aluminium. The supernatant from the cerium hydroxide precipitation was just acidified with hydrochloric acid and oxine reagent added, followed by ammonium acetate to complete precipitation of the aluminium. After removal of the aluminium oxinate by centri-

Table 2. RATIO OF SPECIFIC ACTIVITIES OF FISSION PRODUCTS, AT A TIME 18 MONTHS AFTER FISSION, CALCULATED FROM FISSION YIELD DATA FOR DIFFERENT TYPES OF FISSION

	$\frac{^{95}Zr + ^{95}Nb}{^{144}Ce}$	$\frac{^{106}Rh}{^{144}Ce}$	$\frac{^{125}Sb}{^{144}Ce}$	$\frac{^{137}Cs}{^{144}Ce}$	$\frac{^{90}Sr}{^{137}Cs}$
$^{235}U\ n_{th}$	0·15	0·07	0·004	0·11	0·93
$^{235}U\ n_f$	0·17	0·10	0·02	0·13	0·71
$^{239}Pu\ n_f$	0·17	1·7	0·06	0·17	0·36
$^{238}U\ n_f$	0·15	0·60	0·08	0·15	0·48
$^{235}U\ n_{14}$	0·17	0·95	0·24	0·17	0·51
$^{238}U\ n_{14}$	0·19	0·43	0·32	0·16	0·82
Experimental value Feb. 1960	<0·14	0·57	0·36	~0·14	—

n_{th}, thermal neutrons; n_f, fission spectrum neutrons; n_{14}, 14 MeV. neutrons.

fugation, the beryllium was precipitated with excess ammonia and mounted on a planchette. The γ-spectrum of this precipitate consisted solely of a line at 0·476 MeV., and was identical with that of a beryllium-7 reference standard. There was no measurable β-activity.

Relative Concentrations of Fission Products

Table 1 gives our observed concentrations in air of fission products associated with atmospheric dust during February 1960. Table 2 gives the relative activities of a number of nuclides eighteen months after fission, computed from published data[3] for different fissile materials and various neutron energies. It should be noted, however, that these ratios may need modification when applied in the case of a nuclear detonation. It will be seen that the ratios rhodium-106 : cerium-144 and antimony-125 : cerium-144 are sensitive to the type of fission process. Taken together, our experimental ratios (Table 2) agree best with the theoretical values for 14 MeV. fission of either uranium-235 or uranium-238, and in particular the high antimony concentrations which we have observed do not appear compatible with data for thermal neutron fission of uranium-235. The 14-MeV. neutrons are unlikely to be produced in a normal fission process, but they could be the result of a fusion reaction.

Concentration of Nuclides produced by Cosmic-rays Relative to Fission Products

Table 1 includes data for non-gaseous cosmic-ray produced nuclides. With the exception of beryllium-7, for which our measurements are quoted, the values are estimated from published concentrations in rainwater[11] on the assumption that the relative amounts in air and in rain are the same as for beryllium-7. It should be noted that the activity of beryllium-7 measured by us lies within the range of values 0·5–15 × 10^{-17} c./litre of air (1–30 atoms per litre) reported in Canada in 1956[12].

Table 3 contains some preliminary measurements of the specific activities of beryllium-7, rhodium-106, and antimony-125 in air samples collected during the early months of 1960. The seasonal rise in the beryllium-7 concentration is well known[12], and it is interesting to note that the fission-product concentrations are changing proportionally. This is demonstrated by the constancy of the ratios of antimony-125 : beryllium-7 and rhodium-106 : beryllium-7 activities.

Table 3. RHODIUM-106, ANTIMONY-125 AND BERYLLIUM-7 CONCENTRATIONS IN AIR SAMPLES

Mean collection date	Specific activity at time of collection in 10^{-17} c./litre			$\frac{^{106}Rh}{^{7}Be}$	$\frac{^{125}Sb}{^{7}Be}$
	^{7}Be	^{106}Rh	^{125}Sb		
2/1/60	1·4	0·26	0·12	0·19	0·09
30/1/60	1·6	0·24	0·18	0·15	0·11
18/2/60	2·2	0·41	0·27	0·19	0·12
4/3/60	3·4	0·48	0·32	0·14	0·09

It is noteworthy that by the beginning of 1960 the specific activity of fission products in the air at ground-level has fallen to a value comparable with that of naturally produced beryllium-7. The presence of beryllium-7 and antimony-125 complicates the estimation of the absolute amount of rhodium-106.

We wish to express our appreciation of the guidance and encouragement of Prof. W. V. Mayneord, in whose laboratories the work was carried out. We also wish to thank Dr. D. M. Taylor for help in preparing reference standards.

[1] Anderson, W., Bentley, R. E., Burton, L. K., Crookall, J. O., and Greatorex, C. A., *Nature*, 186, 925 (1960).

[2] Anderson, W., Bentley, R. E., Burton, L. K., and Greatorex, C. A., *Nature*, 186, 223 (1960).

[3] Björnerstedt, R., *Arkiv för Fysik*, 16, 293 (1959).

[4] Strominger, D., Hollander, J. M., and Seaborg, G. T., *Rev. Mod. Phys.*, 30, 585 (1958).

[5] Klement, A. W., United States Atomic Energy Commission, Washington, Wash., 1024, 5 (1959).

[6] Morgan, A., Atomic Energy Research Establishment, Harwell, *R*-3181 (1959).

[7] Arnold, J. R., and Ali Al-Salih, H., *Science*, 121, 451 (1955).

[8] Benioff, P. A., *Phys. Rev.*, 104, 1122 (1956).

[9] Thor, R., and Zutshi, P. K., *Tellus*, 10, 99 (1958).

[10] Green, H. L., and Lane, W. R., "Particulate Clouds, Dusts, Smokes and Mists", 336 (Spon, London, 1957).

[11] Suess, H. E., "Ann. Rev. Nuc. Sci.", 8, 243 (1958).

[12] Cruikshank, A. J., Cowper, G., and Grummitt, W. H., *Canad. J. Chem.*, 34, 214 (1956).

OBITUARIES

Dr. O. J. Silberrad

THE thinning ranks of those British chemists who were trained in Germany before the First World War were further diminished on June 17 by the death of Dr. Oswald John Silberrad at his home at Dryads' Hall, Loughton, Essex, at the age of eighty-two.

Silberrad was educated at Dean Close Memorial School, Cheltenham, the City and Guilds Technical College and the University of Würzburg. In 1902, at the early age of twenty-four, he became the first superintendent of the Chemical Research Department at Woolwich, which was under the ægis of the War Office. The new Department could claim to be the first to be created on modern lines specifically for armament research, although the Government organization that is now the Chemical Inspectorate had from its inception, half a century before, concerned itself with research into materials and explosives as well as with its primary function of inspection, and there was also a military experimental establishment concerned with ballistics.

The next four years were busy ones for the young superintendent. He went to Germany to study the comparable organizations there and designed the new laboratories and other equipment. He gathered a small but enthusiastic staff around him, including as his chief assistant and deputy Dr. R. C. Farmer, a fellow student at Würzburg who, with Dr. Godfrey Rotter (later director of explosives research in the establishment) and Dr. Harold Moore (later director, British Non-Ferrous Metals Research Association), among the seniors, survives him.

This period saw not only the discovery of tetryl and of the means of causing lyddite to detonate effectively in shell (it had conspicuously failed to do this in the Boer War), but also the introduction of T.N.T. into the Service and research into flashless and smokeless propellants and into steels for guns, shells and armour.

Silberrad reported to the Explosives Committee of the War Office, the chairman of which was Lord Rayleigh. In 1906, this Committee was disbanded, and in the same year Silberrad resigned, to become for the rest of his career a consulting research chemist and director of the Silberrad Research Laboratories. Had he remained in Government service, where he was such a distinguished pioneer of modern 'conventional' armaments research, there is no doubt that high office and honours could have been his.

His connexion with the armaments field was not, however, completely severed by his resignation, for in 1908 he was instrumental in providing the Admiralty with a special alloy capable of resisting the erosion suffered by the propellers of high-speed turbine-driven warships. Because of this erosion, the future of such vessels and liners had appeared somewhat problematical. Also, in conjunction with the firm of Hotchkiss, he worked on erosion-resisting steel for guns. Then, in the First World War he was honorary consulting chemist to the Ministry of Munitions. An outstanding achievement of this period was the successful process for manufacturing large charges of lyddite in iron instead of earthenware vessels. This enabled an improved synthesis, requiring a higher temperature than was practicable with the original method, to be used. He also turned his attention once more to flashless propellants and developed one for use in large howitzers.

Silberrad was a brilliant experimenter, and among other achievements of his fertile brain were a new chlorinating agent; a method of manufacturing isoprene; a new means of blasting petroleum wells; and the production of dyestuffs from T.N.T. residues.

I have very pleasant memories of a visit paid to Dryads' Hall and its adjoining laboratory in 1953, when I was collecting material for an article in connexion with the golden jubilee of Silberrad's old establishment, which by then had become the Armament Research Establishment of the Ministry of Supply. I was most hospitably and kindly received by Dr. and Mrs. Silberrad and given access to many old photographs and exhibits, over the assembly of which much trouble had been taken. This first, and unfortunately the last, personal contact with Dr. Silberrad left an impression of a man of intense mental vigour, drive and alertness, in spite of his seventy-five years and the fact that at the time he had not fully recovered from an attack of thrombosis.

Mrs. Silberrad survives her husband, with the only son of the marriage. J. S. Grew

Dr. Eric Ellenbogen

Dr. Ellenbogen was born in Vienna in 1921 and emigrated to the United States in 1940. He received his B.S. degree in chemistry from Indiana University in 1943. During 1943–46 he served with the United States Army in India and Burma. After his discharge, he studied at the Brooklyn Polytechnic Institute, working on inorganic plastics. In 1946 he entered Harvard University, received his M.A. in 1947 and his Ph.D. in 1949 under the guidance of Dr. J. L. Oncley. His dissertation dealt with the determination of the physical-chemical properties of insulin. From 1947 until 1949 he was a teaching assistant in the University Laboratory of Physical Chemistry Related to Medicine and Public Health, Harvard University. He was awarded a U.S. Public Health Service Postdoctorate Research Fellowship in 1949, which he held until 1951 in the Department of Biochemistry, Columbia University College of Physicians and Surgeons, under the sponsorship of the late Dr. E. Brand, studying the properties of tri- and tetrapeptides of specific steric configurations. In 1951 he was appointed research associate in the Department of Biochemistry and Nutrition, Graduate School of Public Health, University of Pittsburgh, and was promoted to assistant professor in 1952 and associate professor in 1957.

In 1959 he took leave from his post at the University of Pittsburgh to travel to the Weizmann Institute at Rehovot, Israel, to study with Prof. E. Katchalski, doing research on physical properties of certain polypeptides as models for certain proteins of biological significance. On the way back from the Weizmann Institute to the United States, Dr. Ellenbogen died of a coronary occlusion in Marseilles on May 29, 1960. He is survived by his wife Lois and two children.

He belonged to several American and British learned societies. His contributions to biochemistry include the study of the physical-chemical behaviour of insulin in dilute solution, the physical chemistry of specific polypeptides, the isolation of a non-insulin hypoglycaemic factor from pancreas, and the physical-chemical characterization of cardiac myosin.

Robert E. Olson

Prof. Eduard Reichenow

Eduard Reichenow, the eminent German protozoologist, died on March 23 in his seventy-seventh year. He was born in Berlin and was the product of a race versed in the natural sciences: his father, Anton, was a well-known ornithologist; his grandfather, Cabanis, a zoologist of note. He himself married Lilly Mudrow, of international fame in the field of malariology and who collaborated with him in his later work on avian malaria; her death three years ago cast a cloud over his life from which he was scarcely able to emerge.

Reichenow was educated at Schiller-Realgimnasium in Charlottenburg; later he entered the Universities of Heidelberg, Berlin and Munich, where he graduated in natural science.

He was associated with the Institute of Tropical Medicine, Hamburg, for most of his academic years, first as a student, for many years as director of its Department of Protozoology, and finally as its president. He travelled extensively in the pursuit of his work, and some of these journeys produced results of great scientific value—the discovery of malaria parasites in gorillas in the Cameroons, the elucidation of the complicated life-cycle of *Karyolysus* and other hæmogregarines in Spain, and the development of piroplasms in animals in East Africa. He investigated Chagas's disease in Venezuela, Mexico and Guatemala, sleeping sickness in Africa, marine biology at Rovigno and in the Baltic. In Germany itself he studied the intestinal protozoa of man, and with his wife he described in detail exoerythrocytic schizogony in *Plasmodium relictum* and other avian species of malaria parasites.

His careful observations on the cycle of piroplasms in the tick led him to conclude that this important group of protozoa belonged more probably to the Sarcodina than to the Sporozoa, among which they had hitherto been placed, and this new view may well act as a guide to their still unknown nature.

Reichenow's work and reputation were consolidated in his successive editions of Doflein's "Protozoology". Doflein's widow asked him to undertake this task and he produced the fifth edition in 1929; the sixth was not completed until 1952. The history of the latter provides a good illustration of his strength of character—the manuscript of the new edition was practically finished during the later years of the Second World War when a bomb fell on his house and the entire work was destroyed; undeterred, he recommenced the task and completed it a few years later.

Eduard Reichenow was a simple, quiet man, cautious and conservative in his scientific outlook, with an absence of flamboyance which did not detract from his ability to disentangle complicated problems in taxonomy or biology. His sound approach made him an ideal court of appeal, and he readily responded to requests for his opinion from all quarters of the globe. In these respects he resembled the English protozoologist, the late C. M. Wenyon, whose views on many problems coincided with his own.

He received many honours towards the end of his life: he was made an honorary member of the Society of Protozoologists, given an honorary doctorate of the University of Granada, and received special recognition from Munich on the occasion of the jubilee of his graduation.

The death of Reichenow has left a gap in the ranks of protozoologists which it will take long, if ever, to fill. He is survived by his daughter.

P. C. C. Garnham

NEWS and VIEWS

Physics at University College, London: Prof. J. Hamilton

Dr. J. Hamilton has been appointed to the newly created second chair of physics in University College, London, from October 1. Dr. Hamilton studied in the Queen's University, Belfast, and later began research at the Dublin Institute for Advanced Study under Heitler. During the War he was engaged on scientific work for the Royal Navy. After a brief appointment as lecturer in theoretical physics at the University of Manchester he moved to Cambridge in 1950 as lecturer in mathematics and was elected to a fellowship at Christ's College. Dr. Hamilton's interests have always lain on the physical side of mathematical physics, and during his time at Cambridge there has been a considerable strengthening in the amount of physics available to students reading the Mathematical Tripos. He has also succeeded in forming an active group of young workers imbued with his own pragmatic spirit. Under his leadership they have been applying modern dispersion relation techniques to low-energy pion physics with most interesting results. This characteristic emphasis on physical content is also to be found in his recent book, "The Theory of Elementary Particles", which contains valuable chapters on phenomenology as well as those dealing with the development of quantum field theory. The appointment of Dr. Hamilton to University College will strengthen considerably the theoretical side of a department which is already active in experimental high-energy nuclear physics.

Mechanical Engineering at Cardiff: Prof. S. P. Hutton

Dr. S. P. Hutton, who has been appointed to the new chair of mechanical engineering at the University College of South Wales and Monmouthshire, was educated at Calday Grange Grammar School and the University of Liverpool, where he graduated in 1941. After a period in industry, he joined the Aerodynamics Department of the Royal Aircraft Establishment in 1942 and was concerned with the design, development and use of high-speed wind tunnels for research on sub-sonic and trans-sonic aircraft. During 1945–46 he was in charge of similar research facilities in Germany. During 1946–49 he was a lecturer in fluid mechanics at the Imperial College of Science and Technology, where he was awarded his Ph.D. for research on water turbines and fans. Since 1949 he has been with the National Engineering Laboratory, East Kilbride, where he supervised the design and commissioning of the hydraulic machinery laboratory, eventually becoming head of the Fluid Mechanics Division in 1954. During 1951–52 he was sent by the Department of Scientific and Industrial Research to the Federal College of Technology, Zurich, where he carried out research under Profs. J. Ackeret and H. Gerber. Since March 1959 he has been deputy director of the National Engineering Laboratory responsible for industrial liaison. His research interests are in engineering fluid mechanics and his publications have been mainly concerned with flow measurement, fans, pumps and water turbines. He is a member of the Hydraulics Group Committee of the Institution of Mechanical Engineers and has been closely associated with the work of national and international standards organizations for water turbines. He has travelled widely and in 1956 was a member of the British Hydroelectric delegation to the U.S.S.R.

Chemical Technology at Edinburgh: Prof. P. H. Calderbank

Dr. P. H. Calderbank has been appointed to the chair of chemical technology in the University of Edinburgh in succession to Prof. K. G. Denbigh, who is going to the Imperial College of Science and Technology, London (*Nature*, January 2, 1960,

p. 14). The chair will be held concurrently with the headship of the Chemical Engineering Department of the Heriot-Watt College. Dr. Calderbank, who is forty-one years of age, was educated at Palmer's School, Essex, and at King's College, London, where he graduated in 1940 with first-class honours in chemistry. He then joined the Ministry of Supply (Explosives Division), where he was concerned with the maintenance and operation of heavy chemicals plant. Afterwards, he joined the firm of Bakelite, Ltd., in Birmingham, and engaged in several research and development projects connected with the manufacture of synthetic resins and polymers. In 1946, Dr. Calderbank was appointed lecturer in the Chemical Engineering Department at University College, London. At University College, Dr. Calderbank undertook research on the kinetics of reactions in fluidized beds of catalysts and was awarded the degree of Ph.D. In 1952, he was appointed professor of chemical engineering in the University of Toronto, where he was an active member of the American Institute of Chemical Engineers. He joined the Department of Scientific and Industrial Research in 1955, and, after a four-month study tour of American universities and research establishments, returned to the National Chemical Laboratory at Teddington, where he proceeded to form and direct a research group of chemical engineers. This research group was transferred to the Warren Spring Laboratory at Stevenage in 1958, and under Dr. Calderbank's direction evolved into a team of forty workers engaged in many aspects of chemical engineering and process development research. Dr. Calderbank is a member of the Institution of Chemical Engineers and has been the recipient of the John Millar Medal for chemistry and the senior Moulton Medal for chemical engineering.

Atomic Energy Research Establishment Appointments

DR. F. A. VICK, at present deputy director of the Atomic Energy Research Establishment, Harwell, has been appointed director. Dr. R. Spence, at present chief chemist, has been appointed deputy director, and Mr. L. Grainger, now head of the Metallurgy Division, has been appointed assistant director, with special responsibilities for applied research. The new appointments will take effect on September 1. Sir Basil Schonland continues as director of the Research Group, of which the Atomic Energy Research Establishment is a part.

Overseas Civil Service

Supplementary Pay and Allowances

IN statements made simultaneously in the House of Commons and in the House of Lords on July 28, it was announced that, subject to Parliamentary approval of the expenditure involved, the Government has decided to offer to take over, where necessary in Colonial territories, the inducement pay and allowances of overseas staff broadly on the lines of the arrangements followed in most technical assistance schemes. Although financial arrangements have already been reached with Nigeria and Sierra Leone in the light of their coming independence, it is also proposed to offer them agreements on those lines and it is intended to apply the arrangements to the High Commission territories. The effect of these proposals would be that, while the local Government would continue to bear the local rates of salary and other conditions of service, the British Government would bear the cost of supplementary pay and allowances which prove to be needed for overseas officers. The statement also recognized the direct responsibility of the Government to maintain stable administration throughout the years of change preceding self-government, while pressing forward with the recruitment and training of officers from the local population. These new arrangements, which will not cease with independence, demonstrate the importance which the Government still attaches to the maintenance of an efficient Overseas Civil Service. They would apply to all its 15,000 members, and the cost is estimated by the Secretary of State for the Colonies, Mr. Iain Macleod, at £10–20 million a year over ten years.

Agricultural and Scientific Research Overseas

IN reply to a question in the House of Lords on July 28, about agricultural and scientific research overseas, Lord Hailsham stated that both the Agricultural Research Council and the Department of Scientific and Industrial Research, like the Medical Research Council, have powers to maintain research workers in overseas territories where this is in the national interest, and the Department of Scientific and Industrial Research has some research staff in stations overseas. Both the Department and the Agricultural Research Council assist overseas territories by seconding staff for definite periods within the limits of their resources, and proposals for extending these arrangements are under examination. While it is considered that existing powers should be adequate for any such extension, Lord Hailsham said that the Government would not hesitate to seek additional powers if necessary.

India's First Agricultural University

THE Government of India has approved the establishment of an Agricultural University, the first of its kind to be planned in the country, at Rudrapur, in Uttar Pradesh. The University, a product of Indo-American co-operation, will be set up on the model of land grant colleges in the United States and is expected to cost Rs. 1.90 crores. The 16,000-acre Tarai State Farm will be attached to the University for use as a laboratory for research and experiment. The University will have three constituent colleges, an Agricultural College, a College of Animal Husbandry and Veterinary Science, and a College of Agricultural Engineering and Technology, and will train 325 students each year. It will provide comprehensive education in agriculture and allied subjects on the basis of an integrated system of teaching, and will pay particular attention to developing rural leadership and competence. The decision to establish the Agricultural University is to be welcomed, particularly at the present juncture, when considerable emphasis is being laid on self-sufficiency in food in the third Five-Year Plan.

Dental Research

THE Minister for Science, Lord Hailsham, stated in the House of Lords on July 27 that current annual expenditure on dental research of the Medical Research Council exceeds £35,000, and a considerable proportion of this sum is used to support investigations into the early development of dental caries at all ages, including the influence of biochemical and bacteriological factors, and the role of fluorine, calcium and other elements in tooth formation and resistance to decay. This expenditure amounts to about 1 per cent of the Council's total expenditure on medical research. He understood that the value of hand-produced sugar confectionery, including chocolate confectionery, in 1959, was £193 million and that the total consumption, based on prices paid by consumers, was £259 million. There is also some £750,000 a year spent on dental work in the Universities through the University Grants Committee, but he agreed that even taking into account work done in private institutions, the total effort falls far short of the country's needs. Lord Hailsham pointed out that one limiting factor is the availability of suitable research workers, and that the school dental service, betterment of which could do much to improve the dental health of the nation, is already handicapped by the shortage of dentists.

Output of Power in Great Britain

In his presidential address to the British Electrical Power Convention on May 30, Viscount Chandos, discussing "Electricity—the New Horizon", emphasized the great problems with which the increase in the capacity of generators faces the electricity manufacturers. The five main manufacturers of heavy-power plant in Great Britain had a capacity of not less than 7,000 MW. a year and the probable demand for new additions to plant for the grid might be put at about 2,750 MW. a year, leaving 4,250 MW. for export. The competitive power of Britain must be largely governed by competitive wages, and if these plants had to work appreciably below 7,000 MW. a year the industry would feel the pinch. To some extent, he pointed out, the amount of power that Britain has to sell for export must depend on the development of power in what are now described as under-developed countries, and in this connexion, while noting the general shortage of capital, Lord Chandos protested against the tendency to lend to uncredit-worthy countries. Besides avoiding inflation, Britain should seek to create new credit to match the ever-increasing sources of wealth which science and technology had to offer. Besides the new horizons in the generation of electricity, there were new horizons in its application. Its use in the home, the mounting use of fractional horse-power motors, its use in lighting and in communications, whether by transport or telephone, offered possibilities which it was as yet difficult to discern precisely, quite apart from the effect of such developments on all aspects of living. Finally, referring to the fact that the European Common Market would lead to some large industrial amalgamations, which would have at hand a larger domestic market than could ever be hoped to be found in Britain or even in the European Free Trade Area, Lord Chandos emphasized the danger of wasting or misusing technical man-power, instancing the waste involved in submitting four tenders for one nuclear power station. Without undermining competition, he suggested attempts should be made to co-operate more in fundamental research over a wide field and the industry should not be open to the charge of having half a dozen different research establishments, using perhaps twice the necessary technical effort, to extend the frontiers of our knowledge in relation to one particular part of the electrical industry.

The Swedish National Committee for Physics

The tenth general physics conference of the Swedish National Committee for Physics was held at the Royal Institute of Technology in Stockholm during June 1–3, 1959. In addition to a large number of contributed papers presented at twenty sessions, special guest lectures were delivered by H. Maier-Leibnitz (Munich), who spoke about the research programme of the Munich reactor, and by C. J. Gorter (Kamerlingh Onnes Laboratory, Leyden), who discussed the problem of orienting atomic nuclei at low temperatures. Introductory papers were given by O. Klein on the systematics of elementary particles and by H. Alfvén on plasma physics and magnetohydrodynamics. Abstracts of all the contributed papers are published in the March issue of *Arkiv for Physik* (16, 481; 1960). Most of the papers deal with aspects of plasma and nuclear physics, but several are concerned with the infra-red examination of semiconductors. A number of new instruments and devices are reported. At the University of Uppsala a high-precision curved quartz crystal gamma spectrometer of the Du Mond type has been constructed and used for precision measurements of the K- and L-levels in the heavier elements. Optical instruments include shearing interferometers for the examination of spectral line broadening (Royal Institute of Technology, Stockholm) and a photo-electric device for measuring spectrograms (University of Lund). At the Nobel Institute of Physics, Stockholm, a new method for measuring half-lives of excited states in the region $< 10^{-10}$ sec., based on the high-frequency deflexion of conversion electrons, has been tested. As a first step in a programme of development of large bubble chambers to be used at the 1,200-MeV. electron-synchrotron at the University of Lund, a 2-in. cylindrical chamber with vertical windows has been constructed. This University has also produced a cylindrical dose-rate meter for X-rays which is of small dimensions (2-mm. diameter) and which utilizes a p-n junction in a gallium arsenide semiconductor. The meter has a relatively low impedance and fast response, which makes it well suited for control measurements during X-ray therapy.

Plankton at Freetown, Sierra Leone

In work on the plankton of the estuary and the immediate offshore waters of the Sierra Leone River (Colonial Office. Fishery Publications, No. 13. Pp. iv+48. London: H.M. Stationery Office, 1960. 35s. net) Mr. V. Bainbridge was faced with a two-part problem imposed by the alternation of wet and dry seasons, the resulting conditions differing very considerably. Throughout the wet season there is a tendency towards a two-layered transport system, with brackish water flowing seawards on the surface and more saline water flowing into the estuary along the bottom. These conditions are, however, scarcely detectable in the dry season. During the wet season most of the phytoplankton within the estuary consisted of benthic forms and, at the offshore station, diatoms were relatively scarce. Very small numbers of diatoms at the offshore station during the dry season were coincident with a large standing crop of phytoplankton within the estuary, comparable in abundance with those found in Long Island Sound and the Rio de Vigo. The zooplankton species appeared to be subjected to a flushing out from the estuary during the wet season, with only a limited transport of a few species back into the estuary in the bottom current. Offshore, the largest variety of zooplankton species occurred late during the dry season, and fluctuations in species composition and abundance seemed to be associated with the oceanic currents. The very heavy standing crop of phytoplankton in the dry season did not appear to be utilized to anything like the full extent possible, either by zooplankton or by the phytoplankton-feeding clupeid fish *Ethmalosa dorsalis*. This fish, locally named the 'bonga', supports an important fishery in the estuary. The thorough examination of the sequence of events in this tropical estuarine area offers a very useful model for the approach to many similar problems, particularly in other areas where a fishery for *Ethmalosa* may be of local importance.

'Telex' and Inter-Library Communications

To arouse interest in the use of 'Telex' in inter-library communication a sub-committee of the Reference, Special and Information Section of the Library Association has compiled a directory listing 131 libraries in the United Kingdom with access to 'Telex' (Pp. ii+15. London: Library Association, 1960). The list was compiled on the basis of a questionnaire sent to the 198 members of the Association of Special Libraries and Information Bureaux, the firms of which are listed in the United Kingdom Telex Directory for October 1958, and to a few other organizations which had notified their interest in response to a notice in Aslib Proceedings of October 1959. The Directory is not for sale, but copies have been sent to public and special libraries, and it is hoped that the libraries listed will come to accept that 'Telex' can play a much greater part in library and information work in future, and that many more libraries will now consider it worth while to instal 'Telex'.

U.S. Translations of Russian Biological Publications

THE American Institute of Biological Sciences announces that it is now translating and publishing seven Russian research journals in biology. These translations are produced with support from the National Science Foundation. Hence the Institute is able to offer these translations at a fraction of their publication cost, with further price reduction to members of the Institute and to academic and non-profit libraries. The journals currently being translated are: *Doklady* (*Biological Sciences Section*); *Doklady* (*Botanical Sciences Section*); *Doklady* (*Biochemistry Section*); *Plant Physiology*; *Microbiology*; *Soviet Soil Science*; and *Entomological Review*. In addition to the translations of Russian biological journals, the Institute has instituted a separate programme of translation and publication of selected Russian monographs in biology. The monographs that have been published are: "Origins of Angiospermous Plants", by A. L. Takhtajan; "Problems in the Classification of Antagonists of Actinomycetes", by G. F. Gauze; "Marine Biology", Trudi Institute of Oceanology, Vol. 20, edited by B. N. Nikitin; "Arachnoidea", by A. A. Zakhvatkin; and "Arachnida", by B. I. Pomerantzev. Further information can be obtained from the American Institute of Biological Sciences, 2000 P Street, N.W., Washington 6, D.C.

Analytical Biochemistry

THE aim of *Analytical Biochemistry* (published by Academic Press, Inc., 1, No. 1, 1960; 15 dollars) is to publish work on new and improved methods of preparation, purification and analysis of substances which are of interest to biochemists, biophysicists, and others in related fields of experimental biology. It will include contributions dealing with qualitative as well as quantitative methods of analysis, and with the design of special apparatus and instruments. The first number (June 1960; pp. 95) contains, among others, communications on flame photometry, scintillation counting, separation of serum lipoproteins, and column analysis of nucleic acids. The editor is Alvin Nason, McCollum-Pratt Institute, Johns Hopkins University, Baltimore.

The Calouste Gulbenkian Foundation, Lisbon

THE trustees of the Calouste Gulbenkian Foundation, Lisbon, have announced the grants made during the first half of 1960. They include grants of up to £1,000 per annum for three years to British undergraduate scientific expeditions, given in consultation with the Royal Geographical Society, as follows: £250 to the Cambridge expedition to British Guiana; £250 towards the Oxford expedition to the Peruvian Andes; £140 to the Oxford Women's expedition to the Azores; £100 to the University of Oxford expedition to Cyrenaica; and £50 to the Wye College Exploration Society expedition to Morocco. Grants in aid of educational institutions include £10,000 to the Oxford Institute of Education and £2,700–£3,400 over two years to the Institute of Education, University of Durham. The grants made in aid of education in Great Britain and the Commonwealth total £23,085. In Portugal, £109,257 has been granted in aid of science and medicine, including the establishment of a centre for the treatment of alcoholism and addiction at the Institute of Psychiatry; campaigns against tuberculosis in Portuguese Guinea, and malaria in the Island of Santiago, Cape Verde Islands: a total of £23,278 has been given to educational institutions. £9,000 has been given for scholarships for Iraqi technicians to study at the National Laboratory of Civil Engineering, Lisbon. Grants have also been allocated to institutions in Brazil, France, Chile and Iran.

Abominable Snowmen

THE problem of the 'Abominable Snowmen' is discussed by S. V. Obruchev (*Priroda*, 10, 60; 1959), who presents a critical review of articles and books on this subject, beginning with Waddell's report of 1898 about the hairy wild man called 'Yeti' by the Tibetans. In the Soviet Press during 1957–59 there appeared a number of articles on this subject, especially on the possible presence of the 'Snowman' in the Pamirs. In 1958 a special expedition sent to the Pamirs to study this problem reported negatively, saying that the 'Snowman' existed only in local legends. Similar legends existed also in Mongolia. At the same time, numerous recent finds of teeth of a huge anthropoid ape—*Gigantopithecus*—in China suggest that the Tibetan 'Yeti' and the legendary 'Snowman' of the Pamirs and Mongolia may all refer to the former, or present-day but rare, presence of this type of ape in the high-altitude regions of the Himalayas and the Pamirs.

U.S.S.R. Fisheries Research by Submarine

VALUABLE oceanographic and fisheries work has been accomplished by a specially constructed submarine, *Severyanka*, as described by V. P. Zaitzev (*Priroda*, 8, 71; 1959). The submarine is provided with a viewing apparatus, several projectors, mechanical arms for collecting specimens from the bottom of the sea, echo-sounding apparatus and a cinema apparatus. The first sailing in the Barents Sea took place on December 14, 1958. Nine scientists were aboard. The second expedition took place during December 29, 1958–January 21, 1959, in the northern part of the Atlantic Ocean, and which covered some 4,000 nautical miles, aimed at the study of herring movements.

National Science Foundation Awards for Graduate Research Facilities

THE U.S. National Science Foundation has awarded grants totalling 2,153,710 dollars to fifty-four colleges and universities to improve graduate research laboratories. These grants are made on condition that the institution concerned provides at least 50 per cent of the funds needed. This permits assistance to a larger number of financially hard-pressed institutions and at the same time stimulates self-help to the greatest extent possible by the institution. Grants provide for construction, conversion or modernization of laboratory facilities.

The Institute of Metals: Annual Autumn Meeting

THE fifty-second annual autumn meeting of the Institute of Metals will take place at Bath during September 5–9. The meeting will be held partly at the Pump Room and partly at Guildhall. Included in the programme are such topics as: "Engineering Properties of Nickel-Base Alloys" and "Lubricants for Cold Rolling Aluminium" (September 5); "Recovery and Recrystallization" and "Engineering Properties of Alloys" (September 6); "The Relative Merits of Extrusion and Other Methods for the Manufacture of Bar, Rod and Wire-Rod" and "Magnesium Alloys for Fuel-Element Components" (September 8). The Autumn Lecture, on "Metals and the World of Engineering Structures", will be given by Sir Alfred Pugsley on September 9. Further information can be obtained from the Secretary, Institute of Metals, 17 Belgrave Square, London, S.W.1.

Announcements

DURING the past few years, many entomologists have inquired for insect suction traps which segregate the catch by dropping disks into the collecting tube. One firm may now agree to make the 9-in. Vent-Axia type (as described in *Annals of Applied Biology*, 37, 80; 38, 582) for approximately £100 each, complete with time switch, provided fifty orders are placed. Will those interested please communicate with Dr. C. G. Johnson, Rothamsted Experimental Station, Harpenden.

A STEERING Committee, originally appointed as a working party by the Faraday Society to consider the future of its work in the field of biophysics, has decided to launch a new and independent society to be known as the British Biophysical Society. The chairman and secretary of the Steering Committee are Prof. J. A. V. Butler and Dr. J. C. Kendrew respectively. The first scientific meeting of the new Society will take place in London in December. A more detailed announcement, giving information about the new Society and about its first meeting, and inviting inquiries from prospective members, will be made shortly.

SUPPLEMENTS 9 and 10 to the Index-Catalogue of Medical and Veterinary Zoology issued by the United States Department of Agriculture, June 1959 and April 1960, respectively, covering authors from A to Z, are now available (Supplement 9. Pp. 1+322. 1.25 dollars. Supplement 10. Pp. i+357. 1.25 dollars. Washington, D.C.: Government Printing Office, 1959 and 1960).

THE fifth annual conference of the British Society for the Philosophy of Science will be held at Wills Hall, Bristol, during September 23–25. Further information can be obtained from Dr. M. B. Hesse, Whipple Museum, Free School Lane, Cambridge.

AN International Congress on Experimental Mechanics will be held during November 1–3, 1961, in New York City. Further information can be obtained from Dr. Roscoe Guernsey, jun., General Engineering Laboratory, General Electric Company, Schenectady 5, New York.

THE twenty-first National Conference for the Preservation of the Countryside will be held at Weymouth during October 13–15. Further information can be obtained from the General Secretary, The Council for the Preservation of Rural England, 4 Hobart Place, London, S.W.1.

THE Metallurgy Society of France is organizing a meeting on "The Heat Treatment of Metals and Alloys" during October 17–21. The meeting will be held at la Maison de la Chimie, 28 bis, rue Saint-Dominique, Paris 7e. Further information can be obtained from the Secretary-General of the Society, 25 Rue de Clichy, Paris 9e.

THE tenth annual Instrument Symposium and Research Equipment Exhibit are to be held at the National Institutes of Health, Washington, D.C., during October 3–6 and October 4–7, respectively. Further information can be obtained from V. B. Davis, National Institutes of Health, Public Health Service, Bethesda 14, Maryland.

THE second International Plastics Exhibition will be held in Utrecht during October 19–26. Immediately preceding the Exhibition, an international congress on "The Technology of Plastics Processing" will be held in Amsterdam during October 17–19. The congress is sponsored by the Association for the Advancement of the Knowledge of Materials, the Royal Institute of Engineers, the Royal Netherlands Chemical Federation and the International Union of Pure and Applied Chemistry. Further information can be obtained from N. V. 't Raedthuys, Tesselschadestraat 5, Amsterdam.

ERRATUM. In the communication entitled "Synergetic Action of 2(*o*-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia", by E. Fischer, J. L. J. Szabó and M. Stamburgo, in *Nature* of June 11, p. 893, the authors state that they gave the chemical name of metoxadone incorrectly; it should read 5(*o*-methoxyphenoxymethyl)-2-oxazolidone in both title and first line of text.

GRADUATE SCHOOLS IN BRITISH UNIVERSITIES

A FEW weeks ago some highly interesting findings were published* of a Committee set up at Oxford last November "to consider and report on the accommodation, facilities and amenities in the University for graduates of this and other universities". The facts unearthed and the suggestions made show the fast-growing importance of Oxford as a centre of graduate study, particularly in the sciences, and the urgency of catering for the needs of this graduate population in new ways. Clearly, there is among Oxford dons a body of informed opinion conscious of practicable measures which might be taken to help to deal with the situation. But the report of the Committee has wider implications, too.

In 1939, out of some 5,000 students at Oxford, 520—or about 10 per cent—were reading for advanced degrees or diplomas; by 1960 this number had grown to 1,758 out of nearly 9,000, or about 20 per cent. Among the contributory factors to this development are the greatly increased numbers of grants for graduate work, the spread of the practice that scientists should take a research degree as a prelude to an industrial as well as an academic career, and the growing number of graduates from other universities who want to work at Oxford. Not merely have the modern universities much more than twice the student population that they had twenty years ago, but also Oxford and Cambridge have an unrivalled attractiveness both as places of learning and as prestige institutions ("above the social strife"). For many a graduate they have, consciously or unconsciously, something of the appeal of an Athenæum Club as well as of a university, short though they are of bedrooms and somewhat deficient in comforts. But so far neither has quite caught up with itself as a centre of graduate migration. Traditionally, they have been places at which to get a good undergraduate education, in a college, between the ages of eighteen and twenty-one or so. To-day, however, 92 per cent of Oxford's graduate students are more than twenty-two years of age, and a quarter of them more than twenty-five; 56 per cent come from other universities and are strangers to Oxford. Many are married, and of these the majority have their wives with them; an appreciable number have their children as well.

What is being done to meet the problems brought about by this state of affairs? The colleges provide some living accommodation, and a certain amount of wise advice is given about lodgings by the University Delegacy. But some of the lodgings are up to fifteen miles from Oxford itself and many stipulate "no children". The costs of good or even satisfactory accommodation are considerable; and outside the city there is much competition for it from Harwell and the surrounding air bases. The Committee believes that colleges ought to extend to unmarried graduates from other universities the privilege of spending at least their first year in college; and that the University ought to be bold in building flats for married couples and in making grants or loans to colleges to help them to convert houses for the use both of single and of married students.

But the graduate may find a roof to cover him and still remain a lonely man, with remarkably little to make him feel that he really belongs not merely to a laboratory or a department but also to the University—and this at a time when it may be of great importance to him to feel that he does so belong. He may, it is true, be a member of his college junior common room and go to lunch at Halifax House (424 of the 544 members of which, incidentally, are science graduates), but Halifax House suffers from inadequate buildings and from having nothing like enough money. (The Committee notes that "it is hoped that a new building for Halifax House will be included in the major building programme for 1964–68". One would have expected a note of greater urgency than this.) That graduate common rooms should be provided in the colleges is an admirable suggestion (only one college at present has such a room); so is the idea that 'study rooms' should be made available for the use of married graduates living out. It would be a great help, too, if the Delegacy of Lodgings made itself an active centre for relaying information affecting the residence outside college of members of the University. In the wealth of their information services, their skilfully compiled maps and brochures, their welcoming spirit efficiently incorporated into administrative terms, American universities certainly have something to teach both older and newer universities in Britain.

It has to be remembered that many of the men and women going from modern universities to Oxford and Cambridge as graduates will not have been resident before, either at school or in a university. This is a new start for them, an introduction to a wider world than they may have hitherto experienced. There may have been little possibility of finding in their honours school at 'Redbrick' the diverse and yet friendly community which a good college can be: and their time at 'Oxbridge'—in a fresh environment and with widening horizons—may find them ready to be newly and intimately receptive. But the defect of the British social system generally—and one which on occasion has applied to graduates going up to Oxford and Cambridge, whether from 'Redbrick' or from overseas—is that it leaves so many feeling that they are not quite within the inner circle. This defect is one which the Committee certainly had at the back of its mind. Its suggestions are essentially suggestions about how to make Oxford a more potent educational force in the lives of the graduates studying within it.

The report, however, has a more wide-spreading significance than for Oxford or 'Oxbridge'. Discernible here is a shift in attitude to the whole problem of the welfare and education of the graduate student and a recognition that if his continued studies are to give him not merely more knowledge and a further degree but also continued—and general—education he must be considered in his own right. The development of graduate schools of character and power is not dependent on the provision of laboratories, libraries, research amenities and supervision alone. This, so far, we have tended not sufficiently to acknowledge: all British universities remain unduly orientated to undergraduate needs. Yet the proportion of graduates will rise everywhere during the coming ten, twenty, thirty years; at some universities indeed (at the Imperial College of Science and Technology, London, for example) this policy is already fast being implemented.

---

* *Oxford University Gazette*, Supp. to Issue No. 3048 (June 16, 1960).

In a period when it is the done thing to marry and have children early, especially in the professional classes, and when a parental means test for the graduate student must before long become a thing of the past, is enough thought being given even in the modern universities to the problems involved? The idea of raising the percentage of graduates accommodated in halls of residence by a variety of means, including the addition of specially planned halls for graduates, must be considered. At some universities already a few houses have been admirably adapted to yield numbers of flats for graduate students (though sometimes at the risk of isolating the graduate further from the life of the university); and there are several active graduate students' councils. But the special needs and aptitudes of the graduate for a liberal education as well as for research training have been little regarded.

No doubt, Oxford and Cambridge are likely for some years to come to be magnets to graduates from elsewhere. But other universities, too, are attracting increasing numbers of students from outside themselves (including some from Oxford and Cambridge) and it is surely good that this should be so. Experience of two universities of differing temper and situation is often likely to be more enriching than of one only.

This pioneer report from Oxford is much to be welcomed—for its encouraging facing of local facts; for its wealth of practical ideas; but also for the example it gives other universities to set in motion corresponding investigations and to think thoughts of their own on their provision for the graduate within them.

W. R. NIBLETT

THE INDIAN OCEAN EXPEDITION

THE Special Committee on Oceanic Research, meeting in Copenhagen and Helsinki in July, was set up by the International Council of Scientific Unions in 1957, on the grounds that a new international scientific organization was needed to strengthen and promote research in marine science. It was to initiate joint programmes in consultation with the scientific unions and other organizations. The Committee met for the first time in the Woods Hole Oceanographic Institution in August 1958, and among other measures proposed a joint expedition to the Indian Ocean. It tried to choose the area most likely to attract the attention of scientists, where the work would appeal to world organizations which promote science and human welfare, and where better understanding is likely to prove most immediately useful to the surrounding countries. The Indian Ocean was an obvious choice[1].

The complete change-round of some of its currents in response to changes in wind direction will give physicists a fairly unique opportunity to study factors that influence water movements. Better knowledge of accompanying biological changes will improve our quantitative understanding of factors that control oceanic productivity. More detailed information about the distribution of fish—especially those that live in mid-ocean—in relation to the boundaries between currents and water layers should advance fisheries science and be readily usable. The Indian Ocean is an ocean with exceptional and prominent features. The exchange of energy between sea and air has much to do with the powerful monsoon winds, and any improvement in long-term forecasting of their onset and intensity will be very useful. We know there are large fish populations in mid-ocean, and records of tremendous mass mortalities occurring from time to time show that they live in critical marginal conditions. In geophysics, as in other aspects, the Indian Ocean offers attractive sites for research.

The justice of trying to boost science by pledging the anticipated success of a new scheme has rightly been questioned, and there is no doubt of the sincerity and good intentions of the editor of the privately circulated "Indian Ocean Bubble", which has voiced very reasonable opposition. He does not quite say that skilled young scientists who form the real backbone of our research laboratories will be swindled by the promoters, but he criticizes the prospectus which probably has promised too much, and sounds a clear warning about the ill effects of hindering new approaches and critical experiments by too much regimented and routine work. He makes chilling reference to recent books, "The Tragic History of the Sea", by C. R. Boxer — three accounts of disastrous early Indian Ocean expeditions—and "The South Sea Bubble", by John Carswell—a general popular account of the venture that he frightens us with.

The effort devoted to marine science is, however, in no way commensurate with the magnitude, variety and difficulty of the problems it has to solve, and after a hundred years work, much of it devoted to fishery problems, we have little idea about the distribution of current with depth in any ocean. We can quote another editor who hailed the departure of one of our greatest expeditions to the Southern Seas with the words, "We may wait, it is true, and consign to centuries to come, the toils, the glories and the hopes of science, or we may rely on an easy effort distributed over length of years for the accomplishment of much that vigorous exertion might now effect". He continues, "There are secrets of Nature we would fain see revealed while we yet live in the flesh—resources hidden in her fertile bosom for the well-being of man upon Earth we would fain see opened up for the use of the generation to which we belong. But if we would be enlightened by the one or benefited by the other, we must lay on power both moral and physical without grudging and without stint". He makes a more encouraging reference to the poet who wrote:

"Nimm die Zogernde zum Rath
Nicht zum Werkzeug deiner That"

These admonitions appeared in the *Quarterly Review* 120 years ago, and they are as timely and well-intentioned as the new cautions.

Extensive investigation of the South Atlantic Ocean by the German *Meteor* Expedition in 1925–27 did much to advance marine science, and there is little doubt that concerted effort with our new techniques in the Indian Ocean will meet with similar success provided we give ourselves as much time to learn from it, and avoid too much organization as a pattern of things to come. Perhaps the new venture follows too soon on the International Geophysical Year surveys, but the organization and the problems are being approached very carefully, by the research-minded scientists as well as those who see the need for some campaigning.

The planning and operating of programmes is being done by national committees for oceanic research. Growing interest in them has already sent research ships from the United States and the U.S.S.R. to the Indian Ocean, and useful observations are also being made by H.M. survey ships and Royal Australian Navy frigates. At the peak of activity, covering the north-easterly and south-westerly monsoons of 1962–63, there may be as many as twelve ships working in fairly close co-operation. It is expected that a ship from the United Kingdom will be there, and that she will play an effective part in the programme as well as serving as a base for scientists whose work is likely to be advanced by special observations in Indian Ocean conditions.

The Special Committee on Oceanic Research chose Copenhagen and Helsinki for its meetings because many marine scientists were already at Copenhagen to take part in intergovernmental discussions arranged by Unesco, and at Helsinki to participate in the scientific meetings of the International Union of Geodesy and Geophysics. There is much careful and detailed work to do. Those taking part will be heartened by the recent announcement from the White House of active support to the U.S. contribution for which the National Academy of Sciences–National Research Council is scientifically responsible.

G. E. R. DEACON

---

[1] See *Nature*, 180, 894 (1957).

WATER RESOURCES IN THE UNITED STATES

THE pressure of growing populations with rising standards of living increasingly brings water into focus as a basic raw material in need of both study and conservation. Nowhere is this realized more fully than in the United States, where development in a wide range of activities is at present limited by water supplies. As a result of Senate Resolution No. 48 of the eighty-sixth Congress of the United States a Select Committee on National Water Resources was set up in 1959 to study the extent and character of water resources activities required to provide the future quantity and quality of water needed for all segments of the economy in the United States.

Headed by Senator Robert S. Kerr from Oklahoma, this Committee has now been at work during the past year and has within a short space of time produced an impressive array of reports on a wide variety of hydrological topics*. Although confined to the United States, many of these reports have relevance to water problems that the United Kingdom and the Commonwealth face, and it is the aim of this review to indicate the coverage of the reports so far available together with their main conclusions. The speed with which the Select Committee has produced a great body of useful basic material is notable, and this has been achieved by the Committee calling upon existing authorities and organizations to provide the appropriate hydrological information.

As a result the reports fall into a number of natural groups largely related to the reporting department, the stage being set by No. 2, where the Legislative Reference Service of the Library of Congress reviews and summarizes the work of more than 20 commissions or committees which have investigated national water policies and problems in the United States during the past fifty years. With few exceptions previous study groups have paid little attention to the questions which the Senate has placed before the present Select Committee; notably, "How much water development is needed? When is it needed? Where is it needed? What should be the pattern of water development? What amounts of water will be required in relation to various levels of population and economic activity? What are the economic limits of water development?"

One of the first authorities that the Committee turned to for basic information was the Geological Survey; this department has prepared reports Nos. 3 and 4 dealing with the national water resources, both surface and underground, and related problems. In addition to furnishing quantitative information showing the use of water, the availability of water, and the amount of storage required to maintain certain rates of river-flow, report No. 3 identifies and discusses water problems in the fields of supply, variability, distribution, natural quality, pollution and floods. The report indicates that almost every part of the United States faces current or potential water problems. An estimated water use in 1960 of 250 thousand million gallons of fresh water a day is projected to rise to 600 thousand million gallons a day by 1980. This fortunately still falls considerably short of the estimated manageable supply of 1,160 thousand million gallons a day, but it does mean that in many areas much water will have to be used over and over again and that pollution abatement becomes critical. Report No. 4 presents in tabular and map form the surface water resources of each State. Data on average, maximum, and minimum discharges in cubic feet per second, and average annual run-off in acre-feet at key-points within each State are given, together with a very interesting set of maps showing comparative river-flows. This report really summarizes in a most effective way the annual surface water supply papers of the United States.

---

* Reports available in June 1960 and printed for the use of the Select Committee on National Water Resources of the United States Senate pursuant to Senate Resolution No. 48 of the Eighty-Sixth Congress. Government Printing Office, Washington.

No. 2, Reviews of National Water Resources during the Past Fifty Years, October 1959; No. 3, National Water Resources and Problems January 1960; No. 4, Surface Water Resources of the United States, January 1960; No. 7, Future Water Requirements for Municipal Use, January 1960; No. 9, Pollution Abatement, January 1960; No. 12, Land and Water Potentials and Future Requirements for Water, December 1959; No. 13, Estimated Water Requirements for Agricultural Purposes and their Effects on Water Supplies, December 1959; No. 16, Flood Problems and Management in the Tennessee River Basin, December 1959; No. 19, Water Resources of Alaska, January 1960; No. 20, Water Resources of Hawaii, January 1960; No. 21, Evapo-Transpiration Reduction, February 1960; No. 22, Weather Modification, January 1960; No. 23, Evaporation Reduction and Seepage Control, December 1959; No. 24, Water Quality Management, February 1960; No. 25, River Forecasting and Hydrometeorological Analysis, November 1959; No. 26, Saline Water Conversion, November 1959; No. 27, Application and Effects of Nuclear Energy, December 1959, No. 28, Water Resources Research Needs, February 1960.

Reports Nos. 7, 9 and 24 emanate from the Department of Health, Education and Welfare ; these deal with the future water requirements for municipal use, pollution abatement, and water quality management respectively. At the turn of the century about 30 million people in the United States had a municipal water supply and were using some 3 thousand million gallons a day. In 1954, the number supplied had increased to more than 100 million people and these were using 16 thousand million gallons of water daily. This is an average rate of nearly 150 gallons *per capita* a day with maxima of more than 200 gallons a day per person in some towns. These figures of course include both trade and domestic use. Report No. 7 shows that with medium rates of growth of population this level of water consumption will probably rise to 29 thousand million gallons a day by 1980 and 43 thousand million gallons a day by the year 2000. With a high rate of population increase the figures would be 33 thousand millions by 1980 and 58 thousand millions by the year 2000. Assuming that certain stimulants of municipal use continue to occur and taking a maximum population increase, a ceiling of 43 thousand millions by 1980 and 88 thousand million by the year 2000 is theoretically possible. Daily consumption *per capita* might then be of the order of 225 gallons. If cities are to continue to supply their residents with adequate supplies of clean fresh-water much forethought is clearly going to be necessary.

Report No. 9 from the same department deals with pollution, and directs attention clearly to the magnitude of the problem which confronts the United States in its search for clean water. In addition to the normal problems of disposal of sewage and ordinary industrial wastes, many new types of pollution have recently appeared. Synthetic organic chemicals, radioactive substances and newly identified viruses and other disease-producing micro-organisms are the problems of principal concern.

The third report from this Department, No. 24 in the series, deals with water quality management. This discusses water quality and quantity requirements for various purposes, the limitations of streams as waste carriers, and the economics of water pollution. It points out that the growing demands for water and limitations on developable supplies inevitably imply a greater re-use of river-flows, and it further emphasizes that many areas are rapidly running out of clean water.

The next group of reports, Nos. 12, 13 and 28, have been prepared by the Department of Agriculture, and these deal respectively with land and water potentials and future requirements for water, estimated requirements of water for agricultural purposes, and the needs of water resources research. Report No. 12 confirms that the use of water for agricultural purposes is the largest consumer of water in the United States, even though in recent years withdrawals of water for industrial purposes have exceeded those for irrigation. Generally, however, more than half the water withdrawn for irrigation is consumed by evaporation and transpiration, while less than a tenth of the water withdrawn for industrial purposes is lost. Agriculture also becomes of increasing significance in the water problem because of the growing trends in the United States to irrigate the humid areas as a means of increasing yields of crops. The report shows that the diversion and storage of water for irrigation in 1954 was 195 million acre-feet, of which 115 million acre-feet were actually used for irrigation. On the basis of projections of medium-level populations the Department of Agriculture estimates that requirements of water for irrigation in 1980 will amount to 181 million acre-feet for storage and diversion with 114 million acre-feet actually used for irrigation. This somewhat surprising and welcome reduction emerges as a result of assuming the application of known improved methods of water management. Failing, however, the adoption of these improved methods of storing, transporting and using irrigation water, enormous additional amounts of water would be required.

In addition to the direct use of water for agricultural production there are a number of other programmes in the United States for the conservation and development of agricultural land which affect water resources. These include the run-off and water-flow retardation schemes, soil erosion prevention, and watershed improvement. Report No. 13 deals with the implications of these : at present programmes for land treatment have been put into effect on some 18 per cent of the crop-land, pastures and woodlands. This should increase to 32 per cent by 1980 and 52 per cent by the year 2000. These programmes will, it is thought, deplete downstream flows by 4·5 million acre-feet in 1980 and by 7·8 million acre-feet in the year 2000. These amounts are small in comparison with the requirements of irrigated agriculture and are not thought to be problematical. Report No. 28, also prepared by the Department of Agriculture, lists the research which will be needed if the best use of water is to be made in the production of essential agricultural and forest products. This report shows a welcome awareness of the importance of water as a prime raw material worthy of care and conservation.

The next group of reports, Nos. 22 and 25, emanate from the United States Weather Bureau and deal with weather modification, river forecasting and hydrometeorological analysis. In the broadest sense weather modification includes all man-made changes in natural conditions of weather and climate. It applies to a wide variety of atmospheric phenomena ranging in scale from micro- to macro-conditions. Report No. 22, however, deals primarily with cloud modification as a means for increasing rainfall. As only 5–15 per cent of the available moisture in a cloud system reaches the ground during a rainstorm, it is obvious that even a slight increase in the amount of precipitation could have a tremendous effect on water supplies. It has been held that this possibility therefore justifies the very considerable expense that has so far been incurred in artificial rain-making. To date, however, the Weather Bureau has had to admit that much uncertainty still remains in the results of cloud seeding and in the practical utility of present methods of artificially increasing rainfall. The Weather Bureau also has the responsibility of forecasting river-flows for the purpose of reducing flood damage and the prevention of loss of life from floods, and report No. 25 deals with future needs and possibilities for improvements in this service as a means of increasing the usefulness of available water supplies.

A further group of reports, Nos. 19–21, 23 and 26, emanate from the Department of the Interior. Nos. 19 and 20 are straightforward accounts of the water resources of Alaska and Hawaii respectively. These two States have been considered separately from the continuous area of the United States as so many of their water problems are different. The report on Alaska shows that four main problems will hinder water supply development in the far north: these are the winter freeze and permafrost, the presence of glacial flour, impervious consolidated rocks limiting ground-water storage, and problems of waste disposal in the winter months. It is interesting to note that irrigation is being employed in Alaska and that eventually this should grow to 50,000 acres. The potential of water-power is enormous and more than 13 million kW. could be developed at some 168 sites. In Hawaii the main problem appears to be the unequal distribution in both time and place of the precipitation, and this produces recurring water shortages despite the abundant rainfall. Immediate problems are not, however, incapable of solution.

Reports Nos. 21 and 23 may be taken together as these deal respectively with evapo-transpiration reduction, and evaporation reduction and seepage control. Evapo-transpiration is the transfer of water to the atmosphere from plants and other surfaces as a result of normal evaporation of precipitation, and also transpiration, which is the release of water vapour to the atmosphere in the process of photosynthesis. The Department of the Interior reports that opportunities for improved yields of water through management of vegetation appear favourable on some 15 per cent of the area of 17 western States; with a possibility of increasing water-yields in amounts ranging from about 1 to 6 inches in certain forest areas of heavy precipitation to as low as 0·25 in. in the pinon-juniper regions. No increase at all is possible on the semi-arid lands covered with grass and shrub which make up the greater portion of the south-west United States. The Department has also investigated the effect of losses from phreatophytes, the water-loving 'well plants' which cause a major loss of water along rivers in the western States. These cover some 16 million acres and discharge 20–25 million acre-feet of water into the atmosphere annually. By controlling the phreatophytes it should be possible to save some 6 million acre-feet of water by 1960 and up to 12 million acre-feet by the year 2000. Much water is also lost from irrigation works by seepage and evaporation, and it is estimated that improvements in irrigation water conveyance works could save up to 4·5 million acre-feet by 1980.

Report No. 26 is concerned with the increasingly important topic of saline water conversion. The search for means of tapping this obvious unlimited source of water has taxed the ingenuity of man for many centuries, and practical methods for desalinization of ocean water in small quantities have been used on ships for more than a century. Attention has more recently been turned to the construction of large-scale land-based plants. A programme of research was launched in the United States in 1952 and further enlarged in 1955. In 1958 Congress authorized the construction of large-scale experimental demonstration plants, and this programme is now under way. In spite of rising prices the cost of converting sea and brackish water to fresh is continually being lowered. Before the Second World War it stood at 4 dollars upwards per thousand gallons: the new experimental plants should be converting saline water to fresh for less than a dollar per thousand gallons, while processes now in the laboratory stage give promise of conversion-rates below 50 cents per thousand gallons. This report details all the current and proposed fundamental research, and is a real mine of information for those concerned with this problem.

Finally, there are two other reports of interest: from the Tennessee Valley Authority comes No. 16 on flood problems and management in the Tennessee River Basin, and from the Atomic Energy Commission there is No. 26 dealing with the application and effects of nuclear energy. The flood problem is the converse of the problem of water shortage and, like the United Kingdom, the United States has had in most parts a multiplicity of authorities dealing separately with problems which are really integrated. Programmes for run-off and water-flow retardation and prevention of soil erosion have been the responsibility of the Department of Agriculture, downstream flood-control works have been in charge of the Corps of Engineers: reclamation work falls to the Bureau of Reclamation. Other authorities are responsible for the development of power, public water supply, irrigation and so on. In the Tennessee River Basin, however, there is an example of an integrated river basin development which is a model of its kind. Here the Authority covers an area of about 40,000 sq. miles and has in its charge all aspects of the hydrological cycle. It was therefore invited to present to the Select Committee any suggestions as to how its experience might be applied to the major water problem in the United States. In report No. 16 it has some interesting recommendations, more particularly in the sphere of development control in flood plain areas.

The particular water needs and problems arising from the development of atomic energy are dealt with in report No. 27 prepared by the Atomic Energy Commission. It is not thought that the requirements and applications of nuclear technology will have any major effect or impact on the development of water resources up to 1980, but the need to recognize the importance of control of water-dispersed waste radioactive products is stressed.

It will be clear that the 600 pages and innumerable diagrams, maps and tables in these 18 reports present a unique and up-to-date picture of the water problems facing the United States. The willingness to look ahead, initially to 1980 and then beyond to the year 2000, at low-, medium- and high-level population densities reveals an awareness of the increasing importance of water in the future; and of the necessity for the present generation to plan for the water needs of the next. In contrast, the British Central Advisory Water Committee in its recent reports was not prepared to look in any detail beyond 1965—which is almost upon us already. A comparison between the two sets of reports also reveals a quite different attitude of mind and approach to essentially the same problems—notably in the case of irrigation in the humid areas. It is to be hoped that the United States Senate Committee reports will become known in Great Britain to all those concerned with the great variety of aspects of the hydrological cycle; notably watershed management, storage of water, supply of water, control of the quality of water, pollution, saline conversion, and irrigation. The reports throw much new light on the increasingly important problem of water conservation.

W. G. V. BALCHIN

SHORTAGES OF SCIENTIFIC PERSONNEL IN EUROPEAN COUNTRIES IN PROCESS OF DEVELOPMENT

THE shortage of scientific personnel is common to all European countries, even those which have a long tradition of scientific and technical development backed by powerful resources. Industrialized countries face ever-increasing requirements, while countries which are primarily agricultural and commercial now feel the need to build up their industrial potential in order to compete with the rest of Europe and raise their standard of living.

For such countries the shortage of scientific personnel is particularly acute and raises problems which are most urgent. Chief of these, according to Rector Capelle, director-general of the Institut National des Sciences appliquées, in a recent issue of *European Productivity* (No. 35; April 1960), are: training of teachers of science and technical subjects; broadening of secondary education to include technical subjects; training of engineers; development of scientific research; and the development of university-industry relations.

Industry's demand for scientists and technicians and the generous salaries offered are frequently a severe handicap to the recruitment of science teachers. Teachers' salaries must be raised if the necessary teachers of high calibre are to be found for the rising school population. This applies not only to secondary schools and technical colleges but also to the universities themselves, where too often a professor's salary at the end of his career is no more than that offered to his students on entering industry. A further demand for teachers comes from industry itself, where the old system of training skilled workers and technicians on the job must be supplemented by proper training courses providing the appropriate general education at each level.

In order to persuade more and more young people to become technicians or engineers, and to attract children from families obsessed with the idea of classical education, the traditional secondary education should be broadened to include technical subjects laying the foundations of a technical humanism supplementing, and in no way conflicting, with traditional humanism. In all secondary education, the laboratory and the workshop should now be used as instruments of learning in the same way as books, which still have too much of a monopoly.

In countries in process of development, engineers are trained to a high level and in physical conditions in no way inferior to those prevailing in countries with a long-established technological tradition. Technical faculties or universities training engineers are compelled to make a strict selection of candidates, but this is a good guarantee of success. Many students who cannot find a place in the higher educational establishments of their own country go to a foreign technical university. This additional supply of engineers—sometimes as much as 50 per cent—is not always appreciated.

The methodical increase of means of production implies making provision for research. It might seem enough to leave the responsibility for research to the countries best equipped for it. This would in the end be detrimental to young industries. The organization of scientific research will become a vital necessity for all countries and will call for the combination of all human and material resources; the Government, the universities and industry must all co-operate, and here the university can play a leading part without any loss of dignity or independence.

Applied scientific research is one of the links to be established between universities and industry, two worlds which are much too far apart in most countries in process of development. Industry should not be governed purely by a shopkeeper mentality.

EAST AFRICAN VIRUS RESEARCH INSTITUTE, ENTEBBE

THE report of the East African Virus Research Institute for July, 1958–June, 1959 by the acting director, J. D. Gillett, shows that the approach to virus studies is still essentially ecological—using the word in its widest sense to cover interaction between virus host and environment (Pp. ii+49. (Nairobi: Government Printer, 1960.) 5s.). Attention has again been confined to those viruses which are transmitted to man by arthropods; 60 different viruses are now known or suspected of being arthropod borne. Mosquitoes are involved or suspected in the transmission of no less than 48 of these, and man has been implicated in 47 of them. Twenty-six of these viruses have been found in Africa, 14 of them coming from East Africa itself. Eleven of the 14 East African viruses were originally isolated in the Institute, three of them during the current year.

The isolation of viruses from the living vertebrate host, including man, is often missed because of the transient nature of the viræmia. Nevertheless, in addition to several strains isolated during an outbreak of yellow fever in the Congo, five isolations have been made in East Africa from man; three of these in the period under review were from members of the Institute staff. Three of the five East African isolates appear to be new agents, or at least new strains. One of the others was an accidental laboratory infection of Wesselbron virus, and opportunity was taken of keeping full clinical and physiological records of the course of this very unpleasant disease.

More than 20,000 wild mosquitoes were caught and processed in the laboratory, but no virus isolations were made. This is the second year in which this usually fruitful source of virus has been unproductive.

The work started the previous year on a possible vaccine against Nairobi sheep disease, the virus of which apparently involves man as well as sheep, has been further developed. The first field-trial with the new experimental vaccine carried out in collaboration with the East African Trypanosomiasis Research Organization at Sukulu has fully justified earlier hopes.

Antibody surveys in local residents have been extended by increasing the number of sera tested and by widening the spectrum of viruses used. Positive reactions have been found in all but one of the ten agents used. Surveys of birds were started again, but no positive results have been obtained.

Results of the antibody surveys on a large number of hippopotamus sera have given unexpected results, and are difficult to interpret. A high proportion of the sera has given positive neutralization against all five viruses tested.

Laboratory studies on the viruses of Rift Valley fever, encephalomyocarditis, Semliki Forest fever and yellow fever have been carried out in rodents, primates, birds and insects respectively.

The outstanding event of the year was the completion of the 120-ft. steel tower in the Mpanga Forest. This has brought about a considerable expansion in the work on the biology of mosquitoes and other blood-sucking flying insects.

The successful transmission of virus by mosquitoes depends partly on an adequate extrinsic incubation period during which the virus multiplies in the insect and reaches the salivary glands. Thus, if a species of mosquito is short-lived in Nature, it is unlikely to take part in virus transmission, even though it may be an efficient transmitter in the laboratory. It is of great importance to be able to tell the age of wild-caught mosquitoes. While this can be done in certain species with considerable accuracy by dissection, it would be an advantage if such determination could be correlated with external features. Work on this problem, started in 1951, was taken up again two years ago and has been continued and extended.

THE CARNEGIE UNITED KINGDOM TRUST

THE forty-sixth annual report of the Carnegie United Kingdom Trust, covering the year 1959, the fourth of the present quinquennium, is largely an account of the working out of ideas, schemes and projects approved and announced some time ago*. During the year, however, the Trustees have noted signs of voluntary work being richly leavened out of all proportion to the contributions made by the Trust, but while, as public responsibility for education at all stages has increased, the opportunities for the Trust have correspondingly diminished, the Trustees continue to find voluntary efforts that are unsupported, or inadequately supported from public funds. The quinquennial provision of £50,000 in aid of museums and art gallery development has been absorbed proportionately over the four years to the end of 1959, and it seems likely that the uncommitted balance will suffice to meet claims upon it in the remaining period. Assistance to the Museums Association was continued, but last year's grant was reduced to £1,200, in the expectation that the Association will thereby be encouraged to become self-supporting. A gratifying feature was the number of museums, earlier grant-aided by the Trust, that put in hand substantial schemes for enhancing the display of their collections and for improving their services generally.

Much of the work of the Museums Joint Committee is concerned with improved museum lay-out, and during the year a further twenty reports were commissioned in connexion with applications for grants for methods whereby collections may be more attractively and dynamically displayed; and arising from the recommendations of these and earlier reports grants totalling £9,065 were offered to seventeen museums and art galleries. After considering in consultation with the Ministry of Works, the Ancient Monuments Board, the National Museum of Antiquities and the Society of Antiquaries, a proposition to rebuild a medieval structure at the north-east of the main block of Iona Cathedral to serve as a lapidarium to house the numerous historical sculptures in and around the Cathedral, the Trustees approved a grant of £6,000 to rebuild the medieval infirmary to be used eventually as a museum of cathedral treasures, but meanwhile to house the most important stones until a permanent lapidarium is provided.

Up to the end of 1959 the Trust had received 1,287 applications from the committees of pre-war village halls, serving small rural communities, for assistance in meeting the cost of renovating and equipping their premises, and of these, 1,031, representing a total commitment of £131,588, had by that date been successful. In consultation with the Scottish Council of Social Service the Trustees have also adopted a modified scheme which will make it easier for such small communities as those on remote islands off the coast of Scotland to embark on the improvement of their halls. Grants totalling £9,190 were promised during the year towards the building of five new village halls in Eire, and under the scheme for providing film projectors and screens for the use of crofting communities, equipment was installed or is about to be installed in thirteen places in the Highlands. A review of progress in the seven schemes for extending into rural areas the advice services available in urban districts through the Citizens' Advice Bureaux, indicates that the experiments have been worth while and the services will be continued when the Trust's grant terminates. The committee set up to study and discuss the development problems of new communities also made satisfactory progress, and the report emphasizes the primary need for leadership in such communities. The National Federation of Community Associations was promised a grant of £5,500 to finance a two-year project for training full-time community centre wardens. The first group of trainees completed their course in March 1959, and a second group started a similar course in the autumn of 1959. Annual grants were also made to the various national councils of social service, and a grant of £6,500 in annual instalments towards the establishment of the North Ireland Association for Mental Health, a like amount being provided by the Government of Northern Ireland. A grant of £2,500 over the first two years was offered towards the cost of an experimental publicity campaign for three years by the Liverpool United Voluntary Organization for the maintenance of voluntary social service.

In education, the Trust supported 173 bursaries, totalling £454, with the Field Studies Council and the Scottish Field Studies Association. Most of the grants in 1959 for field work in archæology were towards the fees and expenses of visiting experts acting as directors of excavations and other field work. Up to 1958 astronomy was the only purely physical science which had qualified for inclusion in the Trust's scheme for the development of amateur scientific activities out of doors. During 1959 the Advisory Committee recommended the inclusion of meteorology, and the Trust has made a grant of £1,000 over 1959 and 1960 towards a scheme prepared by the Royal Meteorological Society. The work during the first season of the Conservation Corps showed a substantial untapped reservoir of potential public service, and the Trust is meeting the cost of a scheme for providing in the Queen Elizabeth Forest Park a hill-top view-point with indicator and shelter at the highest point on Duke's road in the Trossachs and a hill-top pavilion near Aberfoyle. A grant of £12,750 was made to the Homecrafts Advisory Association for the Disabled, established by the Central Council for the Care of Cripples, to finance the development of the Association over five years.

---

* Carnegie United Kingdom Trust. 46th Annual Report, 1959. Pp. 50. (Dunfermline: Carnegie United Kingdom Trust, 1960.)

THE ONTARIO RESEARCH FOUNDATION

THE annual report of the Ontario Research Foundation for 1959 includes a list of papers published during the year and a list of the professional and technical staff (Pp. 40. Toronto: Ontario Research Foundation, 1960). Appended are lists of grants for postgraduate studies in science, 1959–60.

In biochemistry, work continued on long-term projects such as the effect of dietary fats on blood cholesterol-levels, the development of a self-contained domestic sewage unit, the evaluation of spruce bark as a source of tanning materials and drilling mud additives, and the reclamation of purified cellulose from waste paper. In chemistry most of the long-term research and industrial fellowships in wood chemistry were concerned with lignin, including work on the chemistry of vanillin and related compounds, development of a new method for the removal of sugars, based on the solubility in organic solvents of a tertiary amine salt of the lignosulphonates. A reasonably clear understanding of the tanning potentialities of lignin has been obtained and no further work as a major project is contemplated. The activities and staff of the Physical Chemistry Division increased considerably, and basic research was continued on stereo-specific catalysts for the polmerization of 1-butene.

In engineering and metallurgy ore dressing work materially increased, and basic research included trials on five iron ores of an improved flash roaster, evaluation of means for improving electrostatic separating machines and a study of the fundamental properties of magnetites and hæmatites. A major project in process metallurgy was a continuation of the jet smelting programme, and basic research in physical metallurgy was largely concerned with a fundamental study of the fatigue of metals. A possible method for measuring residual microstresses was indicated as well as for studying the ductile–brittle transition zone in certain alloys. An extensive examination of steel and cast-iron mains and services formed part of a more general investigation of safety in natural gas distribution systems for the Ontario Government.

In parasitology, research comprised a survey of parasites of trout in certain lakes in Algonquin Park and an investigation of the mode of transmission of two tapeworms in trout; investigation of selected roundworms; investigation of life histories of blood parasites of birds and the possibilities of their transfer; and blood-sucking insects in relation to their feeding habits and the importance of insects in transmitting blood parasites.

In the Physics Department, basic research centred around the production and application of electron beams. Development of the atmospheric electron probe with X-ray spectrometer continued. An optical bench for investigating electron beams of wide cross-section was designed and its construction almost completed, and construction of a fluorescent probe for the University of Toronto Institute of Aerophysics was completed. In physiography an intimate knowledge of the soils and climate of Ontario continues to be built up, and in studies of crops a heat index was derived from growth-chamber results in Indiana and applied to thirty years records at the Central Experimental Farm at Ottawa. In textiles, continued research on wool sought new and improved methods of increasing resistance to alkali and reducing agents and of lowering felting properties. In the modification of cellulose fibres to improve crease resistance and fabric stability good progress has been made with the use of epoxy resins and of vapour phase reactions with epichlorohydrin.

SOCIAL DEVELOPMENT THROUGH FAMILY AND HOME

THE report of the conference on "Social Development through the Family and Home," which was held at St. Hugh's College, Oxford, during September 7–25, 1959, under the auspices of the Secretary of State for the Colonies, has now been published (Pp. ii+94. (London: H.M. Stationery Office, 1960.) 4*s*. net).

The conference, the third in a series dealing with social development in Britain's overseas territories, was attended by representatives of 28 territories and by participants from four international organizations, from the Colonial Office and from the Secretary of State's Advisory Committee on Social Development.

The report directs special attention to the role of the family as a basic unit of society, and to the need for Governments to adopt a social development policy to support it in conditions of rapid social and economic change. It recommends the establishment, in overseas territories, of 'ministries of social development,' supported by departments or services with trained workers, and the setting up of social development councils to advise Governments. Among its recommendations on the training of social service workers, the report points out the need, in rapidly changing societies, for trained workers. Their training should for preference take place in the territories in which they will work, although it recognizes the advantage of some additional training overseas for occupants of the highest posts.

More specifically, the report recommends the introduction into schools of education for family life, so that both boys and girls may learn to play a happy and considerate part as young people and later as adults in the circle of their families and friends. Informal education among adults "is one of the most important ways of establishing a right relation between formal schooling and social development".

Turning to food, nutrition and health, the report advocates the study of dietary habits, consumer education, and community development campaigns to improve health and hygiene. Recognizing the importance of housing, it calls for advance consideration of the needs and customs of those who will live in houses which are being planned. Against the background of economic development, facilities for employment of women, the establishment of day nurseries, industrial welfare, social security and recreational facilities are considered to assume increasing importance. The report describes as important the availability of advice to families and as urgent the need for study of the legal status of the family, with particular reference to the new patterns of family life emerging as a result of industrialization and the growth of towns.

LABORATORY-TEACHING OF LANGUAGES

WITH the aid of mechanical and electronic devices, students may now use entire class periods for practice in reading, speaking and comprehension during language laboratory sessions (Industrial Bulletin of Arthur D. Little, Inc., No. 373; March 1960).

The language laboratory system emphasizes the 'hearing and speaking' approach which is endorsed by the Modern Languages Association of the United States and the American Council of Learned Societies. The students are exposed to their new material on an essentially private basis. In general, comprehension, performance and speed of learning are greatly improved under the new system.

The Federal Government has recognized the need of language laboratories by providing support for the new facilities, as well as sponsoring scientific research on the mechanics of language teaching. Many colleges, high schools and even private industrial firms have installed language laboratories, where students attend at least once a week. Eventually such laboratories may become so widespread that college entrance requirements in language will include oral as well as written tests.

In class, students sit in semi-sound-proof isolation booths provided with earphones; a master tape-recording is played, and the teacher may project slides or other visual aids simultaneously. Master tapes may be pre-recorded and catalogued and filed like library books; special text-books and exercises accompany each tape. Well-placed pauses in the tape allow the student to repeat phrases; the whole class is monitored by the teacher, who may tune in to make corrections of inflexion and pronunciation. Special instruction may be given to individuals needing it most, thus solving in part the familiar class-room problem of dividing teaching time equally among students.

Language laboratories are not intended to replace teachers, but to supplement them. Although, under the new system, students can progress faster than under the old, and will have more opportunity to develop their conversational abilities, the teacher will still be needed to explain linguistic structure, to correct errors, and to prepare good master tapes.

IONOSPHERIC MODIFICATION OF THE RADIO EMISSION FROM JUPITER

By PROF. ALEX G. SMITH, T. D. CARR, H. BOLLHAGEN, N. CHATTERTON and F. SIX

Department of Physics, University of Florida, and Maipu Radioastronomical Observatory, University of Chile

THE sporadic long-wave-length radio-frequency energy emitted by the planet Jupiter is received in the form of brief pulses, the majority of which range from about 0·2 to 1·5 sec. in duration. Occasionally the radiation is very intermittent, with pulses occurring singly, or at most in twos or threes. However, it is more common for the energy to be received in complex bursts of pulses, with each burst lasting from a few seconds to a minute or more.

An experiment reported in 1958 by Gardner and Shain[1] has thrown considerable doubt on the real origin of these details, suggesting that many of the features may originate in the terrestrial ionosphere. In this experiment, antennæ spaced 25 km. apart were used for simultaneous reception of outbursts from Jupiter, and the received signals were compared by means of high-speed pen recordings. Although only one completely satisfactory pair of records was obtained, it seemed to demonstrate clearly that there were important differences in the signals received at the two sites.

We have recently repeated this experiment, using a much longer base-line. One antenna was located at the University of Florida Radio Observatory, lat. 29° 39′ N., long. 82° 21′ W., while the other antenna was at the Maipu Radioastronomical Observa-

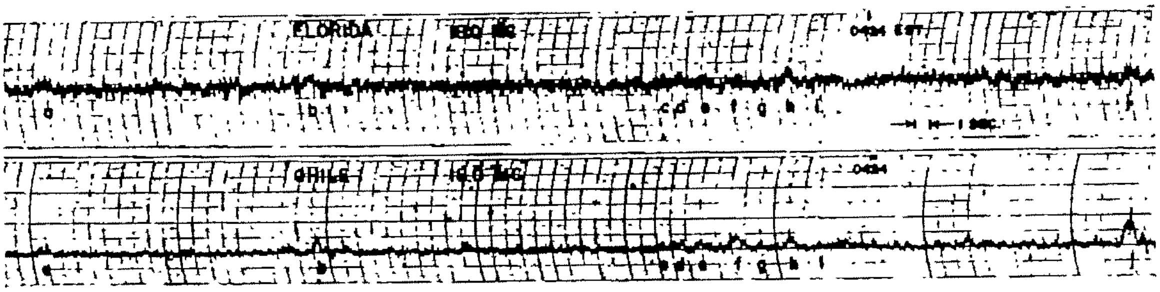


Fig. 1. Period of good correlation from the records of March 29, 1960. Approximate time 4h. 24m. a.m. Eastern Standard Time

tory of the University of Chile, lat. 33° 30′ S., long. 70° 52′ W. The separation of these sites is 7,040 km. Identical receivers were employed at the two Observatories, both receivers being crystal-controlled at 18.000 mc./sec. to eliminate the possibility that differences in the records might be caused by spectral features of the radiation. The recorders were Brush high-speed mechanical oscillographs, having response times of the order of 0·02 sec.; they were operated at a paper speed of 5 mm./sec., which experience has shown is adequate to resolve the details of the pulses.

Simultaneous records of good quality, showing extensive Jupiter activity, were obtained on three nights in early 1960. On March 23 the records overlapped for 31 min., on March 24 for 51 min., and on March 29 for 77 min. Table 1 gives the circumstances of the observations. Time indications were put on all records, either by direct recording of the *WWV* time broadcasts, or by means of a chronometer calibrated against *WWV*; it is believed that the timing was reliable to ± 1/2 sec. Examination of these records immediately confirms the existence of striking differences in the signals at the two sites. While limited sections of the records show fair correlation of the individual pulses, other sections differ so radically that by actual test it proved to be impossible to correlate the records unambiguously without reference to the time marks. In Fig. 1 is shown a period of moderate activity which is rather typical of a number of intervals during which the pulse-to-pulse correlation was reasonably good. To facilitate comparison, the more obvious correlations have been indicated by means of letters. Fig. 2 shows a short section of the records in which the correlation is much poorer. Particularly interesting is the single pulse *a*, which seems to be replaced in the lower record by a series of five or six peaks.

Careful study shows that many of the grosser differences in the records can be explained as the result of alternate fading or scintillation at the two stations; and by comparing the records during times of sustained activity of Jupiter it is even possible to estimate the period of scintillation for each site. In Fig. 3 is shown a typical example of alternate fading at the two locales. Table 2 shows the mean scintillation period for each station for each of the three nights. It will be seen that on these occasions, at least, there were no significant differences in the periods at the two Observatories.

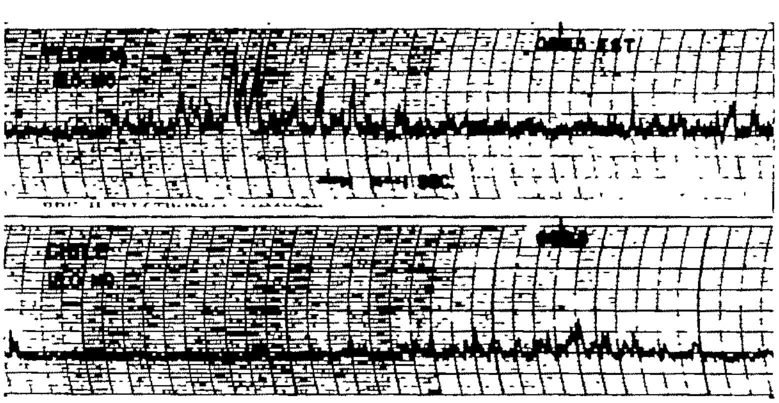


Fig. 3. Out-of-phase scintillations from the records of March 23, 1960. Approximate time 6h. 19m. a.m. Eastern Standard Time

A number of workers have studied the scintillation of radio stars, which is generally attributed to drifting irregularities in the ionosphere[2]. The periods reported range from about 8 sec. to 2 min. and are apparently independent of the wave-length at which the observations are made. These workers have also shown that the scintillation amplitudes increase at the lower radio-frequencies, and for sources of small angular extent. Thus, there is every reason to suppose that the observed Jupiter scintillations are of this type. The more rapid scintillations occurring on March 29 may well be associated with the fact that the geomagnetic activity index *K* was larger on that date than on the two preceding dates, since the radio star observations also indicate that the scintillation frequency increases with *K*.

Although portions of the records can be explained as a simple amplitude modulation of the pulse heights, due to ordinary scintillation, other sections seem to

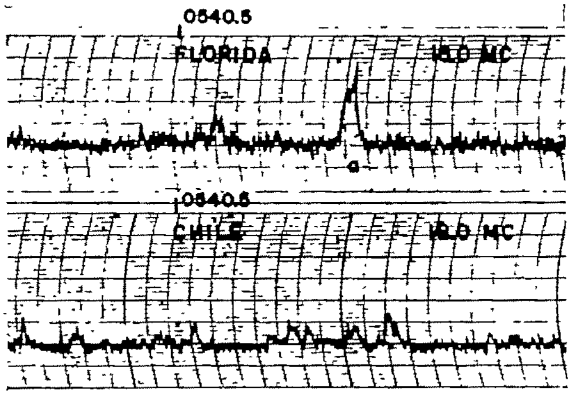


Fig. 2. Period of poor correlation from the records of March 24, 1960. Approximate time 5h. 40m. a.m. Eastern Standard Time

Table 1. CIRCUMSTANCES OF THE OBSERVATIONS

Date	Period of observation (E.S.T.)	Range of altitudes of the planet	
		Florida Station	Chilean Station
Mar. 23	6h. 06m.–6h. 37m. (a.m.)	36°–37°	78°–74°
Mar. 24	3h. 58m.–5h. 48m. (a.m.)	25°–36°	64°–80°
Mar. 29	3h. 40m.–4h. 59m. (a.m.)	25°–33°	64°–77°

Table 2. SCINTILLATION PERIODS FOR THE TWO SITES

Date	Mean scintillation period	
	Florida Station	Chilean Station
Mar. 23	45 sec.	41 sec.
Mar. 24	39 sec.	43 sec.
Mar. 29	28 sec.	29 sec.

show more complex effects. Even where the scintillations are temporarily in phase at the two stations, the individual pulse shapes are frequently distorted beyond recognition, suggesting the presence of a very rapid scintillation component, with a period comparable to the durations of the pulses themselves, superimposed on the slower modulation described above. This effect seems to be present in Fig. 2, and also in the curious distortion of pulse *b* in Fig. 1.

Measurements of the polarization of the sporadic Jupiter radiation received in the northern hemisphere have been reported by Franklin and Burke[3] and by two of us[4]. Southern hemisphere measurements were made by Gardner and Shain[1]. As the latter remark, it is encouraging that all the measurements have indicated right-hand circular or elliptical polarization, since if the effect were terrestrial in origin the sense of the polarization should be reversed in the two (magnetic) hemispheres. Because the previous experiments were not simultaneous, however, some question has remained as to possible influences of the terrestrial ionosphere.

On March 24, March 29, and April 12 of the current year, we obtained simultaneous polarimeter records at a frequency of 22·2 mc./sec. at the Gainesville and Maipu Observatories, the magnetic latitudes of which are + 41° and − 22°, respectively. Because of an undetected partial malfunction of the Gainesville instrument, a quantitative analysis of the records for the axial ratios of the polarization ellipses is probably unreliable. Qualitatively, however, all the records appear to show right-hand circular or elliptical polarization.

In summary, it appears likely that the basic pulse, of the order of duration of 1 sec., originates from Jupiter, since there are periods of good correlation when nearly identical pulses are received at stations 7,040 km. apart. On the other hand, there is evidence that these pulses frequently are seriously distorted by a rapid scintillation component of terrestrial origin, so that individual pulse shapes must be interpreted with caution in these circumstances. Much of the 'burstiness' of the Jupiter radiation—that is, the tendency of the signals to appear as short trains of pulses—seems to be due to a slower terrestrial scintillation component, which in the present experiments had a period of some 30–40 sec. This latter scintillation is probably identical with that commonly observed for the radio stars. The terrestrial ionosphere does not seem to exert any gross influence on the polarization of the Jupiter radiation, since similar polarizations are observed simultaneously in magnetically opposite hemispheres.

This programme has been supported by the National Science Foundation, the U.S. Army Office of Ordnance Research, and the Office of Naval Research. We are greatly indebted to Dr. Federico Rutllant, director of the National Astronomical Observatory of the University of Chile, without whose assistance the establishment of the Maipu station would have been impossible.

[1] Gardner, F. F., and Shain, C. A., *Austral. J. Phys.*, 11, 55 (1958).

[2] See, for example, Booker, H. G., *Proc. Inst. Rad. Eng.*, 46, 298 (1958).

[3] Franklin, K. L., and Burke, B. F., *J. Geophys. Res.*, 63, 807 (1958).

[4] Smith, A. G., and Carr, T. D., *Astrophys. J.*, 130, 641 (1959)

SYNERGISM OF BIVALENT METAL IONS IN TRANSPHOSPHORYLATION

By Dr. JOHN M. LOWENSTEIN

Graduate Department of Biochemistry, Brandeis University, Waltham 54, Massachusetts

ENZYME catalysed transphosphorylations to and from nucleoside polyphosphates constitute many of the key reactions of intermediary metabolism. Most or all reactions of this kind show an absolute requirement for bivalent metal ions, which is commonly met by the ions of magnesium, calcium and manganese. The metal ion specificity of such a reaction may be absolute or relative. In either case, inactive metals may act as competitive inhibitors. Moreover, in the case of relative specificity, the presence of two different, active metal ions may lead to an additive effect, or to an effect which reflects the average of each metal ion taken separately. Finally, the possibility exists that the presence of two different metal ions may lead to a superadditive effect. That the interplay of different bivalent metal ions may be of physiological importance is borne out by a consideration of the concentrations of some metal ions in rat liver. These are magnesium, 9; calcium, 3; and manganese, 0·03 µatoms per gram of fresh tissue[1–3].

Non-enzymic transphosphorylations from adenosine triphosphate to a variety of acceptors also show a requirement for bivalent metal ions[4,5]. The non-enzymic reaction dependent on bivalent metal ions:

$$\text{adenosine triphosphate} + \text{orthophosphate} \xrightarrow{\text{metal}^{2+}} \text{adenosine diphosphate} + \text{pyrophosphate}$$

serves as a model for enzyme catalysed reactions involving nucleoside triphosphates, and provides a chemical basis for the bivalent metal ion requirement of enzyme catalysed transphosphorylations. This reaction proceeds readily in the presence of ions such

Table 1. SYNERGISM OF BIVALENT METALS IN TRANSPHOSPHORYLATION

The reaction mixtures contained 5 μmoles [^{32}P]-orthophosphate (2·0 × 10^4 counts/min.); 50 μmoles of sodium adenosine triphosphate, pH 9; 50 μmoles of diethanolamine–hydrochloric acid buffer, pH 9·0; and bivalent metal chlorides as indicated. The final volume was 1·0 ml., temp. 38°, and time of incubation 2 hr. Analyses were performed as described previously (ref. 4)

	Bivalent metal (μmoles/ml.) Ca^{++}		Mn^{++}		Mg^{++}	Pyrophosphate formed (mμmoles)	Pyrophosphate formed per μmole of first metal (mμmoles)
a			20			0	0·0
					25	0	0·0
			20	+	25	71	3·6
			45			103	2·3
					45	4	0·1
b	15					40	2·7
					25	0	0·0
	15	+			25	428	28·5
	40					*	> 30
					40	1	0·0
c	15					40	2·7
			25			7	0·3
	15	+	25			550	36·7
	40					*	> 30
			40			99	2·5

* Insoluble calcium salts precipitated. Pyrophosphate found in mixture was 1,200 mμmoles.

as calcium, cadmium and manganese, and much more slowly in the presence of ions such as magnesium, beryllium and nickel[4]. Here, too, there exists the possibility that one type of bivalent metal ion may act as a competitive reactant or inhibitor with respect to another type of bivalent metal ion. These possibilities have been studied experimentally using the non-enzymic reaction quoted above. The use together of certain pairs of bivalent metal ions, of which one possesses little or no activity when tested alone and the other possesses high activity when tested alone, leads neither to competitive inhibition nor to an effect which reflects the average of each metal ion taken separately. Instead there can be observed a striking superadditive effect. Results obtained with various combinations of calcium, manganese and magnesium ions are shown in Table 1. In experiment *a* the effects of manganese and magnesium ions were tested separately and together. The first two lines of experiment *a* show that 20 m*M* manganese and 25 m*M* magnesium are insufficient to satisfy the bivalent metal ion requirement of the reaction in the presence of 50 m*M* adenosine triphosphate, and no pyrophosphate is formed. (The symbol m*M* (millimolar), is used to express the concentrations of ions as well as molecules. The terms 'milli-equivalents' and 'milli-ions' are avoided since they may lead to confusion when used for bivalent metal ions in the present context.) However, when these concentrations of manganese and magnesium ions are added together (line 3) they lead to the formation of 71 mμmoles of pyrophosphate. Lines 4 and 5 are controls which show that 103 mμmoles of pyrophosphate are formed in the presence of 45 m*M* manganese, and 4 mμmoles of pyrophosphate are formed in the presence of 45 m*M* magnesium. A concentration of 45 m*M* was chosen for the controls because this was the sum of the concentrations of manganese and magnesium when these were used in combination. It is clear from these results that some, but not all, of the active manganese ions can be replaced by the much less active magnesium ions without loss of activity per μmole of the remaining manganese ions (cf. last column of Table 1). The two metals can therefore be said to work in synergism. The results obtained with calcium and magnesium ions (experiment *b*), and with calcium and manganese ions (experiment *c*) are similar. The synergism is most pronounced when the ion which possesses relatively low activity is present in a concentration which is equal to one-half or more of the concentration of adenosine triphosphate.

Under conditions of pH and adenosine triphosphate/bivalent metal ratio which are suitable for studying the catalytic activity of calcium, manganese and magnesium ions, others, such as barium and strontium ions, give precipitates. The observations reported in Table 1 show that very small concentrations of highly active ions, such as calcium, can be demonstrated to possess catalytic activity in the transphosphorylation reaction if relatively large amounts of, say, magnesium ions are also present. It is therefore possible to test very low concentrations of barium and strontium ions for activity by taking advantage of the sparing action of magnesium ions. The results of such an experiment (Table 2) show clearly that barium and strontium ions can also be classified as highly active in the catalysis of the transfer reaction. This finding could not have been anticipated from previous results[4], which tended to indicate that metal ions active in the non-enzymic reaction have an ionic radius between 0·8 and 1·0 Å.

A bivalent metal ion which possesses little or no catalytic activity on its own can also be classified according to its ability to participate in a synergistic partnership with a highly active metal ion such as calcium. An experiment designed to demonstrate this is shown in Table 3. The ions are listed in descending order of effectiveness as determined by the difference between the activities observed in the presence and absence of calcium ions. The results indicate that some metal ions are very efficient in synergistic partnership with calcium ions, even though they have virtually no activity on their own. Other metal ions are much less effective, whether tested in the presence or absence of calcium ions. An examination of the results obtained with the first four of the metal ions listed in Table 3 also shows that the effectiveness of a metal ion in the synergistic reaction is not directly related to its effectiveness when it is used alone. Thus the increase in the rate of transphosphorylation when calcium ions are added to manganese ions is of the same order as that which is observed when calcium ions are added to magnesium ions. Yet when tested alone, the effectiveness of manganese is much greater than that of magnesium ions. The same considerations apply to a comparison of cadmium and cobalt ions.

The results of Tables 2 and 3 may be summarized as follows: the alkaline earth ions calcium, strontium

Table 2. ACTIVITY OF SOME BIVALENT METAL IONS IN THE PRESENCE OF 40 m*M* MAGNESIUM IONS

The complete reaction mixture contained 5 μmoles diethanolamine [^{32}P]-orthophosphate, pH 9·0 (2·76 × 10^6 counts/min.); 50 μmoles of diethanolamine adenosine triphosphate, pH 9·0; 40 μmoles of magnesium chloride; and 5 μmoles of a second bivalent metal salt as indicated. The total volume was 1·0 ml., temp. 38°, and time of incubation 2 hr.

Bivalent metal salt added	Pyrophosphate formed (mμmoles) with MgCl$_2$	without MgCl$_2$
None	0	—
MgCl$_2$	0	0
Be(NO$_3$)$_2$	0	0
SnCl$_2$	0	2
MnCl$_2$	5	0
CdCl$_2$	6	0
CaCl$_2$	42	0
SrCl$_2$	55	0
BaCl$_2$	44	5

Table 3. ACTIVITY OF SOME BIVALENT METAL IONS IN THE PRESENCE OF 7·5 mM CALCIUM IONS

The complete reaction mixture contained 5 μmoles of diethanolamine [^{32}P]-orthophosphate, pH 9·0 (7·08 × 10^{5} counts/min.); 50 μmoles of diethanolamine adenosine triphosphate, pH 9·0; 7·5 μmoles of calcium chloride; and 40 μmoles of a second bivalent metal salt as indicated. The total volume was 1·0 ml., temp. 38°, and time of incubation 3 hr.

Bivalent metal salt added	Pyrophosphate formed (mμmoles)		
	with $CaCl_2$	without $CaCl_2$	Δ
$MnCl_2$	184	51	133
$MgCl_2$	110	1	109
$CdCl_2$	120	54	66
$CoCl_2$	52	0	52
$ZnSO_4$	23	5	18
$CuSO_4$	11	0	11
$FeSO_4$	14	8	6
None	5	—	5
$HgCl_2$	4	4	0
$NiCl_2$	0	1	0

and barium are highly active in catalysing the transphosphorylation reaction. The ions manganese and cadmium are of moderate activity alone, but are of high synergistic activity. The ions magnesium and cobalt are of very low activity alone, but are of high synergistic activity. Lastly, the ions zinc, copper, iron, mercury and nickel possess very low activity alone, and are of low synergistic activity. Beryllium, which possesses very low activity alone (Table 2 and ref. 4) is probably also of low synergistic activity.

The results presented here demonstrate that the catalytic effect of certain pairs of metal ions is neither the average of the effects observed with each metal independently, nor is it additive. Instead, the effect is superadditive. An attempt will now be made to account for this synergism in terms of the existence of various bivalent metal chelates of adenosine triphosphate.

The postulate that in the active chelate, adenosine triphosphate : bivalent metal ion are as 1 : 1. It is postulated that the chelates adenosine triphosphate–Mg^{2-} and adenosine triphosphate–Ca^{2-} (stability constants K_1) are active in the transphosphorylation reaction, the former possessing a low and the latter a high activity. It is further postulated that the chelates adenosine triphosphate–magnesium–adenosine triphosphate^{6-} and adenosine triphosphate–calcium–adenosine triphosphate^{6-} (stability constants K_2) are inactive in the reaction. These postulates are identical with those which were made to account for variations in the rate of the reaction which are observed on varying the adenosine triphosphate/bivalent metal ratio[4]. If the reaction mixture contains adenosine triphosphate and calcium ions such that the ratio of adenosine triphosphate/$Ca^{2+} > 2$, and if K_2 for Ca^{2+} is sufficiently great, then the main species in the solution will be the inactive chelate adenosine triphosphate – Ca – adenosine triphosphate^{6-}, and the minor species will be the active chelate adenosine triphosphate–Ca^{2+}. If, on the other hand, the solution contains adenosine triphosphate and magnesium ions such that the ratio of adenosine triphosphate/$Mg^{2+} \sim 1$, then provided K_2 for Mg^{2+} is not much bigger than K_1, the solution will contain the low-activity chelate adenosine triphosphate–Mg^{2-} and possibly some of the inactive chelate adenosine triphosphate–Mg–adenosine triphosphate^{6-}. Now if magnesium ions are added to a solution containing adenosine triphosphate/$Ca^{2+} \gg 2$, a shift will occur from the inactive adenosine triphosphate–Ca–adenosine triphosphate^{6-} to the highly active adenosine triphosphate–Ca^{2-} and the low activity adenosine triphosphate–Mg^{2-} (Fig. 1, line i).

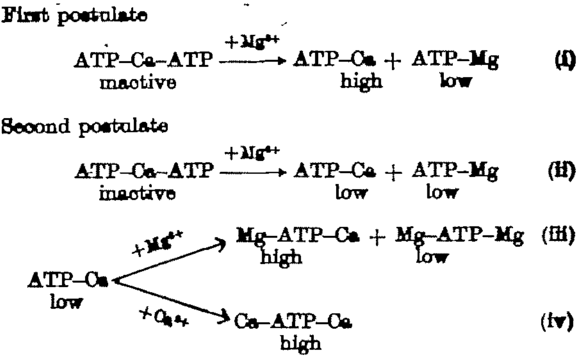


Fig. 1. Various chelates which may be involved in the synergistic effect of two bivalent metal ions on the non-enzymic phosphate transfer from adenosine triphosphate. The word below each chelate refers to the relative rate of phosphate transfer. (Postulate 1 = line i; postulate 2 = lines ii, iii and iv)

The postulate that in the active chelate, adenosine triphosphate : bivalent metal ion are as 1 : 2. It is postulated that the chelates Ca–adenosine triphosphate–Ca and Mg–adenosine triphosphate–Ca are highly active in the transphosphorylation reaction, while the chelates Mg–adenosine triphosphate–Mg, adenosine triphosphate–Mg^{2-} and adenosine triphosphate–Ca^{2-} possess low activity, and those consisting of two molecules of adenosine triphosphate and one bivalent metal ion possess no activity. Suppose that to a solution containing adenosine triphosphate/$Ca^{2+} \gg 2$ there are added magnesium ions, then there will be a shift from the inactive adenosine triphosphate–Ca–adenosine triphosphate^{6-} to the low activity adenosine triphosphate–Ca^{2-} and adenosine triphosphate–Mg^{2-} (Fig. 1, line ii). The addition of further magnesium ions leads to the formation of the high-activity chelate Mg–adenosine triphosphate–Ca and the low-activity chelate Mg–adenosine triphosphate–Mg (Fig. 1, line iii). Addition of calcium ions instead of magnesium ions leads to adenosine triphosphate–Ca^{2-} and thence to the highly active chelate Ca–adenosine triphosphate–Ca (Fig. 1, line iv). The two postulates are not mutually exclusive, and it is possible that both adenosine triphosphate–Ca^{2-} and Ca–adenosine triphosphate–Ca are highly active in the reaction under discussion. Mg–adenosine triphosphate–Ca would then also be highly active.

The results reported here suggest the following hypothesis to account for the differences in the activity of myofibrillar actomyosin adenosine triphosphatase[6,7] in the presence of calcium, magnesium and potassium ions: myosin contains bound bivalent metals[8] (J. Gergely and B. Vallee have found that myosin contains about 1 atom magnesium and 3 atoms calcium per molecular weight of 5 × 10^{5} (personal communication)). It follows that myofibrillar actomyosin adenosine triphosphatase also contains bound bivalent metals. In the absence of added bivalent metal but in the presence of potassium ions there is a slow hydrolysis of adenosine triphosphate which involves the formation of an enzyme–calcium–adenosine triphosphate–potassium complex. At low potassium ion concentrations the rate of hydrolysis of adenosine triphosphate is increased by the addition of magnesium or calcium owing to the formation of enzyme–calcium–adenosine triphosphate–magnesium or enzyme–calcium–adenosine triphosphate–calcium. In the presence of added magnesium the system shows great sensitivity to ethylenediaminetetraacetic acid, because ethylenediaminetetraacetic acid combines preferentially with the bound calcium which is essential for enzyme activity. The formation of enzyme–calcium–adenosine triphosphate–magnesium is prevented by the formation of enzyme–calcium-ethylenediaminetetraacetic acid, and possibly by the subsequent dissociation from the enzyme of some calcium–ethylenediaminetetraacetic acid. In the presence of added calcium the sensitivity of the system to ethylenediaminetetraacetic acid is much lower, and depends in the first instance on the removal of calcium from the solution (and not from the enzyme) by the formation of calcium–ethylenediaminetetraacetic acid. The behaviour of myosin adenosine triphosphatase, although different from myofibrillar adenosine triphosphatase[6], may be accounted for in similar fashion. Myosin adenosine triphosphatase is activated to a much lesser degree by magnesium than is actomyosin adenosine triphosphatase. This reflects a difference in the reactivities of the enzyme–calcium–adenosine triphosphate–magnesium complexes postulated for both hydrolase activities. The postulate is in harmony with the concept that the true substrate of actomyosin adenosine triphosphatase is adenosine triphosphate–calcium or adenosine triphosphate–magnesium, and that free adenosine triphosphate inhibits by being bound to the enzyme without being split rapidly. It does not account for the activation of myosin adenosine triphosphatase which is observed in the presence of ethylenediaminetetraacetic acid under certain conditions[8].

The composite effects of different bivalent metal ions deserve further consideration from the points of view of chelate chemistry and enzyme mechanisms. The importance of such effects in the metabolism of living cells remains to be assessed.

This work was aided by the National Science Foundation and by the Helen Hay Whitney Foundation.

[1] Aldridge, W. N., *Biochem. J.*, 67, 433 (1957).
[2] Watchorn, E., and McCance, R. A., *Biochem. J.*, 31, 1379 (1937).
[3] Skinner, J. T., Peterson, W. H., and Steenbock, H., *J. Biol. Chem.*, 90, 65 (1931).
[4] Lowenstein, J. M., *Biochem. J.*, 70, 222 (1958).
[5] Lowenstein, J. M., *Biochim. Biophys. Acta*, 28, 206 (1958).
[6] Perry, S. V., and Grey, T. C., *Biochem. J.*, 64, 184 (1956).
[7] Weber, A., *J. Biol Chem.*, 234, 2764 (1959).
[8] Friess, E. T., Morales, M. F., and Bowen, W. J., *Arch. Biochem. Biophys.*, 53, 311 (1954).

FLUORINE COMPOUNDS IN NATURE; THE DISTRIBUTION OF CARBON-FLUORINE COMPOUNDS IN SOME SPECIES OF *DICHAPETALUM*

By SIR RUDOLPH PETERS, F.R.S., and R. J. HALL

Agricultural Research Council Institute of Animal Physiology, Babraham, and Department of Biochemistry, University of Cambridge

THE presence of an organic compound of fluorine in Nature has been known since Marais[1] isolated fluoroacetic acid from the leaves of *Dichapetalum cymosum*, the South African plant called gifblaar, which is poisonous to cattle; fluoroacetic acid was first synthesized by Swarts[2]. Another plant of the same genus, namely, *Dichapetalum toxicarium*, also called ratsbane, has been known for a long time. It grows in Sierra Leone (West Africa) and is responsible for the condition of 'brokeback'[3], a paralytic state in man. The signs described in animals after eating the seeds of this plant resemble so much those produced by fluoroacetic acid that we examined its seeds for a fluorine compound. Fluoroacetate was present only in traces; but we have now isolated two new fluorine compounds from the seeds of *D. toxicarium*. (1) A fluoro-fatty acid constituting most of the toxic material, which has been finally identified as ω-fluoro-oleic acid[4]. (2) The other, present in much less amount, is a saturated long-chain fatty acid possibly having 17 carbon atoms.

Several problems of botanical and other interest arise from these observations.

The question is whether the difference in fluoro compounds in the seeds of *D. toxicarium* as compared with the leaves of *D. cymosum* is a property of the species or whether it is merely due to the storage of the C_2 acid by conversion in the seeds to long-chain fluoro-fatty acids. This has led us to examine the leaves and seeds of *D. cymosum* for fluoro-oleic acid and other fluorine compounds.

D. cymosum seeds. We are indebted to Dr. R. A. Dyer, chief of the Division of Botany, Department of Agriculture, Pretoria, for sending us some of these seeds, which are stated to be rare, as the plant is difficult to find in fruit.

No trace of fluorine was found in the powdered dried seed after ashing. This proved the absence of any fluoro compound within the sensitivity of the tests. There was not enough material for animal tests to confirm whether these seeds were toxic. It has been stated in the literature that the seeds are toxic so the matter requires further investigation; but it seems evident that any fluoroacetate made is not being metabolized and stored in these seeds as a long-chain acid, as happens in *D. toxicarium*.

D. cymosum leaves. These were examined to see if there was present any long-chain fluoro-fatty acid, and if so, whether it was identical with the material from *D. toxicarium*.

The leaves were finely ground in a Cassell mill, and 100 gm. extracted with light petroleum (boiling range 40–60°). The residue after removing the solvent was saponified with methanolic potassium hydroxide, the saturated long-chain fatty acids were separated from acetone solution at $-20°$ C. and discarded. The acetone solution now contained 0·624 gm. of an oil, mainly of unsaturated acids, and analysis showed that it contained 1·415 mgm. fluorine. When injected into three rats at doses, which in terms of fluorine content would have been toxic as a long-chain fatty acid, no effect was found.

The crude acids were treated according to the recent method given[4] for purifying fluoro-oleic acid. About 20 mgm. of a purified oil was obtained which, when chromatographed by a modification of the

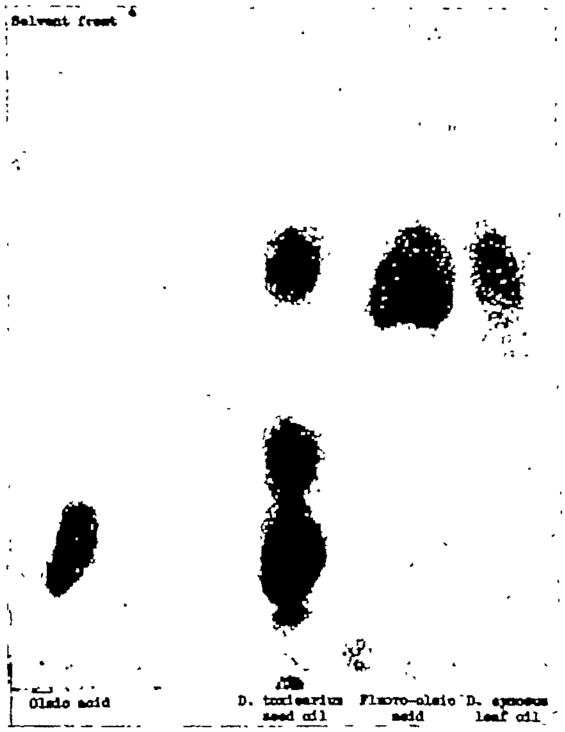


Fig. 1. Ascending chromatogram of unsaturated fatty acids of *Dichapetalum* species, etc., on Whatman No. 531 filter paper impregnated with liquid paraffin, developed with 85 per cent v/v acetic acid/water and demonstrated with iodine vapour

method of Schlenk *et al.*[5], gave the chromatogram shown in Fig. 1. There was present, therefore, a long-chain acid with approximately the same R_F value as fluoro-oleic acid. A long-chain fluoro-fatty acid with an even number of C atoms has a powerful inhibitory effect on citrate metabolism when tested on kidney particle preparations from the guinea pig *in vitro*; 5–10 μgm. of the acid shown to travel as fluoro-oleic acid on the chromatogram was found to inhibit the metabolism of citrate in such preparations. The unknown acid therefore had some of the properties of fluoro-oleic acid, but it differed in that it was not toxic *in vivo* at double the usual fatal dose to rats. The problem requires further exploration; our tentative interpretation is that the leaves of *D. cymosum* can contain in small amounts a long-chain fluoro-fatty acid of 17 or 18 C atoms, which is different from those at present known, though an alternative explanation could be that the crude acids contain a component interfering with toxicity *in vivo*. One batch of *D. cymosum* leaves which we received contained none of this compound. In accordance with previous work by others[6], we have found that the total fluorine content of specimens of leaves varied greatly; from 63 to 270 μgm. fluorine per gm. of dried leaves.

D. toxicarium leaves. When these were ground and extracted in the manner as were the leaves of *D. cymosum*, no fluorine was detected on ashing and no trace of a long-chain fluoro-fatty acid.

From the preceding observations it can be concluded that the presence of fluoro-oleic acids in the seeds of *D. toxicarium* is a property of the seeds of this species and not of the seeds of the genus in general. Furthermore, the leaves of this species cannot contain much fluoroacetic acid (Table 1) as no fluorine was found on ashing. There is a distinct indication that there are still more fluorine compounds to be discovered in *D. cymosum* leaves, though it seems unlikely that the toxicity is due to such compounds, which would be present only in traces compared with fluoroacetic acid.

The question also arose whether leaves from a plant of *D. cymosum* grown in England would also contain large amounts of fluorine. Some seeds were kindly brought back from Johannesburg five years ago by Sir Edward Salisbury, who arranged for these to be grown by Mr. Stenning, at the Royal Botanic Gardens, Kew. Two leaves were taken from a plant about 12 in. in height, and were analysed for fluoride after combustion, using a micro-diffusion technique[7]. Relatively large amounts of fluorine were present, 112 μgm./gm. This is in the range of our other figures for total fluorine, and that of the 150 μgm./gm. recorded by Marais[1]. These amounts are to be compared with those of grasses generally, 9–26 μgm./gm. and alfalfa 15–36 μgm./gm.[8]. These authors noted that the fluorine increased as the plants grew and the season advanced; lawn grass was found to contain 16 μgm./gm. dried grass in May and 53 μgm. fluorine/gm. in November. Specimens of tea may give higher values; for example, we found 150 μgm./gm. in a sample of Indian tea.

Other Dichapetalum species. During the course of our work, we have been able to examine leaves and stems and roots from several other African species. The scientific interest was reinforced by the possibility that the ingestion of some might account for unexplained deaths of cattle in East Africa. The plants examined have been the following:

Belgian Congo: (1) *D. flabellatiflorum*, Hauman., origin, Germain 0594; (2) *D. thonneri*, de Wild, origin, Louis 6712; (3) *D. thonneri*, de Wild, origin, Louis 13016. East Africa: (4) *D. ruhlandii*, East Africa; (5) *D. mossambicense*, Engl.; (6) *D. stuhlmanii*, Engl.

Tests were made of toxicity to rats mainly by dosing orally. The material was finely ground and administered with rat cake, a method which demonstrates well the toxicity of *D. toxicarium* seeds. None of the plants tested with doses up to about 2·0 gm. proved toxic to the extent of killing the animal. In two cases with *D. stuhlmanii* a temporary depression of the heart-rate was observed. On killing the animals some hours later the citrate contents of the hearts were 326 and 141 μgm./gm. wet tissue and in the kidneys 553 μgm./gm. and 73 μgm./gm. wet tissue respectively, which is to be compared with a normal value of 40 μgm./gm. ± 10.

Table 1. FLUORINE COMPOUNDS IN LEAVES AND SEEDS OF *D. cymosum* AND *D. toxicarium*

	Fluorine μgm./gm. dry wt.				
	Total	F_i†	$F_{alk.}$‡	F. acetate	F. oleic*
Leaves					
D. cymosum					
Sample (1)	270	36	217	++	0
Sample (2)	70	14	9	+	+
D. toxicarium	0	12	8	0	0
Seeds					
D. cymosum	0			0	0
D. toxicarium	2,035			trace	++

0 = not measurable.

* Or long-chain fluoro-fatty acid

† Extracted at *p*H 1·0.

‡ After hydrolysis with conc. sodium hydroxide, represent fluoroacetate and any other alkali labile CF compounds.

As a further control the residues from light petroleum extracts, equivalent to 20 gm. of the leaves of (4) and (5), were injected in acetone into rats; they were non-toxic and without effect upon the citrate content of heart, liver or kidney. This proved the virtual absence of toxic long-chain fluoro-fatty acids.

Since some of these plants have been described as toxic in the literature and presuming their toxicity is due to fluorine compounds, we conclude that the toxicity varies as it does in *D. cymosum* and possibly that the specimens collected for us were harvested at the less-toxic period.

Some of our results are summarized in Table 1.

In addition to those mentioned, we are indebted to Prof. Z. M. Bacq, Dr. M. F. Jurion, director-general, Institut national pour l'Etude agronomique du Congo Belge, and others for help in collecting the plants from the Belgian Congo, to Dr. Galley and staff of the Tropical Products Institute, London, for helping in collecting the West African specimens; to Dr. Greenway for East African plants, and to South African colleagues for specimens of *D. cymosum* leaves. We are also grateful to Miss R. Shawdon and to D. Harbidge for skilful technical assistance with part of the work, and to Prof. F. G. Young for facilities provided.

[1] Marais, J. S. C., *Onderstepoort J. Vet. Sci. Animal Ind.*, **20**, 67 (1944).

[2] Swarts, F., *Bull. Acad. Roy. Med. Belg.*, **11**, 675 (1896).

[3] Renner, W., *Brit. Med. J.*, i, 1314 (1904).

[4] Peters, R. A., Hall, R. J., Ward, P. F. V., and Sheppard, N., *Biochem. J.* (in the press).

[5] Schlenk, H., Gellerman, J. L., Tillotson, J. A., and Mangold, H. K., *J. Amer. Oil Chem. Soc.*, **34**, 377 (1957).

[6] Badenhuizen, N. P., and Slinger, J., *S. African J. Sci.*, **50**, 269 (1954).

[7] Hall, R. J., *Analyst* (in the press).

[8] Churchill, H. V., Rowley, R. J., and Martin, L. N., *Anal. Chem.*, **20**, 69 (1948).

SUSTAINED ACTION OF INJECTED CHELATING AGENTS

By Dr. A. LINDENBAUM and Dr. J. SCHUBERT

Division of Biological and Medical Research, Argonne National Laboratory, Lemont, Illinois

It is noteworthy that, following a single injection of an appropriate chelating agent in subjects whose tissues contain foreign radioactive or non-radioactive metals such as plutonium, thorium, or lead, the subsequent urinary excretion of the metal usually remains well above the control levels for days and even weeks. Since most of the chelating agent administered is rapidly eliminated from the body, this is an unexpected phenomenon which merits investigation. For example, within 6 hr. after injection into rats, about 94–98 per cent of ethylenediaminetetraacetic acid and diethylenetriaminepentaacetic acid is excreted, and at the end of 24 hr. most of the retained dose is in the gastrointestinal tract, with smaller amounts generally diffused throughout the tissue[1]. A very small fraction of the injected dose of the pentaacetic acid persists in the blood for several days[1].

Evidence has been adduced[2] to indicate that these chelating agents combine with the metal to form diffusible chelates within the tissues (though not necessarily intracellular). It is reasonable to assume that the sustained excretion of plutonium after treatment with diethylenetriaminepentaacetic acid[3] reflects the slow but steady diffusion of the metal chelate from the tissues into the blood-stream and thence into the urine. We have made a direct test of this assumption in experimental animals by measurement of the ultrafilterability of the tissue deposits of different radioisotopes following treatment with chelating agents. Ultrafiltration techniques have been useful in determining the state of radioelements in solution[4]. They offer a simple, rapid and effective means for screening potential chelating agents for the treatment of radioelement poisoning, as shown here and elsewhere[5].

Low-pressure ultrafiltration techniques were used[4]. In earlier work described in Fig. 2, suitable pressure was applied by a water pump using 150 mm. mercury pressure. In all other experiments ultrafiltrates were obtained by centrifugation at about 900*g* in a modification of the method of McFarland and Hein[6]. It was possible with the latter technique to obtain 0·1–0·5 ml. of filtrate after centrifugation of a 2–5 gm. sample for 15–45 min. In order to minimize the uncertainties resulting from uneven deposition of colloidal particles due to hydrolysis of plutonium and thorium, we have studied the ultrafilterability of the radioisotopes from blood and tissues taken from intravenously injected animals rather than by *in vitro* addition of the radioisotope to tissue samples. In some cases the chelating agents were added *in vitro* to the tissues of animals previously injected with the radioisotope but not treated with the chelating agents. In other cases, ultrafilterability of the radioisotopes was measured from tissues of treated animals.

In preparation for ultrafiltration, rat bone (the entire weighed calvarium) was fragmented with scissors and crushed in a glass homogenizer with the aid of 5 ml. added saline. The entire weighed liver was either similarly homogenized or was simply cut into small pieces before being placed without saline in Visking bags. The radioactivity of the ultrafiltrate was determined in duplicate or triplicate. The values obtained after treatment with, or addition of, chelating agent were corrected for dilution differences and compared with those from ultrafiltrates of appropriate control tissues.

The effects of diethylenetriaminepentaacetic acid on excretion of plutonium are of interest. The calcium salt (335 mgm./kgm. body-weight as the acid form) or saline was given intraperitoneally to rats three days after a single intravenous injection of a solution containing 35 μgm. plutonium-239 in 1 per cent sodium citrate at *p*H 5–6. The rats and their saline controls were killed at intervals of 1, 2, 3 and 7 days after injection. The ultrafilterability of plutonium from the bone, liver, and plasma was measured directly (see Fig. 1). It is evident that plutonium deposited in the tissues has been rendered diffusible by the pentaacetic acid and that the diffusibility remains ten or more times greater than that of the control animals for at least 7 days after a single injection of plutonium.

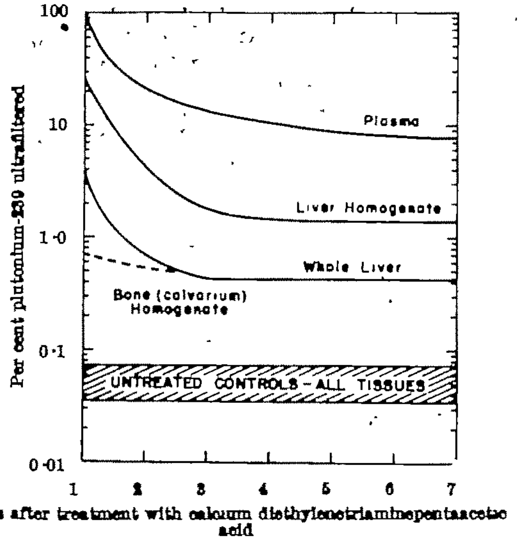


Fig. 1. Ultrafilterability of plutonium-239 from tissues of rats injected intraperitoneally with calcium diethylenetriaminepentaacetic acid (235 mgm./kgm. body-weight as the acid form) three days following intravenous injection of 35 μgm. plutonium-239

The effectiveness of diethylenetriaminepentaacetic acid relative to ethylenediaminetetraacetic acid in promoting the ultrafilterability of plutonium was tested using plasma and heparinized whole blood. The plutonium was injected intravenously into rats, and 2 ml. of blood was withdrawn 15 min. later. Solutions of the chelating agents were added to the whole blood or to the plasma to provide final concentrations ranging from 10^{-8} to 10^{-4} M. The superiority of diethylenetriaminepentaacetic acid over ethylenediaminetetraacetic acid is shown by the sharper rise in the plutonium content of the ultrafiltrates at concentrations of chelating agent in the range 10^{-6} M–10^{-4} M (Fig. 2).

It has been previously pointed out[7] that as a result of the mass-action equilibrium, the presence of calcium ions in blood prevents any appreciable chelation of strontium ions. Consequently, ethylenediaminetetraacetic acid and related chelating agents, in the usual therapeutic doses, are useless for treatment of radiostrontium poisoning. In ultrafiltration experiments, the lack of interaction of strontium with ethylenediaminetetraacetic acid was shown directly by adding strontium-85 and known amounts of the calcium salt of the latter to rat plasma. At concentrations of ethylenediaminetetraacetic acid as high as 10^{-3} M the ultrafilterability of the strontium-85 was unchanged from that of the controls (75 per cent compared with 74 per cent), as could be predicted from the mass-action equations[7]. At a concentration of 2×10^{-2} M ethylenediaminetetraacetic acid—a blood concentration unattainable in living animals—there was an increase in the amount of ultrafilterable strontium.

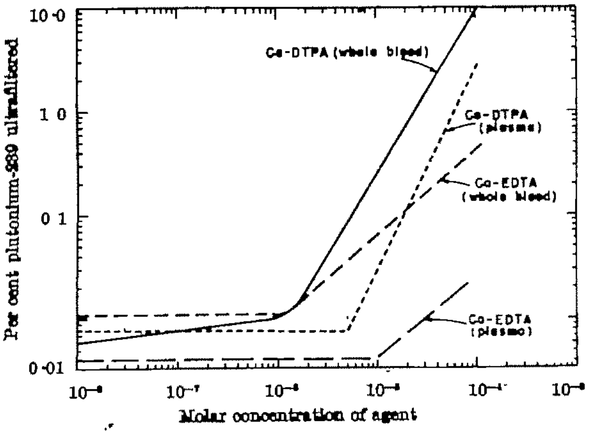


Fig. 2. Effect of concentration of chelating agent on ultrafilterability of plutonium-239 in blood. Plutonium was injected intravenously; chelating agent was added *in vitro*

Experiments similar to those described above for plutonium were made with thorium using thorium-234 as tracer. The ultrafilterability of thorium from plasma and tissues obtained from rats injected intravenously with thorium-234 was measured in the presence of 10^{-4} M chelating agent added *in vitro*. The marked superiority of diethylenetriaminepentaacetic acid relative to ethylenediaminetetraacetic acid and other chelating agents is shown in Table 1. A similar superiority of the former over the latter in accelerating the excretion of thorium from animals has also been demonstrated[8]. Such results confirm what could be anticipated by comparison of the constants[9] for formation of the 1 : 1 chelates (log K(Th-EDTA) = 23·2; log K(Th-DTPA) = > 27),

Table 1. EFFECT OF CHELATING AGENTS ADDED *in vitro* ON THE ULTRAFILTERABILITY OF THORIUM-234 FROM RAT TISSUES

Chelating agent (calcium salt)	Thorium-234 content ultrafiltered (per cent)		
	Plasma	Liver	Bone
Saline controls	0·26	1·2	0
Ethylenediaminetetraacetic acid	2·3	—	—
1 : 2-*Bis*-[2-di (carboxymethyl) aminoethoxy] ethane	3·9	—	—
2 : 2′-*Bis* [di (carboxymethyl) amino] diethyl ether	4·2	—	—
Diethylenetriaminepentaacetic acid	26	85	~10

The plasma and tissues were obtained from rats killed 15 min. after injection of a carrier-free solution of thorium-234 in 1 per cent sodium citrate at pH 5. The chelating agent was added to give a final concentration of 10^{-4} M.

It should be mentioned that, unlike the situation with radioactive metal poisons, where maximum elimination is a necessary goal, an effective therapeutic agent need not increase the ultrafilterability of a non-radioactive metal poison, and may in fact decrease it. A case in point is acute beryllium poisoning, in which successful treatment has been shown to involve inactivation of beryllium without necessarily increasing its excretion or diffusibility[10].

This work was carried out under the auspices of the U.S. Atomic Energy Commission.

[1] Foreman, H., chapter entitled "The Pharmacology of Some Useful Chelating Agents", in Hahnemann Medical College Symposium on Metal-Binding in Medicine (to be published by J. B. Lippincott Co.).

[2] Tobinger, J., Zumanová, R., and Zezula, L., *Amer. Med. Assoc. Arch. Indust. Health*, 17, 295 (1958).

[3] Fried, J. F., Graul, E. H., Schubert, J., and Westfall, W. M., *Atompraxis*, 5, 1 (1959).

[4] Schubert, J., and Conn, E. E., *Nucleonics*, 4, 2 (1949).

[5] Rosoff, B., Lewin, R., Hart, H. E., Williams, G. L., and Laszlo, D., *Arch. Biochem. Biophys.*, 78, 1 (1958). Heller, H. J., and Catsch, A., *Strahlentherapie*, 109, 464 (1959). Fried, J. F., Schubert, J., and Lindenbaum, A., *Amer. Med. Assoc. Arch. Indust. Health*, 20, 473 (1959).

[6] McFarland, R. H., and Hein, R. E., U.S. Atomic Energy Comm. Report *TID*-5098, 27 (1953). Also see Rosoff, B., *et al.*, *Arch. Biochem. Biophys.*, 78, 1 (1958).

[7] Schubert, J., *Atompraxis*, 4, 393 (1958).

[8] Fried, J. F., and Schubert, J., *Nature*, [186, 551 (1960).]

[9] Bogucki, R. F., and Martell, A. E., *J. Amer. Chem. Soc.*, 80, 4170 (1958).

[10] Lindenbaum, A., White, M. R., and Schubert, J., *Arch. Biochem. Biophys.*, 52, 110 (1954).

SAP-TRANSMISSIBLE VIRUSES ASSOCIATED WITH DISEASES OF GRAPE VINES IN EUROPE AND NORTH AMERICA

By C. H. CADMAN
Scottish Horticultural Research Institute, Invergowrie, by Dundee

H. F. DIAS* and B. D. HARRISON
Rothamsted Experimental Station, Harpenden, Hertfordshire

DEGENERATION of the grape vine has been recognized as a major factor in viticulture since the nineteenth century and has been attributed to many causes, ranging from unfavourable soil conditions to bacteria, fungi and viruses[1]. In Europe, three main groups of diseases have been transmitted by grafting and therefore ascribed to viruses[2]: (*a*) court-noué, Reisigkrankheit, urticado; (*b*) panachure, Panaschüre, clorose infecciosa; (*c*) enroulement, Rollkrankheit. Recently, Ochs[3] has claimed to have transmitted potato viruses *X* and *Y* and cucumber mosaic virus to herbaceous plants by inoculation of sap from grape plants affected by diseases of types (*a*) and (*b*). However, later work failed to confirm Ochs's results[4].

Virus diseases which appear similar to those in Europe also occur in Californian vineyards, and two of these diseases, fanleaf and yellow mosaic (similar to groups (*a*) and (*b*), respectively), are contracted from soil[5,6]. The virus that causes fanleaf disease is transmitted by a soil-inhabiting dagger nematode, *Xiphinema index* Thorne and Allen[7].

Grape vines are little grown in Britain; but three groups of soil-borne viruses have been reported in other crops[8], and members of each group also occur in Continental Europe[9–11]. All these viruses are readily transmitted by inoculation of sap to a wide range of herbaceous species, and one of them, *Arabis* mosaic virus, has a dagger nematode (*Xiphinema diversicaudatum* Micoletzky) as a vector[12,13]. We now report the transmission of viruses from grape vines to herbaceous hosts and describe some properties of the viruses. Our results show that viruses isolated either from North American or from European grape vines have similar properties to *Arabis* mosaic (= raspberry yellow dwarf) virus, and that they have some of their antigens in common with it.

Isolation of Viruses from European and North American Grape Vines

Sap from vine leaves seems to contain little or no tannin but has a pH value of about 3·5. Young grape leaves were therefore macerated in 0·07 *M* phosphate buffer at pH 8·0 or in 2·5 per cent nicotine solution, in an attempt to raise the pH value of the sap, and hence to lessen both virus inactivation and damage to inoculated leaves of test plants. 'Celite' abrasive powder was added to all inocula. Using this method, viruses were transmitted from diseased vines obtained from four different countries to *Chenopodium amaranticolor* Coste and Reyn., tobacco (*Nicotiana tabacum* L. var. White Burley), *N. clevelandii* Gray, cucumber (*Cucumis sativus* L.) and French bean (*Phaseolus vulgaris* L. var. Prince). No transmissions were obtained from normal plants of several of the same vine varieties (Table 1). The symptoms in *C. amaranticolor*, which resemble those caused by *Arabis* mosaic virus[14], are chlorotic lesions in the inoculated leaves and systemic symptoms, which start in the young leaves as chlorotic vein-banding or mottling; later, the whole plant is stunted and the leaves deformed. Different isolates from vine vary greatly in virulence, and systemic symptoms in *C. amaranticolor* take 7–20 days to appear, whereas those caused by *Arabis* mosaic virus usually take only 5–10 days.

In the other species symptoms also develop more slowly than with *Arabis* mosaic virus. All the vine isolates caused chlorotic or necrotic local lesions in inoculated leaves of tobacco and systemic mottling or necrotic ringspot symptoms in *N. clevelandii*. The Portuguese urticado *A*, Swiss court-noué and North American fanleaf *A* isolates produced systemic yellow blotching in cucumber, and chlorotic local lesions in inoculated leaves of French bean together with systemic mottling. Portuguese urticado *B*, Portuguese clorose infecciosa, French court-noué and North

Table 1. EXAMPLES OF VIRUS TRANSMISSIONS FROM GRAPE VINES TO HERBACEOUS SPECIES

Country of origin	Variety*	Disease status	Grape vines supplied by	Transmission of virus to herbaceous species
Portugal	Fernão Pires	urticado *A*	H. F. Dias	+
Portugal	Fernão Pires	urticado *B*	H. F. Dias	+
Portugal	Fernão Pires	clorose infecciosa	H. F. Dias	+
Portugal	Fernão Pires	normal	H. F. Dias	0
France	Chardonnay	court-noué	A. Vuittenez	+
France	Vialla	panachure	A. Vuittenez	+
Switzerland	Chasselas	court-noué	R. Bovey	+
Switzerland	Chasselas	normal	R. Bovey	0
Switzerland	*Vitis* hybrid *S.* 5755	panachure	R. Bovey	+
United States	*V. rupestris* St. George	fanleaf *A*	W. B. Hewitt	+
United States	*V. rupestris* St. George	fanleaf *B*†	W. B. Hewitt	+
United States	*V. rupestris* St. George	normal	W. B. Hewitt	0

* *Vitis vinifera* unless otherwise stated.
† Vine plants to which virus was transmitted by *Xiphinema index* (ref. 7).

---

* Calouste Gulbenkian Foundation Research Fellow from the Estação Agronomica Nacional, Portugal.

American fanleaf *B* isolates were less virulent than these three. Least virulent were French panachure and Swiss panachure isolates: these caused chlorotic local lesions in inoculated cucumber cotyledons but did not become systemic. They did not infect French bean, and they caused much milder symptoms in tobacco, *N. clevelandii*, and *C. amaranticolor* than those caused by the first group of isolates.

Many of the isolates (for example, Portuguese) came from grape plants that were infected by grafting, with ungrafted grape plants of the same clone serving as control material. The plants generously supplied from California by Dr. W. B. Hewitt, however, included six plants of *Vitis rupestris* var. St. George, each of which had become infected with vine fanleaf virus when exposed to infective *Xiphinema index*, and six normal St. George plants of the same clone. Virus was transmitted to *C. amaranticolor* and *N. clevelandii* from five fanleaf-infected plants (the sixth died) but from none of the normal ones, indicating that the isolates are consistently associated with fanleaf disease and are transmissible by *X. index*.

Properties of the Viruses

Table 2 shows that the five isolates selected for more detailed study have broadly similar stabilities *in vitro*. The differences seem to result from the greater concentration in sap attained by the more virulent isolates.

Portuguese urticado *A* and Portuguese clorose infecciosa are examples of isolates that have similar effects on herbaceous plants and have similar properties *in vitro*, but yet come from grape plants that show very different types of symptoms: such isolates should not, therefore, be assumed to be strains of the same virus. However, they are sufficiently closely related for the presence of one to affect the other[15]. Thus, *C. amaranticolor* inoculated simultaneously with both isolates showed symptoms intermediate between those shown by plants infected with only one or other of the isolates. Similar interactions were observed between the Portuguese urticado *A* and a North American nematode-transmitted (fanleaf *B*) isolate.

Electron microscopy of partially purified preparations (made from *C. amaranticolor* by a butanol/chloroform method[16]) of the Portuguese urticado *A*, Portuguese clorose infecciosa and North American nematode-transmitted (fanleaf *B*) isolates showed that all three contain many spherical particles of diameter approximately 30 mμ (Fig. 1). No such particles occurred in preparations made by the same method from healthy *C. amaranticolor* plants.

Sap from *C. amaranticolor* plants infected with the vine isolates did not precipitate specifically with antisera to tomato black ring or raspberry ringspot viruses, two soil-borne viruses from Britain that have many properties in common with the vine viruses. By contrast, tests with antisera to *Arabis* mosaic virus and to North American fanleaf *A* isolate showed that these two viruses have some of their antigens in common (Table 3). All the French and Swiss isolates also precipitated specifically with both antisera, but at lower antiserum titres than the homologous viruses. There seems no possibility that the grape vine isolates were mixtures of *Arabis* mosaic and some other virus, for none of them infected *Petunia hybrida* plants systemically, a reaction characteristic of *Arabis* mosaic virus. Moreover, *C. amaranticolor* plants systemically infected with North American fanleaf *A*, Portuguese urticado, Swiss court-noué and French panachure isolates are susceptible to infection with *Arabis* mosaic virus. This is further evidence that the vine isolates and *Arabis* mosaic virus are only distantly related strains of the same virus.

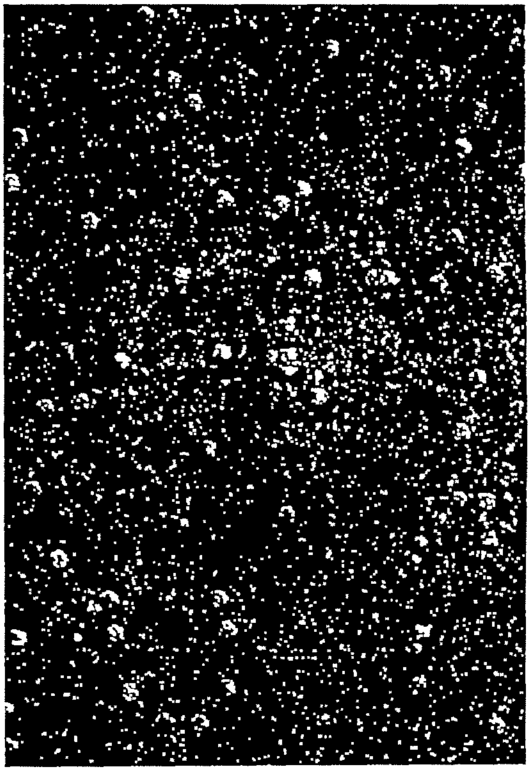


Fig. 1. Electron micrograph of a partially purified preparation of Portuguese urticado *A* isolate. Shadowcast with platinum/iridium. The scale mark represents 0·1μ

Table 2. PROPERTIES *in vitro* OF VIRUS ISOLATES FROM GRAPE VINES

Isolate	Properties*		
	Thermal inactivation point (°C.)	Dilution end-point	Longevity *in vitro* at 18° C. (days)
North American fanleaf *A*	60–62	1/5,000–1/10,000	14–21
Swiss court-noué	60–62	1/1,000–1/2,500	—
Portuguese urticado *A*	62–65	1/5,000–1/10,000	21–28
Portuguese clorose infecciosa	58–60	1/500 –1/1,000	7–14
French panachure	58–61	1/500 –1/1,000	6–11

* In sap from *Chenopodium amaranticolor*. Figures are the limits between which infectivity was lost.

Association of *Xiphinema index* with Urticado Disease in Portuguese Vineyards

Although several workers have obtained evidence that vine viruses are contracted from the soil in Europe[17], and fanleaf virus is transmitted by *X. index* in California[7], the identity of the vectors in Europe is uncertain. In Portugal, urticado disease often occurs patchily in vineyards, and examination of soil samples from two different vineyards showed that the distribution of urticado coincides with that of a nematode probably identical with *X. index*, whereas another species of *Xiphinema*, *X. americanum* Cobb, occurred in soil from all parts of the vineyards. The

Table 3. PRECIPITATION END-POINTS OF ANTISERA TO *Arabis* MOSAIC AND GRAPE VINE VIRUSES

Antigen*	Antiserum to†				
	Arabis mosaic virus	*Arabis* mosaic virus (absorbed with 3 vol. fanleaf *B* antigen)	North American fanleaf isolate *A*	North American fanleaf isolate *A* (absorbed with 3 vol. *Arabis* mosaic virus antigen)	Normal rabbit serum
Arabis mosaic virus	1/512	1/256	1/16	0 (1/4)	0 (1/4)
North American fanleaf isolate *A*	1/128	—	1/512	1/256	0 (1/4)
North American fanleaf isolate *B*	1/128	0 (1/4)	1/256	—	—
Normal *Chenopodium amaranticolor* sap	0 (1/2)	—	0 (1/4)	—	0 (1/4)

* Partially purified preparations made from *C. amaranticolor* or *Nicotiana clevelandii* leaves and used at constant dilution.

† Figures are the precipitation end-points of the antisera after incubating with the antigens for 5 hr. at 35° C. Figures in parentheses are the smallest dilutions tested.

ecology of the virus causing urticado and other similar European vine diseases may thus be similar to that of vine fanleaf virus in California.

Conclusions

Although it is not yet certain that the vine viruses can be transmitted to herbaceous plants so readily that this method can be used for routine diagnosis of virus infection in grape vines, its application on an experimental scale provides a new approach to the study of the relationship between the viruses associated with grape vine diseases, particularly those in the following two groups: (1) fanleaf, Reisigkrankheit, urticado, court-noué, and (2) yellow mosaic, clorose infecciosa, Panaschure and panachure. Our results show that similar viruses can be isolated from plants with each of these diseases, regardless of the group to which the diseases belong, but not from normal plants. However, vines with 'yellow mosaic' may perhaps also contain avirulent strains of fanleaf virus, because 'fanleaf' is usually common in vineyards where 'yellow mosaic' occurs: thus, the isolates obtained from grape vines with 'yellow mosaic' may not be the cause of the yellow mosaic symptoms. We have transmitted North American fanleaf *A* isolate back to grape vine by grafting to infected *Chenopodium amaranticolor*, but to what extent the other viruses we have transmitted to herbaceous plants are responsible for the vine diseases with which they are associated must remain uncertain until further tests have been made. The results of the serological tests indicate that the sap-transmissible isolates from grape vines, and *Arabis* mosaic virus, are all strains of one virus, but they also suggest there are considerable antigenic differences between isolates. Further work is in progress to find whether these differences reflect vector specificity or geographical variation, or both.

We are much indebted to Dr. W. B. Hewitt, Davis, California; Dr. R. Bovey, Nyon, Switzerland; and Mr. A. Vuittenez, Colmar, France, for supplying normal and infected grape vines; to D. J. Hooper for identifying the nematode species, and to H. L. Nixon, J. Cathro and R. D. Woods for examining preparations with the electron microscope.

[1] Dias, H. F., Thirteenth Congresso Luso-Espanhol para o Progresso das Ciencias, Lisbon, 5, 167 (1950).
[2] Bovey, R., *Vitis*, 1, 237 (1958).
[3] Ochs, G., *Z. Pflanzenkrankheiten u. Pflanzenschutz*, 65, 11 (1958).
[4] Niemeyer, L., and Bode, O., *Z. Pflanzenkrankheiten u. Pflanzenschutz*, 66, 640 (1959).
[5] Hewitt, W. B., *Phytopath.*, 46, 15 (1956).
[6] Hewitt, W. B., and Delp, C. J., *Phytopath.*, 43, 475 (1953).
[7] Hewitt, W. B., Raski, D. J., and Goheen, A. C., *Phytopath.*, 48, 586 (1958).
[8] Cadman, C. H., and Harrison, B. D., *Ann. App. Biol.*, 47, 542 (1959).
[9] van der Want, J. P. H., *Tijdschr. Pl. Ziekt.*, 54, 85 (1948).
[10] Böning, K., *Z. Parasitenk.*, 3, 103 (1931).
[11] Cadman, C. H., *Virology* (in the press).
[12] Jha, A., and Posnette, A. F., *Nature*, 184, 962 (1959).
[13] Harrison, B. D., and Cadman, C. H., *Nature*, 184, 1624 (1959).
[14] Harrison, B. D., *Ann. App. Biol.*, 46, 221 (1958).
[15] Holmes, F. O., *Virology*, 2, 611 (1956).
[16] Harrison, B. D., and Nixon, H. L., *Virology* (in the press).
[17] Petri, L., *Boll. regia staz. patol. vegetale* (N.S.), 9, 101 (1929).

POLYPLOIDY IN HUMAN TUMOURS

By N. B. ATKIN and ANGELA J. ROSS

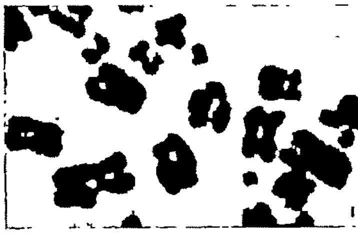
Department of Cancer Research, Mount Vernon Hospital, Northwood, Middlesex

MALIGNANT tumours, like normal tissues, exhibit varying degrees of polyploidy, but whereas in normal somatic tissues the great majority of cells usually retain the diploid chromosome complement, malignant tumours often have a pronounced secondary complement of polyploid cells, or may have undergone a shift to a basically near-tetraploid chromosome number. Although primary tumours may have an apparently normal chromosome complement, aneuploidy is a common finding and moreover is the rule in animal tumours which have been transplanted for a long time[1]; in the mouse, the change to aneuploidy often appears to involve a doubling of the chromosome complement, since many of the tumours have near-tetraploid chromosome numbers. The significance of polyploidy in the evolution of transplantable mouse tumours has been discussed by Levan[2,3], who has demonstrated that near-tetraploid tumours show much more evidence of structural chromosomal change than do near-diploid tumours. It is uncertain, however, to what extent the findings in experimental animal tumours have their parallel in human malignant disease.

We wish to present some evidence relating to the occurrence of polyploidy in human tumours. We have now accumulated data on the chromosome complement and deoxyribonucleic acid content of malignant tumours from a variety of different sites. Whereas extensive chromosome counts have been made on only a few suitable tumours, microspectrophotometric estimations of deoxyribonucleic acid, not being similarly restricted by technical considerations, have been performed on a large number of tumours[4-6]. We have already noted[4] that, although individual tumours extend over a wide range, they tend to fall into two groups as regards their modal deoxyribonucleic acid value, which are centred in the hyperdiploid and tetraploid regions respectively. This has been confirmed by a further study on 165 uterine tumours[5], in which the deoxyribonucleic acid data have been considered in relation to the histological and clinical features of the tumours. In this work it was found that the cervical carcinomata (132 cases) fell into two approximately equal groups; the majority of corpus tumours however, fell into the hyperdiploid group. If the modal deoxyribonucleic acid value, derived from measurements on interphase cells, can be taken to be representative of the stem-line of the tumours, it would appear that, in a considerable proportion of cases, the stem-line chromosome complement of the tumour has doubled at some stage of its evolution.

It is of interest that published data on the chromosome numbers of human tumours do not appear to show a similar bimodal distribution[7-9]. This might be because there has been a selection of those tumours that prove most suitable for chromosome counting: near-triploid tumours may have been selected because they more frequently provide countable prometaphases or metaphases in squash preparations than do those having higher numbers. Another possible reason for the discrepancy is a lack of parallelism that we have found in some tumours between deoxyribonucleic acid content and chromosome number: in a series of 14 tumours[10] we found on an average a significantly higher ratio of modal deoxyribonucleic acid content to chromosome number than for the homologous normal cells, and it appeared that this difference was on the whole greater for those tumours with high chromosome numbers. Thus a nearly triploid tumour might have a modal deoxyribonucleic acid content which would correspond to a hypotetraploid chromosome number if the average amount of deoxyribonucleic acid per chromosome were the same as that in the normal diploid cells. Perhaps chromosomal doubling is commonly followed by structural changes and loss of chromosomal material, resulting in a reduction in the number of chromosomes and an increase in their average size.

It is of course possible that some of the tumours that are 'tetraploid' as regards modal deoxyribonucleic acid content are polytene and not polyploid, but we have so far obtained no direct evidence for the occurrence of polyteny in human tumours. It is also possible that the presence of a large component of cells which have synthesized deoxyribonucleic acid prior to mitosis might result in a tumour with a near-diploid stem-line chromosome number having an interphase population that is mainly 'tetraploid' as regards deoxyribonucleic acid content, as was in fact described for an ovarian carcinoma by Bader[11]. However, chromosome counts of greater or lesser accuracy on most of our 'tetraploid' tumours have been in keeping with the deoxyribonucleic acid data. Moreover, with a few exceptions (see below), the tetraploid tumours do not retain any cells having diploid amounts of deoxyribonucleic acid, and where measurements of deoxyribonucleic acid have been made on cells in mitosis, these have been consistent with a near-tetraploid rather than a near-diploid chromosome number.



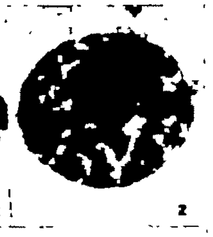


Fig. 1. Endoreduplication: diplochromosomes at metaphase (carcinoma of the corpus uteri). (× 2700)

Fig. 2. Endomitosis (carcinoma of the cervix uteri). (× 1320)
Acetic orcein squash preparations

Our results are derived from patients at the time that they enter hospital for treatment, and it is not known at what stage the doubling of the chromosome complement has occurred in the near-tetraploid tumours. Evidence is forthcoming, however, from cytological studies that polyploidization is occurring in some of these tumours. The work of Biesele, Poyner and Painter[12] and of Levan and Hauschka[13] has demonstrated the part played by endomitosis and endoreduplication in the growth of experimental tumours of the mouse. In human tumours, we have likewise noted these two phenomena; but whereas endoreduplication, as revealed by the presence of diplochromosomes in succeeding mitoses, has been found occasionally in a number of tumours, we have noted that certain tumours are characterized by a high frequency of cells exhibiting chromosomal contraction and splitting within the nuclear membrane, corresponding to the classical picture of endomitosis[14]. The highest incidence of endomitosis was seen in certain undifferentiated squamous cell carcinomata and adenoacanthomata of the cervix uteri. In general, endomitosis was a fairly frequent phenomenon in squamous cell tumours, but was only rarely seen in adenocarcinomata. The deoxyribonucleic acid data derived from tumours showing a high frequency of endomitosis are of interest: the modal deoxyribonucleic acid value fell most often in the hypertetraploid region, but several tumours also had a smaller secondary hyperdiploid mode; a few of the tumours had a hyperdiploid primary mode and a prominent secondary hypertetraploid mode. These tumours may be in a state of equilibrium; alternatively, they may be in the process of transition from a hyperdiploid to a hypertetraploid state. It was noted that endomitosis was not a feature of tumours which had a hypotetraploid deoxyribonucleic acid mode.

The question arises as to whether the incidence of endomitosis and endoreduplication in a particular tumour is an unchanging feature of the tumour, or whether it is dependent on environmental influences, for example, varying hormonal levels. In Levan and Hauschka's[13] work on mouse tumours, each tumour was characterized by a particular level of endomitosis or endoreduplication. In certain normal tissues, however, there is evidence that hormonal factors may determine the occurrence of polyploidy. Thus Arias-Stella[15] has demonstrated the association of nuclear hypertrophy in endometrium with retained chorionic tissue. He has suggested that the atypical pattern results from hormonal activity of the chorionic tissue, and also quotes instances of nuclear enlargement in other tissues which may be the result of endocrine activity. The occurrence of polyploidy in human[16] and mouse[17] liver may be dependent on anterior pituitary growth hormone. So far as the human cervical tumours are concerned, no clear evidence for a hormonal or other 'host' factor has come to light, but an apparent difference in age-distribution between tumours with different deoxyribonucleic acid modes is perhaps suggestive of a hormonal influence: it was noted[5] that the age-distribution of those tumours with high modal deoxyribonucleic acid values was flatter, with relatively fewer cases in the middle age-groups, than that of the near-diploid tumours, and 11 cases aged over 74 had tetraploid modes, as compared with one which was diploid. These differences, however, are not statistically significant. On the other hand, when we calculate the relative height of the secondary (tetraploid) mode in 25 near-diploid squamous cell cervical tumours chosen at random, we find that in 9 cases more than 20 per cent of the cells fall within ±15 per cent of the secondary mode, and of these 7 were from patients aged over 54. Only 5 of the 16 tumours with smaller secondary modes were from patients aged over 54. This difference is just significant ($p = 0.033$). A similar calculation for 18 near-tetraploid tumours shows that 6 out of 8 occurring in patients aged over 54 have prominent secondary octoploid modes, as compared with 4 out of 10 in younger patients. The presence of a prominent secondary mode at twice the value of the primary mode does not necessarily imply that there are many cells with a doubled chromosome complement; but there is no evidence that other factors, such as the frequency of cells entering mitosis, are responsible for the observed differences, which may therefore reflect the incidence of endomitosis or other doubling processes.

It was found[5] that the modal deoxyribonucleic acid value of nearly a third of the squamous cell tumours of the cervix fell within ± 15 per cent of the normal diploid value. Most of these tumours had only small or moderate secondary 'tetraploid' modes. The tumours showing endomitosis, however, frequently had modes (primary and secondary) which were at least 15 per cent higher than the corresponding normal diploid or tetraploid values. It is hoped that further work now being undertaken will shed some light on the significance of this difference and on other problems connected with the occurrence of endomitosis and related phenomena in human tumours. As to the relation between polyploidy and the degree of differentiation of the tumours, we have noted that there appears to be a correlation in the case of tumours of the corpus uteri, well-differentiated tumours being mainly near-diploid; no such correlation has, however, been found for squamous cell carcinomas of the cervix, or for squamous cell tumours arising at other sites.

In summary, human tumours frequently have a primary modal deoxyribonucleic acid value in the tetraploid region, suggesting that chromosomal doubling has occurred in the majority of, or all, the cells. Further, cytological observations suggest that endomitosis or some other doubling mechanism may play a part in the growth of human tumours, endomitosis in particular being a prominent feature of some tumours, which usually have hypertetraploid modes. There is evidence to suggest that the incidence of polyploidy in carcinoma of the cervix may bear a relation to the age of the patient.

Thanks are due to Dr. Alma Howard and Dr. L. H. Gray for helpful discussion; also to Mr. G. Lee for technical assistance. This investigation has been supported by a grant from the British Empire Cancer Campaign.

[1] Klein, G., *Cancer Research*, 19, 343 (1959).

[2] Levan, A., *Ann. N.Y. Acad. Sci.*, **63**, 774 (1956).

[3] Levan, A., *Exp. Cell Research*, 11, 613 (1956).

[4] Atkin, N. B., and Richards, B. M., *Brit. J. Cancer*, 10, 769 (1956).

[5] Atkin, N. B., Richards, B. M., and Ross, A. J., *Brit. J. Cancer* (in the press).

[6] Atkin, N. B., Conf. on Human Chromosomal Abnormalities, King's College, London, Sept. 1959, 13, 773 (1959).

[7] Ising, U., and Levan, A., *Acta Path. Microbiol. Scand.*, **40**, 13 (1957).

[8] Makino, S., Ishihara, T., and Tonomura, A., *Proc. Jap. Acad.*, **35**, **252** (1959).

[9] Manna, G. K., *Proc. Zool. Soc., Calcutta*, Mookerjee Memorial Vol. 95 (1957).

[10] Richards, B. M., and Atkin, N. B., *Acta Unio contra Cancrum*, 16, 124 (1960).

[11] Bader, S., *J. Biophys. Biochem. Cytol.*, **5**, 217 (1959).

[12] Biesele, J. J., Poyner, H., and Painter, T. S., Univ. Texas, Pub. **4243**, 1 (1942).

[13] Levan, A., and Hauschka, T. S., *J. Nat. Cancer Inst.*, 14, 1 (1953).

[14] Geitler, L., *Z. Zellforsch.*, **26**, 641 (1937).

[15] Arias-Stella, J., *A.M.A. Arch. Path.*, **58**, 112 (1954).

[16] Swartz, F. J., *Chromosoma*, **8**, 53 (1956).

[17] Leuchtenberger, C., Helweg-Larsen, H. F., and Murmanis, L., *Lab. Invest.*, **3**, 245 (1954).

THE ANTARCTIC CONVERGENCE—AND DIVERGENCE

By Dr. K. WYRTKI

Division of Fisheries and Oceanography, Commonwealth Scientific and Industrial Research Organization, Cronulla, Sydney

IN a recent paper, Wexler[1] gives observational evidence of prevailing divergent motion along the line which is usually called the Antarctic Convergence. Mackintosh[2] has determined the position of this line from surface-temperature data, considering the strong temperature gradient at the boundary of the antarctic and the sub-antarctic surface waters as indicative of its position. But until now no observational evidence has been given for convergent motion along this line, as the sinking of the antarctic intermediate water occurs usually a few degrees farther to the north, as can be seen from the salinity sections given by Deacon[3].

Considering the Antarctic Convergence as a surface phenomenon in the light of Ekman's theory, it is evident that divergent motions connected with upwelling must occur to the south of the maximal westerlies and convergent motions and sinking to the north of them, but such a transverse circulation would not lead to the formation of a distinguishable water mass boundary. Consequently, this boundary must be related to the dynamics of the antarctic circumpolar current. Stommel[4] has sketched a Sverdrup-type solution for the circumpolar current, in which the wind stress is balanced by a zonal pressure gradient, caused by the boundary formed by South America. This model explains the southward shift of the current; but it implies that the current is situated completely to the south of the maximal westerlies.

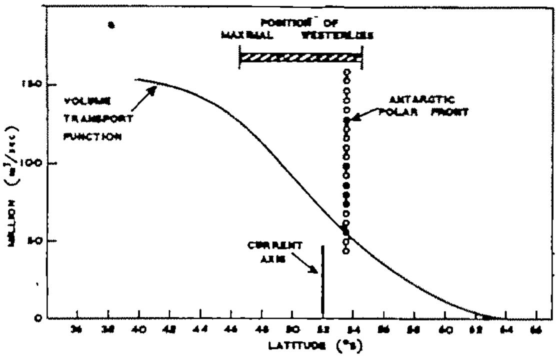


Fig. 1 Average positions of the belt of maximal westerlies of the antarctic polar front and volume transport function of the antarctic circumpolar current

In order to check the relative positions of the belt of maximal westerlies, the circumpolar current and the Antarctic Convergence, their average positions have been determined. In Fig. 1 the position of the belt of maximal westerlies according to Wexler[1], that of the Antarctic Convergence according to Mackintosh[2] and the volume transport function relative to the antarctic continent according to Kort[5] are given. This diagram shows clearly that the axis of the circumpolar current coincides almost with the maximal westerlies and that the Antarctic Convergence lies just to the south of this position. Consequently the circumpolar current cannot be explained exclusively by a Sverdrup-type solution; but friction must also be of importance, and its effect will be to make the current coincide with the west wind belt. In fact, in Wexler's diagram, this belt shows a shift to the south, corresponding to that of the circumpolar current.

A frictional conception of the circumpolar current allows an explanation of the water mass boundary, usually called the Antarctic Convergence. In the presence of friction the motion is no longer geostrophic, but has a down-slope component. If friction is considered to be proportional to the velocity, the angle α between the velocity vector and the isobars is given by $\tan \alpha = \frac{r}{f}$, where f is the Coriolis parameter and r the friction coefficient. With $f = 10^{-4}$ sec.$^{-1}$ and $r = 2\ 10^{-6}$ sec.$^{-1}$, $\tan \alpha$ is 1/50 and $\alpha = 1{\cdot}2°$, which is indeed a small angle.

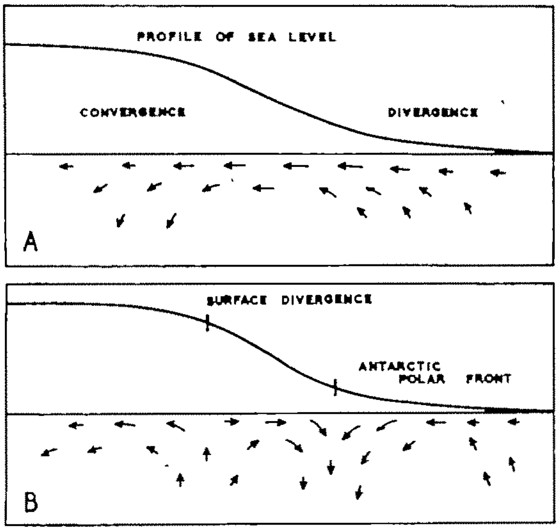


Fig. 2. Schematic representation of the topography of sea-level and of the transverse circulation in the surface layer of the antarctic circumpolar current at (A) strong west winds, and (B) weak west winds

The meridional motion at the surface near the centre of the current is now the result of the combined effects of the northward component of the Ekman drift current and of the down-slope motion due to friction, caused by the meridional pressure gradient. The north component of the velocity v_E of the Ekman drift current is $v_E = \frac{\pi\,\tau}{\delta D f}$, where τ is the zonal wind stress and D the depth of the Ekman layer. With $\tau = 0{\cdot}8g$ cm.$^{-1}$ sec.$^{-2}$, $D = 100$ m., $\delta = 1g$ cm.$^{-3}$, $v_E = 2{\cdot}5$ cm./sec. results, representing the north component of the drift current under average wind conditions. The down-slope component of the gradient current, on the other hand, is given by $v_g = \frac{1}{r}\frac{\partial h}{\partial y}$, where $\frac{\partial h}{\partial y}$ is the meridional slope of the sea-level. Across the current axis a slope of 50 cm. within 100 km. is quite a likely value, and at the above given value of r, a velocity of $2{\cdot}5$ cm./sec. would result in a southward direction.

With these estimates of the meridional components of the motion near the centre of the current, we can now discuss the effect of strong and of weak winds on the transverse circulation in the current. At strong west winds ($\tau > 0{\cdot}8$) the surface flow is divergent to the south of the maximal westerlies, a northward transport of surface waters occurs across the current axis, because the velocity of the drift current exceeds the down-slope velocity, and convergent motion occurs to the north of the maximal westerlies. This pattern of the transverse circulation is sketched in Fig. 2A and is almost identical with the conception of Wexler[1] of divergent and ascending motion just to the south of the maximal westerlies. At weak west winds ($\tau < 0{\cdot}8$) the down-slope flow in the centre of the current exceeds the drift current, causing a convergence at the right flank of the main current and a sinking motion, which intensify the water mass boundary there. The circulation pattern (Fig. 2B) shows, moreover, a divergence to the north of the maximal westerlies, which appears clearly in charts of surface currents[6].

A diagram giving G.E.K. vectors along a section across the circumpolar current, taken by a Russian ship[7] along 20° E., shows clearly that the meridional components of the motion are southwards between 49° and 51° S., where the temperature diagram indicates the Antarctic Convergence, and northwards to the north as well as to the south of this belt.

From this discussion it must follow that the 'Antarctic Convergence' is a divergence at strong west winds, and a convergence at weak west winds, but as it is always a water mass boundary and a clearly distinguishable feature in the antarctic waters, it is suggested that it be named the 'Antarctic Polar Front'. This does not specify the character of vertical movements along this line and is in accordance with the terminology used for the corresponding feature in the northern hemisphere.

[1] Wexler, H., Rossby Mem. Vol., 107 (1959).

[2] Mackintosh, N. A., *Discovery Rep.*, **23**, 177 (1946).

[3] Deacon, G. E. R., *Discovery Rep.*, **15** (1937).

[4] Stommel, H., *Deep Sea Res.*, **4**, 149.

[5] Kort, V. G., U.S.S.R. Arctic Antarctic Sci. Res. Inst. Soviet Antarctic Exped. Inf. Bull., **9**, 31 (1959).

[6] Schott, G., *Ann. Hydrogr. Berl.*, **70**, 11 (1942); **71**, 281 (1943).

[7] Maximov, E. B., "To the Southernmost Land, Antarctica", chap. 15 (Moscow, 1959)

LETTERS TO THE EDITORS

COSMOLOGY

Interpretation of Cosmology

Prof. W. H. McCrea's views on the interpretation of cosmology[1] call for some comment. If the universe turns out to have an inhomogeneous character, then his remarks may be justified. But, in view of the paucity of observational tests that have been adequately investigated so far, it would seem that he takes up a prematurely pessimistic position.

McCrea asserts that there is an uncertainty of knowledge of the factors affecting the physical conditions in those remote parts of the universe which we now see at an early stage in their history, due to the finite velocity of light. This uncertainty, he claims, increases with the observed red shift, and he is led to suggest that differences between various cosmological models cannot be detected as a matter of principle. In particular, calculated distinctions between a steady-state universe and an evolving universe may be meaningless.

There is, of course, uncertainty about the factors affecting any set of phenomena, until we put forward a definite theory accounting for them. For this purpose it may even be necessary to introduce factors or agents that we cannot ourselves observe, if we have reason for believing that they must be observable to other observers whose past experience has been similar to our own. This is in accordance with accepted scientific method. We must try to fit the facts to what seems the most likely interpretation.

In the case of the cosmological problem the simplest and most direct approach, suggested by the Hubble law and the nebular counts, is to assume the 'cosmological principle'. This leads to a definite set of cosmological models: one is the steady-state model and the rest are evolutionary.

As I have shown in recent papers[2,3] there are several tests which, given a plausible continuation of present advances in astronomical technique, should definitely decide whether the universe is in a steady state or not. It is true, as McCrea points out, that the steady-state predictions differ from those of the evolutionary cases only in terms of order z, where z is the red shift. But on the other hand, the predictions for a steady-state model are quite definite and must be realized in a steady-state universe on a statistical basis, if we always choose fair samples for our observational data. There is no uncertainty in principle about the conditions prevailing in remote regions of a steady-state universe, since they must be the same conditions that we experience in our own 'neighbourhood' at the present moment. Consistent agreement of the universe with the various features predicted by all possible tests for the steady-state model must therefore establish it, scientifically, as the correct fit. Consistent disagreement, in ways that cannot be explained by observational errors, must eliminate it.

If the universe is found to be not in a steady state then, retaining the cosmological principle, we must next regard it as evolving in a systematic way. In this case there are indeed great difficulties in predicting exactly what we should see in remote regions in the various models, because of the uncertain degree of evolution that has taken place during the 'light time'. However, it should be appreciated that, by the cosmological principle, the conditions viewed right up to our observational horizon were realized in our own neighbourhood at the same cosmic epochs in the past. It is not inconceivable, therefore, that we may ultimately find an adequate description of these phenomena in agreement with our own discovered past. Such a possibility should not be excluded as a matter of principle.

The difficulties of interpretation which arise in an evolutionary universe were of course pointed out by the original advocates of the steady-state model[4]. Even greater difficulties arise if we drop the cosmological principle and assume, say, a hierarchical model of the universe. In this case the uncertainty of the universe *in toto* would indeed be of the fundamental character that McCrea has envisaged.

An observational decision in favour of a steady-state, evolutionary, or hierarchical universe would have an importance not confined to physics. In due time it would find its place in the basic philosophical outlook of all mankind. Every possible effort should therefore be made to reach it.

W. Davidson

Mathematics Department,
Battersea College of Technology,
London, S.W.11. June 30.

---

[1] McCrea, W. H., *Nature*, 186, 1035 (1960).

[2] Davidson, W., *Mon. Not. Roy. Astro. Soc.*, 119, 665 (1959).

[3] Davidson, W., *Mon. Not. Roy. Astro. Soc.*, 120, 271 (1960).

[4] Bondi, H., and Gold, T., *Mon. Not. Roy. Astro. Soc.*, 108, 252 (1948).

Dr. Davidson re-states the orthodox view, and it is this view that I venture to call in question.

Suppose we know all about the laws of interaction of different parts of the universe, and suppose we make all the observations of the universe that are possible to us in principle. Then, for the reasons that I stated, I conclude that there is an uncertainty about what we can predict about the universe. The orthodox view is that theory can enable us to overcome this uncertainty. The view I suggested is that we cannot do better than in the circumstances just supposed, and that therefore theory ought to be modified so that it does not claim to do better.

The uncertainty contemplated here is of a more novel and fundamental kind than appears to be altogether recognized in Dr. Davidson's discussion. Also, there is nothing necessarily pessimistic about it. If we could properly take account of it, it would be expected to lead to the discovery of new phenomena just as the sacrifices made in going from classical theory to relativity and quantum theory led to the discovery of new phenomena. Finally, there is nothing contrary to the 'accepted scientific method'. For, in regard to what Dr. Davidson has to say on the subject, we have to recall that no amount of agreement with observation can 'establish' a theory; all that such agreement means is the absence of what we deem to be a contradiction.

W. H. McCrea

Royal Holloway College,
Englefield Green, Surrey.

PHYSICS

Diamagnetic Moment of Gaseous Plasmas measured by Spin Resonance Techniques

WE report here typical experimental results obtained in measuring the diamagnetic moment of plasmas immersed in static or quasi-static magnetic fields. Nuclear and electron spin resonance techniques were used for detection of magnetic field shifts; the results indicate that such techniques may be of value as a diagnostic tool in high-energy plasma research.

A well-known theorem in statistical mechanics by Van Leeuwen[1] states that the magnetic moment of a classical free electron gas in thermodynamic equilibrium in a magnetic field is zero. The physical interpretation of this result is due to N. Bohr[2], who argued that the moment due to the electron Larmor orbits in the volume of a substance is identically cancelled by a boundary current of electrons elastically reflected by its surface.

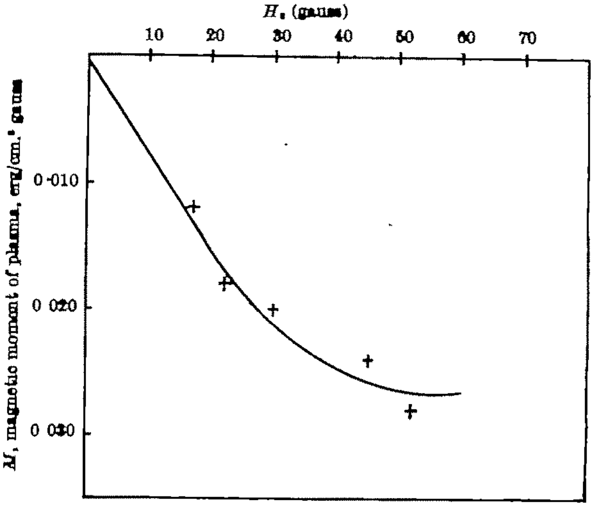
Since Bohr considered the electron gas in a metal, which is degenerate rather than classical, his result appears to be irrelevant. Also, in view of the larger paramagnetic susceptibility of the electron gas in most metals, the diamagnetic moment from the Larmor motion is inaccessible to direct measurement.

A dense free electron gas in a laboratory gaseous plasma is a classical gas which ordinarily is Maxwellian distributed except under special conditions. However, in general it is not in thermodynamic equilibrium; energy and particles are diffusing continuously to the surface or other limiting boundaries. The bounding surface, which provides a region of recombination for electrons and ions in a plasma, is more absorbing than reflecting. It follows that a gaseous plasma immersed in a magnetic field will have a non-zero diamagnetic moment. Using a conventional model for ambipolar diffusion in a plasma, Alfven[3] showed that the moment of the plasma should be:

$$M = -\frac{nk(T_e + T_i)}{H_0} \frac{1}{1 + \frac{\nu_e \nu_i}{\omega_{He}\omega_{Hi}} + \frac{\nu_e^2}{\omega_{He}^2} + \ldots} \qquad (1)$$

where n is the number density of charges, T_e and T_i are the electronic and ionic temperatures, ω_{He}, ω_{Hi} are the electronic and ionic cyclotron frequencies, and ν_e, ν_i are the collision frequencies for momentum transfer of the electrons and ions. For our work at low pressures and degrees of ionization (less than 3 per cent) and relatively high electron temperatures (greater than 10^4 deg. K.), the momentum transfer collisions are determined by the elastic and inelastic cross-sections of the neutral molecules. M is a maximum for $\nu_e\nu_i = \omega_{He}\omega_{Hi}$.

To measure the functional form of M for low fields, we use an electronic spin resonance in diphenylpicrylhydrazyl[4] to record the small decrease in magnetic field observed just outside the discharge tube on its axis. This is done by placing about 0·1 gm. of diphenylpicrylhydrazyl in a coil which forms one arm of a balanced bridge, fed by a radio-frequency of 40–160 Mc./s. Resonances about 1¼ gauss wide are displayed on an oscilloscope when H_0 is modulated by a periodic signal. If the plasma is pulsed every other period, then the entire resonance is displaced alternately on the oscilloscope, and field shifts as low as 0·1 gauss may be detected. The results of such a study on a low-pressure d.c. mercury discharge are shown in Fig. 1. The moment, which is obviously zero at zero field, appears to reach a maximum near 50 gauss, and from equation 1, one obtains an energy density of 2·8 ergs/cm.³. This agrees within 10 per cent with data on energy density taken by pulsed Langmuir probe techniques[5]. Low-field measurements on M taken many years ago by Steenbeck[6], using different methods, agree with our results.



Mercury discharge, 5μ pressure
j = 0·75 amp./cm.²

Fig. 1. Diamagnetic moment of a mercury plasma

The above method is limited in its applications by (1) poor sensitivity because of the wide resonance line width of diphenylpicrylhydrazyl and (2) because measurements of the shift of the electronic spin resonance must be made in the presence of a noisy plasma.

For measurements at high magnetic field intensities, we have used a 'π/2 pulse' proton resonance technique such as described by Hahn[7] and Spokas and Slichter[8]. A pulse of radio frequency, tuned to the resonance frequency of protons in a glycerine sample in or near a plasma in a Varian electromagnet, nutates the nuclear magnetization 90 degrees into a plane perpendicular to H_0 in a few microseconds. The radio-frequency excitation is removed from the sample, and the frequency of precession of the nuclear spin magnets following the pulse is compared with the frequency of the radio-frequency source; the accumulated phase difference between the two signals provides a measure of the field deviation from resonance. Any

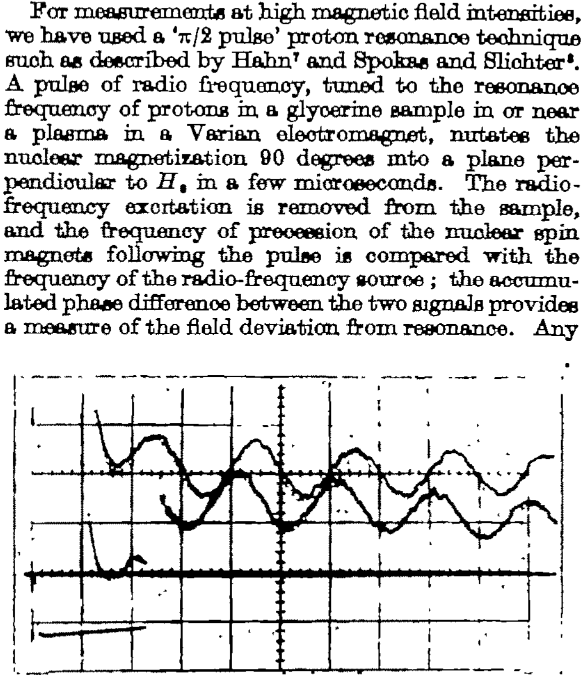


Fig. 2. Upper traces, nuclear magnetic resonance signals for phase comparison; lower trace, discharge tube current. 200 μsec./cm.

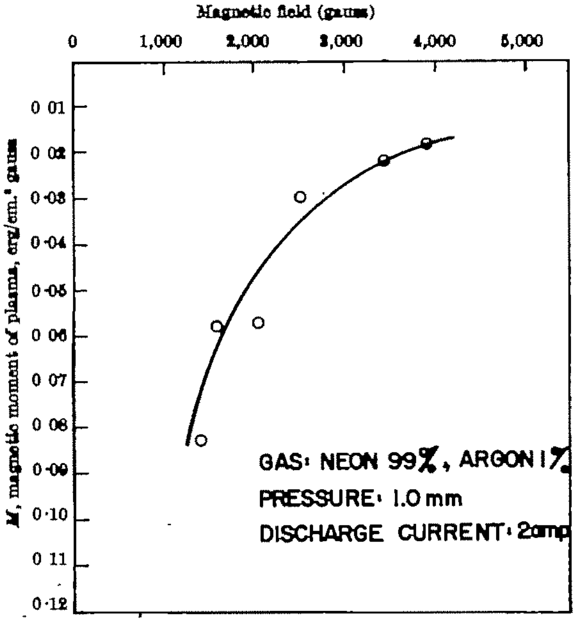


Fig. 3. Diamagnetic moment of a noble gas plasma

field produced by the diamagnetism of the plasma will further alter this deviation.

Fig. 2 shows the signals obtained. The upper damped sinusoid shows the nuclear resonance signal as it is phase detected after removal of the radio-frequency pulse (over-loaded portion far to left). The lower trace shows the same signal, but after a discharge current pulse was applied to a xenon plasma at about 5μ pressure. The discharge tube current, about 6 amp., is displayed as the square pulse at the lower left. The spin precession signals are displaced in phase and in this instance the field shift amounts to 0·12 gauss. The discharge tube here was a modified Phillips ion gauge type[9] which gives a high ionization efficiency in a magnetic field. The energy density is about 50 ergs/cm.³. The phase shift was consistent in sign with the diamagnetism. Stray fields owing to currents passing through the discharge tube were found to give no observable phase shifts of their own. Fig. 3 shows typical results obtained in a relatively strong magnetic field.

The limit of small field detection would appear to be about 1 part in 10⁶, with suitable narrow-banding techniques to improve the signal/noise ratio. Note that these measurements can be made after the plasma discharge, the principal noise source, is over.

An experiment to increase further the electronic energies by cyclotron resonance heating of the electrons at microwave frequencies is now in progress.

The above results imply that spin resonance techniques may be useful in high-energy plasma research and thermonuclear work, for example: (1) Measuring energy densities of plasmas in magnetic fields utilizing plasma diamagnetism as given by equation 1. (2) Measuring any quasi-static magnetic field in a discharge using a small nuclear magnetic resonance probe, which yields $\int B(t)\,dt$ directly.

We gratefully acknowledge the assistance of Prof. C. P. Slichter in giving advice on the nuclear resonance experiment.

This work was supported by Air Force Cambridge Research Center.

T. C. MARSHALL
R. A. KAWCYN
L. GOLDSTEIN

University of Illinois,
Urbana,
Illinois.

[1] Van Leeuwen, J. H., Dissertation, Leyden (1919). See also Van Vleck, J. H., "Theory of Electric and Magnetic Susceptibilities", 94 (Oxford Univ. Press).

[2] Bohr, N., Dissertation, Copenhagen (1911).

[3] Alfven, H., "Cosmical Electrodynamics", 62 (Oxford Univ. Press).

[4] Townes, C. H., and Turkevich, J., *Phys. Rev.*, 77, 148 (1950).

[5] Waymouth, J. F., *J. App. Phys.*, 30, 1404 (1959).

[6] Steenbeck, W., *Wiss. Veroff. aus den Siemens-Werken*, 15, 2, 1 (1936).

[7] Hahn, E. L., *Phys. Rev.*, 80, 580 (1950).

[8] Spokas, J. J., and Slichter, C. P., *Phys. Rev.*, 113, 1462 (1959).

[9] Operation described by Backus, J., *J. App. Phys.*, 30, 1866 (1959).

Distorted Wave Approximation for Scattering Phase-Shifts

THE elastic scattering wave-function for a short-range potential function $V(r)$ may be written in the form:

$$[\psi_l(r) = kr[j_l(kr)\cos\delta_l - g_l(r)n_l(kr)\sin\delta_l] \qquad (1)$$

where $j_l(x)$ and $n_l(x)$ are the spherical Bessel and Neumann functions respectively, δ_l is the scattering phase-shift, and $g_l(r)$ is a form factor measuring the distortion of the incident wave by the potential. $g_l(r)$ must satisfy the boundary conditions

$$g_l(r \to 0) \sim r^{2l+1},\ g_l(r \to \infty) \to 1$$

We substitute (1) into the integral equation for the phase-shift[1];

$$\sin\delta_l = -(2\mu\hbar^2k)\int_0^\infty V(r)krj_l(kr)\psi_l(r)dr \qquad (2)$$

leading to:

$$\tan\delta_l = B_{1l}/(1 - B_{2l}) \qquad (3)$$

where:

$$B_{1l} = -(2\mu/\hbar^2k)\int_0^\infty V(r)k^2r^2j_l^2(kr)dr \qquad (4)$$

$$B_{2l} = (2\mu/\hbar^2k)\int_0^\infty g_l(r)V(r)k^2r^2j_l(kr)n_l(kr)dr \qquad (5)$$

B_{1l} is the first Born approximation integral and B_{2l} a new integral which is large at low energies, corresponding to strong distortion of the incident wave-function, and small at high energies.

The simplest choice of $g_l(r)$ is made by introducing a cut-off range r_a beyond which the potential tail is negligible:

$$\begin{aligned} g_l(r) &= f_l(r) \qquad (r < r_a) \\ &= 1 \qquad (r > r_a) \end{aligned} \qquad (6)$$

$f_l(r)$ must obey the boundary conditions:

$$f_l(r \to 0) \sim r^{2l+1},\quad f_l(r_a) = 1,\quad f_l'(r_a) = 0 \qquad (7)$$

$g_l(r)$ and $f_l(r)$ are in general series expansions in r. However, $g_l(r)$ is involved only in the integral (5) for B_{2l}, and this has an integrand behaving like r^{2l+2} for small r. Also for $r > r_a$ this integrand is negligible, so that B_{2l} is determined almost entirely by intermediate values of r which are less than r_a. For light nuclei and small and intermediate k values, $f_l(r)$ may be approximated by any monotonically increasing function of r satisfying the constraints (7). To a first approximation, B_{2l} is independent of the detailed shape of $f_l(r)$ as the latter's contribution to the integral is dependent mainly on the second and third conditions (7). Thus B_{2l} is a function of r_a alone to a first approximation.

For non-singular potential wells, B_{2l} is a slowly varying function of r_a, so that r_a may be chosen arbitrarily by inspection of the potential. Singular wells such as the Yukawa potential are somewhat more sensitive to the choice of r_a. In general, best results are obtained if the zero-energy scattering length a is known for the potential $V(r)$. Using the definition:

$$a = \lim_{k\to 0}\left(-\frac{\tan\delta_0}{k}\right) \qquad (8)$$

(3) may be used to find the value of r_a leading to the correct a. Values of r_a obtained by this zero energy normalization procedure are slightly different according to the function used for $f_l(r)$. A simple polynomial expression which is found to give good results for a number of potential shapes is:

$$f_l(r) = \tfrac{1}{2}[(2l+3)(r/r_a)^{2l+1} - (2l+1)(r/r_a)^{2l+3}] \qquad (9)$$

For k large, $B_{2l}/B_{1l} \to 0$ and δ_l is small, so we get a second Born approximation from (3):

$$\delta_l \approx B_{1l}(1 + B_{2l}) \qquad (10)$$

For k small, (3) reduces to the shape-independent formula[2]:

$$k\cot\delta_0 = 1/a + \tfrac{1}{2}r_0k^2 + 0(k^4) \qquad (11)$$

with approximate values of the parameters a and r_0.

A simple illustration of the application of formula (3) for δ_l is given by the ^3S and ^1S scattering of neutrons by protons at low energies, assuming square well potentials. We take for the nuclear well dimensions the following values[3]:

$$^3S: V_0 = 36{\cdot}354 \text{ MeV.}, b = 2{\cdot}0048 \times 10^{-13} \text{ cm.}$$

$$^1S: V_0 = 14{\cdot}052 \text{ MeV.}, b = 2{\cdot}5860 \times 10^{-13} \text{ cm.}$$

where V_0 and b are the depth and range respectively of the potential.

In this case we should take $r_a = b$. Values of δ_0 calculated by the exact formula, by the first Born approximation B_{10}, and by (3) are given in Table 1.

Table 1. CALCULATED VALUES OF PHASE-SHIFTS δ_0 FOR ^3S AND ^1S n–p SCATTERING BY SQUARE WELLS

Spin state	k	Exact δ_0	Born approximation B_{10}	δ_0 from (3)
^3S	0·1	2·6283	0·2337	2·6019
	0·25	2·0590	0·5600	2·0381
	0·5	1·5176	0·9626	1·5319
^1S	0·1	1·0026	0·1938	1·0198
	0·25	1·1020	0·4493	1·1055
	0·5	0·9214	0·6979	0·9479

Values of δ_0 are improved by an order of magnitude at all energies over first Born approximation results. Similar results are obtained for other potential shapes with r_a chosen in these cases by the zero energy normalization method above.

For non-singular wells, such as gaussian, exponential or Woods–Saxon interactions, the accuracy of phase-shifts obtained using (3) is better than 2 per cent. Singular wells such as the Yukawa potential may give somewhat less accurate (but still good) results, as the spherical Neumann function $n_l(kr)$ in (1) no longer correctly describes the irregular solution of the wave equation. This actually contains logarithmic terms for a potential with a $1/r$ singularity.

P. SWAN

Physics Department,
University of Melbourne.

---

[1] Mott, N. F., and Massey, H. S. W., "The Theory of Atomic Collisions", second ed. (Oxford University Press, 1949).

[2] Mather, K. B., and Swan, P., "Nuclear Scattering" (Cambridge University Press, 1958).

[3] Blatt, J. M., *Phys. Rev.*, **77**, 647 (1948).

METEOROLOGY

Small-Scale Turbulent Diffusion in the Atmosphere

Frenkiel and Katz[1] have recently published under this title the results of their experiments with instantaneously created smoke puffs. Starting from Taylor's expression for the variance of the mean concentration in such a puff, assuming $R(\alpha)$, the Lagrangian correlation function, to be near unity for small values of the diffusion time, they have derived an expression for the radius of the outer visible boundary of the smoke puff, a, as a function of the diffusion time, t. They arrived at a nearly linear relationship between a and t for small values of t. This conclusion is fully supported by their experimental results.

However, one can doubt the validity of the assumption $R(\alpha) \sim 1$, since the experiments were carried out under conditions of unstable equilibrium of the atmosphere. According to Sutton's arguments[2], or following the more rigorous treatment of Clarenburg[3] for the diffusion of smoke puffs emerging from an instantaneous point source, it seems better to put a proportional to $t^{2-n/2}$, at least for small values of t, where n is a parameter depending on the turbulent state of the atmosphere.

To decide which of the two relations is the better one, we have calculated: (1) $R(a,t)$, the correlation of a as a function of the time and the diffusion time plus 3 sec., thus allowing for the fact that the experiments were not carried out with a perfect point source. (2) $R(a,t^{2-n/2})$, the correlation of a as a function of the time and $(t+3)^{2-n/2}$.

The results obtained are summarized in Table 1. The values of a as a function of the time were taken from the tables published by Frenkiel and Katz.

Table 1

Date	Puff No.	$R(a,t)$	$R(a,t^{2-n/2})$*	$R(a,t)-R(a,t^{2-n/2})$
27/2/1950	4	0·9937	0·9948	− 0·0011
	5	0·9644	0·9670	− 0·0026
	7	0·9442	0·9464	− 0·0022
	8	0·9563	0·9599	− 0·0037
	16	0·9872	0·9862	+ 0·0010
	18	0·9813	0·9894	− 0·0081
	19	0·9642	0·9644	− 0·0002
	20	0·9784	0·9808	− 0·0024
28/2/1950	1a	0·9865	1·0000	− 0·0135
	1b	0·9554	0·9610	− 0·0056
	2a	0·9842	0·9851	− 0·0009
	2b	0·9933	0·9941	− 0·0008
	3	0·9909	0·9899	+ 0·0010
	5	0·9634	0·9668	− 0·0034
	9	0·9841	0·9821	+ 0·0020
	10	0·9650	0·9698	− 0·0048
	11	0·9760	0·9846	− 0·0086

*For n the value 0·26 was taken.

As can be seen from Table 1, both correlations are highly significant. However, $R(a,t^{1-n/2})$ is in nearly all cases somewhat greater than $R(a,t)$. Applying Student's t test to the differences $[R(a,t) - R(a,t^{1-n/2})]$, it appears that $R(a,t^{1-n/2})$ is significantly ($P < 0\cdot5$ per cent) higher than $R(a,t)$.

From the experiments of Frenkiel and Katz it may therefore be concluded that the more complete theory of diffusion yields results which are in better agreement with the experimental data. Because the difference between our treatment and that of Frenkiel and Katz is already clearly demonstrated for unstable atmospheric equilibrium, it must be expected, for reasons the discussion of which would be beyond the scope of this communication, that this difference will be even more pronounced for stability of the atmosphere.

We wish to thank the Board of the National Defence Research Council, T.N.O., for permission to publish this communication.

L. A. Clarenburg
C. E. Spaans-v. d. Tang

Chemisch Laboratorium RVO-TNO,
Rijswijk (Z.H.), Nederland.

[1] Frenkiel, F. N., and Katz, L., *J. Met.*, 13, 388 (1956).

[2] Sutton, O. G., "Micrometeorology" (McGraw-Hill, London, 1953).

[3] Clarenburg, L. A., "A Study on Air Pollution" (doctoral thesis, Utrecht, 1960).

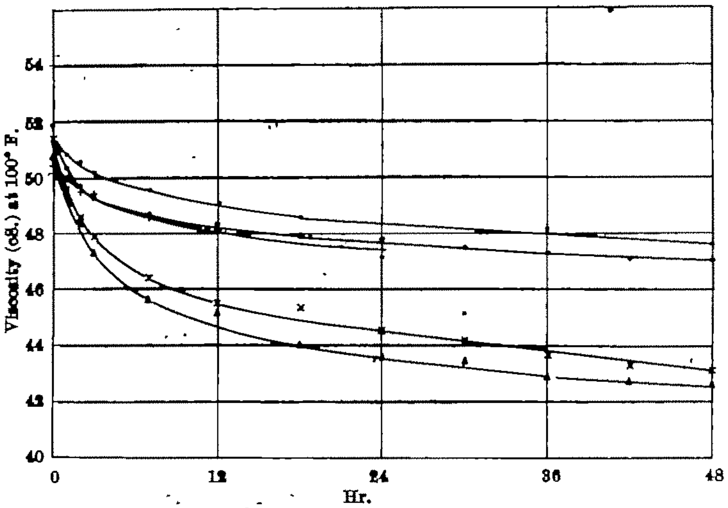


Fig. 1. Permanent loss of viscosity of lubricant. ●, Engine 'motored'; ○, lead-free fuel; +, fuel containing 0·21 ml. tetraethyl lead/Imp. gallon; ×, fuel containing 1·85 ml. tetraethyl lead/Imp. gallon; Δ, fuel containing 3·57 ml. tetraethyl lead/Imp. gallon

ENGINEERING

Initiation of Chemical Reactions by Mechanical Forces

It is well known that large molecules can be degraded mechanically, and the rupture of a chemical bond by a high shearing stress under conditions of laminar flow has been demonstrated with a 'jet viscometer'[1]. The free radicals formed on degradation by shear give rise to oxidation and other chemical reactions. Evidence of such an initiation of chemical reactions by mechanical forces was found with lubricating oils which had been used in an internal combustion engine while the engine was run 'cool' (sump temperature: 69·4° C.). A comparison was made of the change in viscosity and the dependence of viscosity on temperature of the oils when, on one hand, the engine was driven by an electric motor and, on the other hand, run on a fuel the lead content of which was varied. It appeared that the lead content of the fuel promoted a breakdown of large molecules and the combination of free radicals with oxygen molecules, which in their turn formed linkages for the growth of splinter molecules.

In all these experiments the viscosity of the oil decreased logarithmically with the time of running the engine, while the temperature coefficient of the viscosity increased. The permanent loss of viscosity during running of the engine on a lead-free fuel was very similar to that obtained when the engine had been driven by an electric motor (Fig. 1). The fuel dilution was less than half per cent. With 'leaded fuel', however, the permanent loss of viscosity was appreciably larger and increased with the lead content of the fuel. Yet, the increase in the temperature coefficient of the viscosity of the oil did not exceed in these cases the increase obtained when the engine had been driven by electric motor (Fig. 2). The temperature coefficient of the viscosity is here:

$$\alpha = \frac{d\ (\log\ \log\ (\nu + 0\cdot6))}{d\ (\log\ T)}$$

where ν is the kinematic viscosity in cS. and T the absolute temperature. This could indicate that a greater number of large molecules was broken down in the presence of lead and that also the reactions

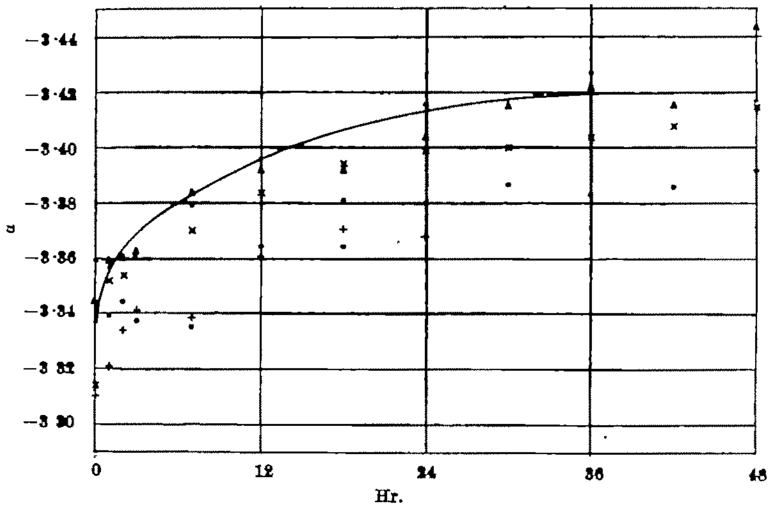


Fig. 2. Viscosity–temperature coefficient of used oil. ●, Engine 'motored'; ○, lead-free fuel; +, fuel containing 0·21 ml. tetraethyl lead/Imp. gallon; ×, fuel containing 1·85 ml. tetraethyl lead/Imp. gallon; Δ, fuel containing 3·57 ml. tetraethyl lead/Imp. gallon

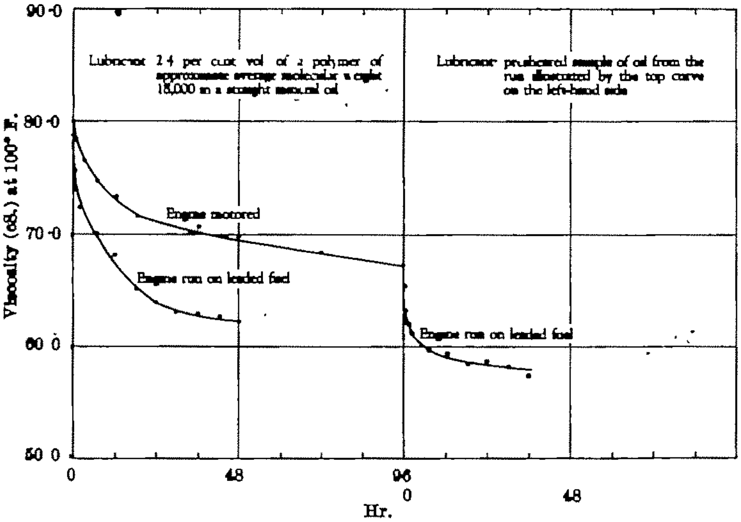


Fig. 3. Permanent loss of viscosity of lubricants

of the free radicals with oxygen molecules were promoted by the presence of lead. In fact, the sludge and acidity of the used oil showed a noticeable increase with the lead content of the fuel on which the engine had been run (Table 1).

Table 1

Sludge and acidity of used oil containing 1·2 per cent volume of a polymer of approximately average molecular weight of 18,000 in a straight mineral oil

Lead content	Duration of run (hr.)	Naphtha insolubles (per cent)	Acidity (mgm. pot. hydrox./gm.)
0	48	0·045	0·05
0·21 ml.*	48	0·18	0·1
1·85 ml.	48	0·16	0·18
3·57 ml.	48	0·19	0·29
Comparison of data from 'motoring' the engine	48	0·06	0·05

* Lead content as ml. tetraethyl lead per Imperial gallon.

Table 2

Permanent loss of viscosity during motoring of an internal combustion engine

Type of polymer	Approximate average molecular weight of polymer	Permanent loss of viscosity (per cent)
Polybutene	900	0
Polyisobutene	18,000	~ 8 (~ 15 on doubling the concentration of the polymer)
Polyisobutene	80,000	~ 43

Table 3

Comparison of the results obtained with an oil containing 2·4 per cent volume of a polymer of approximately average molecular weight 18,000 in a straight mineral oil before and after it had been sheared. In both cases the engine had been run on the same 'leaded fuel'

Lubricant	Initial viscosity (cS.) at: 100° F.	Initial viscosity (cS.) at: 210° F.	Initial viscosity temperature coefficient	Final viscosity (cS.) at: 100° F.	Final viscosity (cS.) at: 210° F.	Final viscosity temperature coefficient
New oil	78·7	11·95	−3·060	62·9	10·02	−3·151
Used oil from 'motoring' the engine for 96 hr.	65·3	9·80	−3·229	57·4	9·12	−3·101

The dependence of the mechanical degradation of the oil for a given shearing stress upon the size and concentration of large molecules was confirmed when the engine was driven by an electric motor (Table 2).

Proof was also obtained that an oil the large molecules of which had previously been degraded by driving the engine for a prolonged period (96 hr.) with an electric motor suffered afterwards very little permanent loss of viscosity while running the engine on a 'leaded fuel' (Fig. 3). Its viscosity-temperature coefficient (Table 3), instead of further increasing, decreased noticeably, while the naphtha insolubles and the acid number increased significantly, from 0·12 to 0·24 per cent and from 0·18 to 0·32 mgm. potassium hydroxide/gm., respectively.

In all these experiments, the engine was run at a speed at which it was estimated that the mean rate of shear in the main bearings was of the order of 10^7 sec.$^{-1}$.

Robert Schnurmann
Ivor S. Stringer

Esso Research Ltd.,
Abingdon, Berks.

---

[1] Morris, W. J., and Schnurmann, R., *Nature*, 160, 674 (1947).

Growth of Sulphide Films on Steel

Sulphur and its compounds are widely used as 'extreme pressure' additives in gear oils. They can prevent scuffing of the gears by the formation of protective sulphide films. The kinetics of the formation of such films at high temperatures is of technological interest, and a study of this problem was made in this Laboratory, using radioactive tracers and electron microscopy.

In order to simulate the brief temperature flashes, which occur when gear teeth mesh, rectangular pulses of electric current were passed through a metal wire, a method of heating previously used in the Thornton Research Centre. The pulses lasted for 4 m.sec. and were followed by periods of 40 m.sec. during which no current was passed. The wire was kept immersed in liquid paraffin, containing sulphur or sulphur compounds, labelled with the isotope sulphur-35. After passing a number of pulses, the radioactivity acquired by the wire was measured. The film thickness was calculated by using a suitable calibration procedure. The wires were 2·5 cm. long and 0·025 cm. diameter and were of mild steel, stainless steel, 'Armco' iron, copper or brass. Pulse temperatures over the range 100–700° C. were used in the experiments. Only the results obtained with mild steel will be discussed here.

It was found that the results followed the generalized parabolic law of film growth[1]:

$$d^2 + k_1 d = k_2 t \qquad (1)$$

where d is the film thickness and t the time of reaction; k_1 and k_2 are constants. For the present experiments it was permissible to substitute N, the number of pulses for t, and the applicability of equation (1) was tested by plotting d versus N/d. Straight lines intersecting the d-axis showed that the law was applicable,

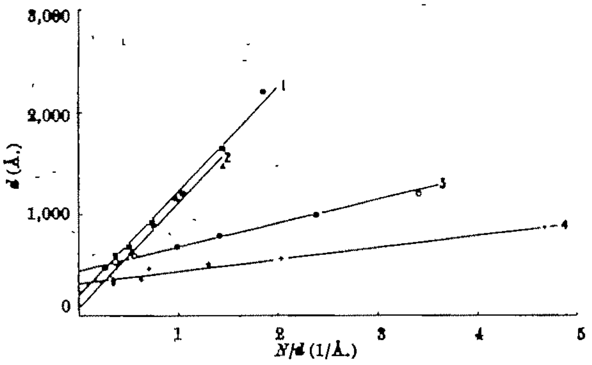


Fig. 1. d, film thickness; N, no. of pulses. Mild steel, pulse temperature, 400° C. 1, 2, dibenzyl sulphide; 3, 4, elemental sulphur

and this is illustrated in Fig. 1. Curves 1 and 2 relate to solutions of dibenzyl disulphide, containing the equivalent of 0·5 and 0·25 per cent by weight of sulphur. Curves 3 and 4 refer to elemental sulphur in similar concentrations. Mild steel wires and pulse temperatures of 400° C. were used in these experiments. The results can be interpreted as follows: during the first few pulses a fast reaction led to the build-up of relatively thick sulphide films (reaction-rate constant k_1). Soon, however, the reaction-rate slowed down and was then governed by a diffusion mechanism, characterized by the constant k_2. The coefficient of diffusion, D, and the energy of activation, ΔE_D, could be calculated from the experimental results. For elemental sulphur solutions and mild steel at 400° C., D was about 5×10^{-12} cm.^{2}/sec. and ΔE_D about 20 kcal./mole.

It seemed important to establish whether, during the initial stages, a uniform film developed over the surface or localized growth occurred. This was investigated using an *E.M.*6 Metropolitan-Vickers electron microscope. Two techniques were employed. Extraction replicas were prepared by evaporating carbon on to the surface of the wire. The film was removed by etching the wire for a short time in 10 per cent nital, then transferring it to distilled water where the film became detached from the wire and was collected in the usual way. Fig. 2a shows a micrograph obtained by this method. Apart from relatively thick regions, a large number of whiskers can be seen. Further information about the structure of the film was obtained by examining sulphided wires directly in the electron microscope. Fig. 2b shows the shadow cast by the edge of a wire. Large-scale growth of sulphide had occurred in a few places (marked *A*). The uppermost surface of these areas of growth shows the roots of the whiskers (marked *B*). The primary film of sulphide formed on the surface is shown not to be uniform and to consist of localized growth terminating in fine whiskers.

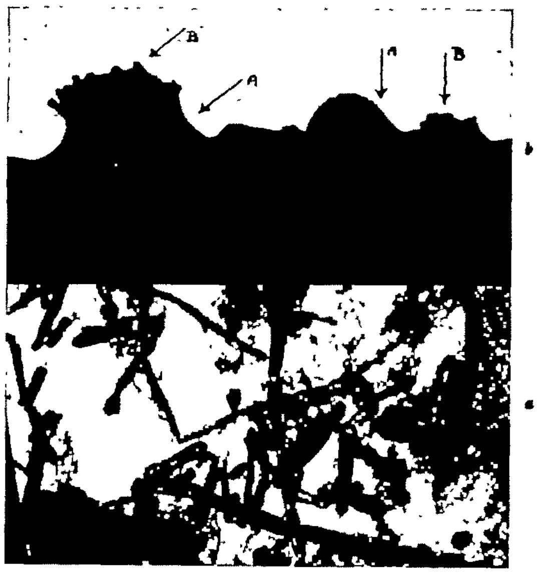


Fig. 2. (× c. 26,700).

A fuller account of the work will be published elsewhere.

R. B. Campbell
L. Grunberg
H. M. Scott

Lubrication and Wear Division,
National Engineering Laboratory,
Thorntonhall,
Glasgow.

[1] Kubaschewski, O., and Hopkins, B. E., "Oxidation of Metals and Alloys", 37 (Butterworths, London, 1953).

METALLURGY

An Iron-Silicon Carbide

Many microconstituents alleged to be iron carbides containing silicon have been reported[1-3]. Marles[4] carried out a systematic microscopic examination of rapidly cooled irons containing up to 7 per cent silicon and 1·7–3·6 per cent carbon. A non-heat-tinting constituent described as a 'silico-carbide' was found associated with cementite. Hurst and Riley[5] found a micro-constituent containing carbon and silicon in rapidly cooled iron–silicon–carbon alloys containing 10–15 per cent silicon. More recently, Owen and Street[6] identified another micro-constituent, believed to be a carbide containing silicon, in slowly cooled high-purity alloys containing 5–8 per cent silicon and small amounts of carbon. This carbide was designated the *X*-constituent.

Previous X-ray work[6] on these carbides failed to detect any similarities in their crystal structure, and the exact structure of each carbide was not ascertained. We have completed a detailed examination of the Marles carbide, the Hurst and Riley carbide and the *X*-constituent in solid and in extracted specimens. Using lithium fluoride monochromated radiation with a Debye–Scherrer technique, we find that all three carbides have the same crystal structure. The unit cell is hexagonal with $a = 11\cdot7$ Å., $c = 10\cdot8$ Å. and $c/a = 0\cdot925$, and no variation of these parameters with composition was detected.

We have attempted to determine the chemical composition of the hexagonal carbide by lineal analysis of selected micro-structures. In addition the carbide has been extracted and chemically analysed by the British Cast Iron Research Association. The general results suggest that the carbide contains approximately 9 per cent silicon and 6·5 per cent carbon, giving a formula for the carbide of $Fe_{10}Si_2C_3$. However, there is considerable scatter in the results, and this formula cannot be taken to be firmly established.

Harry[7] and Leslie *et al.*[8,9] have reported carbides other than cementite in low-carbon silicon steels, containing up to 0·10 per cent carbon and between 3 and 4 per cent silicon. The reported X-ray diffraction and electron diffraction patterns cannot be reconciled with the pattern obtained from the hexagonal carbide reported here.

This work formed part of a larger research which will be described in the *Journal of the Iron and Steel Institute*. The work was supported by the Andrew Carnegie Research Fund.

J. G. HUMPHREYS
WALTER S. OWEN

Department of Metallurgy,
University of Liverpool.

[1] Gonterman, W., *J. Iron and Steel Inst.*, No. 1, 421 (1911).

[2] Honda, K., and Murakami, T., *J. Iron and Steel Inst.*, No. 1, 545 (1923).

[3] Kriz, A., and Poborıl, F., *J. Iron and Steel Inst.*, No. 2, 191 (1930); 323 (1932).

[4] Marles, D., *J. Iron and Steel Inst.*, 158, 433 (1948).

[5] Hurst, J., and Riley, R. V., *J. Iron and Steel Inst.*, No. 1, 213 (1944).

[6] Owen, W. S., and Street, B. G., *J. Iron and Steel Inst.*, 172, 15 (1952).

[7] Harry, H. D., *J. Iron and Steel Inst.*, 167, 241 (1951).

[8] Leslie, W. C., Fisher, B. M., and Sen, N., *Acta Met.*, 7, 632 (1959).

[9] Konoval, G., Swell, L., German, L., and Leslie, W. C., *Nature*, 184, 1862 (1959).

CHEMISTRY

Ionic-Covalent Bonding in Crystals

IN discussions in the literature regarding bonding in inorganic semiconducting (or insulating) crystals there seems to be some confusion between bond ionicity on one hand and charge separation effects due to electronegativity differences on the other. This appears to have arisen from the common assumption that the ionic component of bonding in solids is determined solely by the electronegativity difference (Δx) between the constituent atoms (that is, that a compound with, say, $\Delta x = 1 \cdot 0$ must be more ionic than one with $\Delta x = 0 \cdot 5$). Without some qualification, this assumption can be very misleading.

Some elementary arguments regarding electronegativity will serve as a useful introduction. This parameter, defined following Mulliken as the mean of the first ionization constant and the electron affinity of an isolated atom, can be considered a measure of relative electron attracting power. It is not, however, a constant since it depends on the orbital employed (for $s - p$ hybrids it has been shown to decrease as the orbital becomes more strongly directed[1]), on the degree of hybridization, and also on the effective ionic charge (increasing with positive charge, decreasing with negative[2]). Most existing scales of electronegativity, incidentally, take little account of these effects.

When atoms with different electronegativities combine, the more electronegative element tends to become negatively charged, which lowers its electronegativity, while the opposite is true of the less-electronegative element; at equilibrium both atoms have the same effective electronegativity[3]. Conversely, if before combination there is no electronegativity difference, no charge transfer will occur. These arguments apply equally to diatomic molecules and to the quasi-infinite molecules in ionic-covalent crystals.

It will be assumed in the following discussion, as a matter of definition, that by a covalent bond is understood one in which the bonding electrons are equally shared between the bonded atoms, and by an ionic bond one in which they are associated solely with the electronegative constituent[1,4]. It will also be assumed that continuous linear variation in bonding electron distribution is possible between the two extreme forms, and that effects associated with overlap can be neglected.

Applying the previous arguments to a typical ionic-covalent crystal, zinc sulphide, it follows that no charge separation would take place if zinc and sulphur, as free atoms, had the same electronegativities. In this case each atom in the lattice would have its normal complement of valence electrons associated with it (zinc two, sulphur six).

Such an electron distribution gives the 'neutral' formulation $Zn^{0}S^{0}$, which is to be compared with the extreme covalent formulation Zn^{2-}–S^{2+} (equal sharing of the electrons, see, for example, Pauling[4]), and ionic formulation $Zn^{2+}S^{2-}$ (electrons associated solely with the electronegative constituent).

It will be noted that, lying exactly midway between these extremes, the 'neutral' bonds of $Zn^{0}S^{0}$ would be formally 50 per cent ionic (or 50 per cent covalent), that is, with equal contributions from covalent and ionic forms.

Neutral bonds of this type, however, would only be formed in the absence of any difference in electronegativities. Sulphur has in fact a considerably higher electronegativity than zinc, so that in crystalline zinc sulphide charge separation will take place with respect to the neutral bond state, the sulphur atoms becoming negatively charged and the bonds becoming more than 50 per cent ionic.

This simple approach (which appears first to have been pointed out some years ago[5]) is capable of general application to ionic-covalent solids (and also to dative bonds in simpler molecules), since in all cases the neutral bond state is the natural zero point for charge separation arising from electronegativity differences. If only one type of bond is present in the lattice the neutral bond state can be deduced by inspection. Thus for all $A^{II}X^{VI}$ compounds (of which zinc sulphate is an example) it occurs at 50 per cent ionic bonding, for $A^{I}X^{VII}$ compounds such as sodium chloride (covalent form A^{I3-}–X^{VII3+}, ionic form $A^{I1+}X^{VII1-}$) at 75 per cent, and for $A^{III}X^{V}$ compounds such as aluminium nitride (covalent form A^{III1-}–X^{V1+}, ionic form $A^{III3+}X^{V3-}$) at 25 per cent. For more complex compounds in which more than one type of bond is present each type can be assigned its specific neutral-bond ionicity independently. The actual bonds in compounds will of course depart from the neutral form(s) to an extent dependent on the appropriate electronegativity difference(s).

This raises the problem of what scale of electronegativity is applicable to solids. It is not proposed to discuss this matter in any detail, but the following observations appear pertinent.

In principle there is a separate electronegativity scale for every type of bonding orbital, equally applicable to atoms in solids or in simpler molecules. The relative order of the elements should show little variation from scale to scale, but, as mentioned above, absolute electronegativity values can change with directivity or hybridization of bonding orbital. It would seem, however, that even between extreme cases this change is unlikely to exceed 0·5 unit, so that Pauling-type scales are probably not grossly misleading (particularly for large electronegativity differences) if one wishes to obtain some idea of the sign and relative extent of charge separation. (It should be noted, however, that there are in any event errors arising in determining Pauling type electronegativities which are probably of the order of ± 0·1 unit or more.) The Sanderson scale[6,7], for tetrahedral co-ordination, also appears of interest since it is apparently derived for the case of a single bonding orbital.

Finally, even for simple molecules there appears to be no reliable relationship between charge separation and electronegativity difference, and little attempt has been made to establish one for solids. In this connexion the alkali halides, with an electronegativity difference of ~ 2 units, must presumably show separation of, effectively, a whole electronic charge. Perhaps values for smaller electronegativity differences may eventually be deduced from reststrahlen frequency measurements, but, as pointed out by Matossi[8] and others, this approach is not promising. For the present one can only assume a monotonic increase of charge separation with electronegativity difference.

Some examples to illustrate these points follow:

Consider the isoelectronic pair sodium fluoride ($A^{\mathrm{I}}X^{\mathrm{VII}}$ group) and magnesium oxide ($A^{\mathrm{II}}X^{\mathrm{VI}}$ group). Neutral-bonded sodium fluoride would be 75 per cent ionic (see above); the large difference in the electronegativities of sodium and fluorine brings about the transfer of presumably about a whole unit of charge to make the real sodium chloride lattice almost 100 per cent ionic. In contrast neutral-bonded magnesium oxide is 50 per cent ionic, and, with a much smaller electronegativity difference than for Na—F, the real magnesium oxide lattice is unlikely to be even 75 per cent ionic (the appreciable covalency of its bonds gives magnesium oxide very different properties from sodium fluoride, for example hardness).

With regard to semiconducting compounds the present approach indicates that III–V zinc blende compounds are all more than 25 per cent ionic while the related II–VI compounds (like zinc sulphide) must be more than 50 per cent ionic. This is in agreement with microcleavage data[9] and, for the case of gallium arsenide, with estimates based on an analysis of spin-orbit splitting in infra-red transmission spectra[10].

Pyrites (FeS_2) is a simple example of more complex compounds in which more than one kind of bond may be present. The S—S bonds in pyrites can be assumed covalent, leaving 12 electrons for 6 Fe—S bonds[11]. Only two of these 'belong' to Fe, so that the neutral form of the Fe—S bond is 2/6 (that is, 33·3 per cent) covalent. The actual difference in the electronegativities of Fe and S will further reduce this covalent contribution in the real lattice, but will have no comparable effect on the S—S bonds.

Generally compounds tend to be more ionic than the neutral-bonded form since, as would be expected, 'anionic' elements usually have higher electronegativities than 'cationic' elements. (It should be noted that HgTe may be an exception since the appropriate electronegativity difference is only 0·2 unit, which is within the limit of accuracy of available electronegativity scales. Similar arguments may also apply to As_2Te_3. Electronegativity values are taken from Haissinsky[12].)

From many points of view it would appear useful to differentiate two ionic components of bonding in solids: structural ionicity associated with a neutral-bond structure, and charge separation ionicity arising from electronegativity differences. It is the second of these which is responsible for optical scattering of charge carriers in semiconductors, and, to some extent at least, for the difference between high- and low-frequency dielectric constants in 'ionic' crystals (in connexion with the latter effect, the simple approach here outlined should enable the sign of the charge separation to be deduced, a matter of argument in the past). Both components must be taken into account when considering bond-strength and related properties.

C. H. L. GOODMAN

Research Laboratories,
The General Electric Co., Ltd.,
Wembley, England.

[1] Coulson, C. A., "Valence" (Oxford University Press, 1952).
[2] Daudel, P., and Daudel, R., *J. Phys. Radium*, 7, 12 (1946).
[3] Sanderson, R. T., *J. Amer. Chem. Soc.*, 74, 272 (1952).
[4] Pauling, L., "The Nature of the Chemical Bond" (Cornell University Press, New York, 1945).
[5] Goodman, C. H. L., *J. Electronics*, 1, 115 (1955).
[6] Sanderson, R. T., *J. Chem. Educ.*, 29, 539 (1952).
[7] Sanderson, R. T., *J. Inorg. Nucl. Chem.*, 7, 288 (1958).
[8] Matossi, F., *Z. Naturforsch.*, 14a, 791 (1959).
[9] Wolff, G. A., and Broder, J. D., *Acta Cryst.*, 12, 313 (1959).
[10] Braunstein, R., *J. Phys. Chem. Solids*, 8, 280 (1959).
[11] Goodman, C. H. L., *J. Phys. Chem. Solids*, 6, 305 (1958).
[12] Haissinsky, M., *J. Phys. Radium*, 7, 7 (1946).

Optically Active Forms of a Derivative of Tetra-substituted Sulphur

THE concept of the configuration of unevenly tri-substituted sulphur derivatives as an incipient tetrahedron is borne out by both physical studies and resolutions; but the evidence for the tetrahedral structure of tetra-substituted sulphur rests solely on physical investigations.

The simplest member of a new class of sulphur compound, dimethyl sulphoximine, was first prepared by permanganate oxidation of *SS*-dimethyl-*N*-toluene-*p*-sulphonylsulphidimine to *SS*-dimethyl-*N*-toluene-*p*-sulphonylsulphoximine, followed by acid hydrolysis[1]. As part of a study of an optically active chloramine-*T*, one stereoisomer of sodium-4-(3-menthyl)-benzenesulphonchloramide, it seemed of interest to attempt its conversion to the sulphoximide of a mixed sulphide in order to investigate possible isomerism of the *dC.dS*. and *dC.lS*. type, suggested by the following facts. The sulphur–nitrogen linkage, in the sulphidimine, and the sulphoxide bond are stereochemically analogous[2,3], and oxidation of the latter gives sulphones which are known to have an approximately tetrahedral structure[4].

Model experiments confirmed the previous observations of the instability of sulphidimines of mixed sulphides, bearing more complex substituents than dimethyl, under oxidizing conditions[2,5]. Chloramine-*T* and *p*-nitrophenylmethylsulphide gave the normal sulphidimine, m.p. 161°; identical material resulting from the condensation of *p*-toluenesulphonamide with *p*-nitrophenylmethyl sulphoxide, in presence of phosphorus pentoxide[6]. Treatment of this sulphidimine with permanganate under various conditions only gave starting material or *p*-toluenesulphonamide.

The oxidation product was eventually obtained by condensing, in dry pyridine, toluene-*p*-sulphonylchloride with the basic *p*-nitrophenylmethylsulphoximine[7] (prepared by the more general route of treating the sulphoxide with hydrazoic acid), giving the required sulphoximide as a neutral stable compound, m.p. 203–204°. The infra-red spectra showed nitro-adsorption at 6·6 and 7·4μ and strong bands at 7·7, 8·1, 8·7 and 9·2μ, which are also the principal bands in the spectra of the *SS*-dimethyl-*N*-toluene-*p*-sulphonylsulphoximine, and compared with the spectra of the *p*-nitrophenylmethylsulphidimine showed shifts in the position of the major bands identical to those observed between the spectra of the dimethyl analogues.

Condensation of the optically active 4-(3-menthyl)-benzenesulphonylchloride, m.p. 13°, $[\alpha]_{5461}^{24} + 64\cdot6°$, obtained by suitable treatment of an optically pure strychnine 4-(3′-menthyl)-benzenesulphonate with *p*-nitrophenylmethylsulphoximine gave *S*-*p*-nitrophenyl-*S*-methyl-*N*-[4-(3-menthyl)-benzenesulphonyl]-sulphoximine as a mixture of diastereoisomerides, m.p. 133–136°, $[\alpha]_{5461}^{24} + 34\cdot0°$, which showed large changes of rotatory power on recrystallization. The less-soluble form, thick hexagonal plates from methanol–chloroform, had m.p. 150°, $[\alpha]_{5461}^{21} - 155°$, $[\alpha]_{D}^{21} - 124°$. (Found: C, 57·7; H, 6·2; N, 6·0; S, 13·5. $C_{23}H_{30}O_5N_2S_2$ requires C, 57·7; H, 6·3; N, 5·9; S, 13·4 per cent). Systematic fractionation of the mother-liquor has given an extreme crop, m.p. 138–140°, $[\alpha]_{5461}^{19} + 171\cdot9°$, $[\alpha]_{D}^{19} + 138°$. (Found: C, 57·6; H, 6·3; N, 6·1; S, 13·1 per cent.) The infra-red spectra of the diastereoisomers were almost identical and showed the characteristic sulphoximide adsorption.

These results give an indication of asymmetry at the tetrasubstituted sulphur atom and therefore it seems that, like the sulphones and sulphuryl halides[4], this class of sulphur compound has a tetrahedral structure.

I thank the Council of Bedford College for a post-graduate studentship, Dr. D. G. H. Daniels, and the Research Director of the Research Association of the British Flour-Millers for specimens of the dimethyl sulphidimine and sulphoximide for infra-red comparison, and Mr. J. F. Robinson for technical assistance.

M. BARASH

Bedford College,
University of London.

---

[1] Bentley, H. R., and Whitehead, J. K., *J. Chem. Soc.*, 2081 (1950).
[2] Clarke, S. G., Kenyon, J., and Phillips, H., *J. Chem. Soc.*, 188 (1927).
[3] Bell, R. V., and Bennett, G. M., *J. Chem. Soc.*, 1798 (1927); 92 (1928).
[4] Abrahams, S. C., *Quart. Rev.* (*Chem. Soc.*), 10, 425 (1956).
[5] Bentley, H. R., and Whitehead, J. K., *J. Chem. Soc.*, 1572 (1952).
[6] Tarbell, D. S., and Weaver, C., *J. Amer. Chem. Soc.*, 63, 2939 (1941).
[7] Minami, F., Fair, T. W., and Reiner, L., *J. Amer. Chem. Soc.*, 73, 459 (1951).

A New Method for the Synthesis of Cyclic Ethers

HETEROCYCLIC compounds having four members in the ring are difficult to prepare, and are generally less well known than the 3-, 5- and 6-membered rings of the same type. In the cyclic ethers, for example, oxetanes have been studied relatively little compared to oxiranes and tetrahydrofurans.

The oxetanes have considerable potential as chemical intermediates and solvents provided that they could be made economically. For example, oxetane polymers, particularly from 2,2-disubstituted oxetanes, have interesting properties. However, most of the known syntheses of oxetanes are tedious, expensive and give moderate yields, at best[1]. The only exceptions are the ring closures involving the trihalo derivatives of pentaerythritol[2] and the pyrolysis of hydroxy-cyclic carbonates[3].

Recently[4], a new, general synthesis of oxetanes has been reported. This synthesis is a direct, cheap process giving fair yields, and it has been further investigated to determine its scope and limitations.

The synthetic procedure is simple. A diol with the hydroxy groups separated by 3 carbons is dissolved in concentrated sulphuric acid. The mixture is dropped into a boiling solution of aqueous caustic. The product oxetane distils over as it is formed. The distillate separates into two layers, as a general rule. The ether is salted out of the aqueous phase, dried over calcium hydride, and distilled. The procedure is also useful for the preparation of other cyclic ethers, such as tetrahydrofurans and tetrahydropyrans.

The various oxetanes which have been made by this procedure are listed in Table 1. In all runs, 55·5 ml. of 98 per cent sulphuric acid was used to dissolve the diol.

Table 1. CYCLIC ETHERS

Diol (gm.)	Caustic (gm. and per cent)	Product (gm.)	Boiling point (° C.)
Neopentyl glycol (104)	240 (55)	2,2-dimethyl oxetane (24·5)	79·2–80·3
2-Butyl, 2-ethyl 1,3-propanediol (142)	240 (55)	2-butyl, 2-ethyl oxetane (44·4)	181·2–183·9
1,3-Butanediol (90)	240 (64)	1-methyl oxetane (about 15)	58–61
2 Ethyl-1,3 hexanediol (146)	240 (55)	1-*n*-propyl, 2-ethyl oxetane (24·3)	152·5–155·5
2,2-Diethyl 1,3-propanediol (132)	240 (55)	2,2-diethyl oxetane (38·3)	139–141
1,4 Butanediol (90)	240 (55)	tetrahydrofuran (47·1)	
1,5 Pentanediol (104)	240 (55)	tetrahydropyran (85·4)	
2,5-Dimethyl, 2,5-hexanediol (146)	240 (55)	2,2,5,5-tetramethyl tetrahydrofuran (87·3)	110–112

In an attempt to obtain an optimum yield of 2,2-dimethyl oxetane from this synthesis, a factorial experiment was run, in which the factors were the following:

Acid, strength: 98 per cent, oleum.
Acid, quantity: equimolar, 50 per cent excess with respect to glycol.
Base, strength: 40 per cent, 70 per cent.
Base, quantity: stoichiometric, 50 per cent excess with respect to acid.

The results of the experiment, together with replications, are given in Table 2. The values are grams of product obtained from 208 gm. neopentyl glycol as starting material.

Table 2. FACTORIAL DESIGN USED TO DETERMINE SIGNIFICANCE OF VARIABLES

Sodium hydroxide		Sulphuric acid H_2SO_4 Stoichiometric	Sulphuric acid H_2SO_4 50 per cent excess acid	H_2SO_4-Oleum Stoichiometric	H_2SO_4-Oleum 50 per cent excess acid
Initial 70 wt. per cent conc.	50 per cent excess caustic	49·2 46·0	37·1 31·3	48·1	36·4
	Stoichiometric	16·2	19·9	13·1	14·6
Initial 40 wt. per cent conc.	50 per cent excess caustic	7·8	11·5	5·6	13·7 21·5
	Stoichiometric	7·0	2·0 2·3	2·0	3·9

An analysis of variance of the factorial experiment shows that only the amount of caustic, the concentration of caustic, and their interaction have significant effects on the yield of oxetane.

Because of the nature of the process, it is felt that the instantaneous concentration of caustic is the variable actually affecting the yield of oxetane. The amount of excess base only affects the range of concentrations during a run. In another experiment, a number of runs were made at varying concentra-

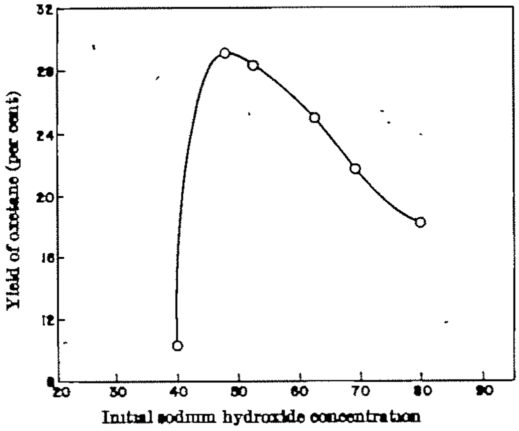


Fig. 1. Effect of sodium hydroxide concentration upon the yield of 3,3-dimethyloxetane

tions of caustic. In each case, 200 per cent excess caustic was used so that the concentration of base remained fairly constant during the run. The results are given in Fig. 1. It is seen that the maximum yield of oxetane occurs at an initial concentration of base of about 50 per cent.

Since the yield of oxetane is relatively low, and since only small amounts of non-condensable by-products were noted, the composition of the residual solution was briefly investigated. In one experiment, using 104 gm. neopentyl glycol, 55·5 ml. sulphuric acid, and 480 gm. of 50 per cent sodium hydroxide, 21·2 gm. of dimethyl oxetane was produced. The residual solution was neutralized with sulphuric acid and extracted with ether. A total of 38 gm. of material was recovered from the extracts. This material appeared to be substantially unchanged neopentyl glycol.

In another experiment, using 208 gm. neopentyl glycol, 111 ml. sulphuric acid and 440 gm. of 54·5 per cent caustic, 53 gm. of dimethyl oxetane was produced, and 73 gm. of crude glycol was recovered by a chloroform extraction of the diluted and filtered residue. The recovered glycol was distilled, and 50 gm. of the material came over between 200° and 207° C. A few grams of residue remained when decomposition began. The results of the two experiments are seen to be quite similar. In the latter experiment, 135 gm. of glycol was consumed, a conversion of 65 per cent; the yield of product is 53 gm., or 47 per cent, based on the amount of glycol actually used up.

It was noted that additional material could be recovered by a chloroform extraction of the residual solution, after the solution had been neutralized with sulphuric acid. This material was recovered as a viscous liquid, which slowly crystallized, and was clearly not neopentyl glycol. Because of the limited solubility of this material in chloroform, it was not quantitatively recovered.

About 30 gm. of crystalline material, of moderate solubility in water, insoluble in chloroform and acetone, and having an infra-red spectrum consistent with an ionic sulphonate, was isolated from the run in the factorial experiment made with 50 per cent excess oleum, and 50 per cent excess of 70 per cent caustic. This material was not further identified. Presumably, the formation of this, and similar materials, accounts for the greater part of converted glycol not appearing as oxetane. As already noted, very little volatile by-product is formed. Further work is in progress to identify these side-products and to obtain a complete material balance, as well as to improve the yields of cyclic ethers.

L. F. Schmoyer*
L. C. Case

Department of Chemical Engineering,
Purdue University,
Lafayette, Indiana.

---

* Present address: Atlas Powder Company, Wilmington, Delaware.

[1] Allen, J. S., and Hibbert, H., *J. Amer. Chem. Soc.*, 56, 1398 (1934). Lespieau, R., *Bull. Soc. Chim.*, 7, 254 (1940). Rose, J. B., *J. Chem. Soc.*, 542 (1956). Searles, S., *et al.*, *J. Amer. Chem. Soc.*, 79, 948 (1957). Noller, C. R., "Organic Syntheses", 3, 835.

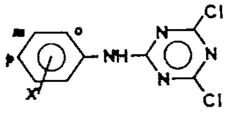
[2] Fonteyne, R., and Ticket, M., *Natuurwiss. Tijdschr.*, 25, 49 (1943). Hercules Powder Co., Brit. Pat. 764,053; 764,248 (Dec. 19, 1956); U.S. Pat. 2,794,027 (May 28, 1957).

[3] Pattison, D. B., *J. Amer. Chem. Soc.*, 79, 3455 (1957).

[4] Schmoyer, L. F., and Case, L. C., *Nature*, 183, 389 (1959).

An *Ortho* Effect influencing Fungitoxicity, Electronic Absorption Spectra, and Chemical Reactivity with Mercaptalbumin

The derivative of 2,4-dichloro-6-anilino-*s*-triazine containing a chlorine atom in the benzene ring *ortho* to the imino group is less toxic to conidia of *Neurospora sitophila* (Mont.) Shear and Dodge than the corresponding *meta* or *para* isomer[1].



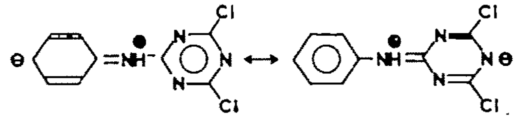
The principal effect of *ortho* substitution is to reduce the amount of toxicant taken up by the fungus spores from the ambient solution, the *ED*50 values of the three compounds being approximately the same on a spore-weight basis. More recent results obtained on conidia of *N. sitophila* reveal that the same order of uptake is followed when the substituent group is methyl or ethoxy (Table 1), and that substitution of the imino hydrogen on the bridge connecting the aromatic and heterocyclic rings with a methyl group also reduces accumulation of the chemical by the spores. The effect is greatest when both an *ortho* hydrogen and the imino hydrogen are replaced by methyl groups. In this case only 15 per cent of the applied dose is taken up compared to 77 per cent for the *p*-methyl derivative. The same pattern is also found for the uptake of these compounds by conidia of *Myrothecium verrucaria* (Alb. and Schw.) Ditm. ex Fr., *Glomerella cingulata* (St.) Sp. and von S., and *Aspergillus niger* van Tiegh.

These observations suggest that maximum uptake of the triazine is obtained when the aromatic and heterocyclic rings can assume a coplanar configuration, since bulky groups in an *ortho* position of the benzene ring or on the bridge nitrogen would interfere with free rotation through van der Waals repulsion

Table 1. Influence of Isomerism on the Uptake of *s*-Triazine Derivatives by Conidia of *N. sitophila* at Applied Doses of 6 Micromols per Gram of Spores

Substituent(s)	Percentage of isomer taken up: *Ortho*	*Meta*	*Para*
Cl	81	86	87
C_2H_5O	55	78	74
CH_3	53	75	77
N—CH_3, CH_3	15	40	48

forces and steric hindrance. An alternative hypothesis is that *ortho* substituents might decrease binding to metabolic substrates by interfering with the formation of hydrogen bonds between the imino group and electron- or proton-donating groups at receptor sites within the spores. In either case it should be possible to demonstrate crowding at the imino bridge through changes in electronic absorption spectra, since substituents that reduce degree of coplanarity would concomitantly reduce interannular resonance. This would result in a shift of absorption maxima to shorter wave-lengths and lower molar extinction coefficients, since absorption of radiation by these compounds arises predominantly from $\pi - \pi^*$ transitions. In particular, the weights of ionic valence-bond structures of the following type in predicting electron density distribution in the resonance hybrid would be reduced:



On comparing the electronic spectra of *s*-triazines substituted in various positions with methyl groups, it can be seen that *ortho* substitution produces a hypsochromic shift of 32 mμ coupled with lowering of intensity when the solvent is acetonitrile (Table 2). Substitution on the imino group causes a blue shift of 25 mμ, but the molar extinction is not changed appreciably. In *cyclo*hexane solution, the blue shift arising from *ortho* substitution is only 3 mμ, but the molar extinction coefficient is reduced by 20 per cent. The *N*-substituted isomer exhibits a pronounced blue shift in both solvents. By contrast, small red shifts occur in both the polar and non-polar solvents when methyl groups are substituted for hydrogen in the *meta* or *para* positions. Similar results are obtained when chlorine atoms and ethoxy groups are substituted in the aromatic ring, indicating that bulky *ortho* substituents reduce conjugation. This is highly correlated with the amounts of these compounds that are taken up by fungus spores.

Table 2. ELECTRONIC ABSORPTION DATA ON *s*-TRIAZINE DERIVATIVES IN *cyclo*HEXANE AND ACETONITRILE

Substituent	Acetonitrile λ_{max}	Acetonitrile ε	*Cyclo*hexane $\lambda_{max.}$	*Cyclo*hexane ε
None	269	17,700	271	18,900
o-Methyl	237	14,200	268	13,300
m-Methyl	271	16,900	275	19,300
p-Methyl	273	17,500	276	19,900
N-Methyl	244	17,300	245	16,100

Concurrent studies on the kinetics of the nucleophilic substitution reactions that take place between the *s*-triazines and bovine mercaptalbumin[2] indicate that an *ortho* effect occurs here as well, the *o*-methyl isomer being only about 10 per cent as reactive with the protein as the *meta* and *para* isomers. It is unlikely that this results from a higher energy of activation in the reaction of the *ortho* isomer with mercaptalbumin, since the second-order velocity coefficients for the reactions of the three isomers with glycine are about the same. Steric effects are unlikely to be involved to a major extent in this latter case, because of the small size of the glycine molecule. Therefore the net electron-releasing power of the methyl group, arising from induction and hyperconjugation, has the same order of magnitude at all three positions in the aromatic ring, leaving steric hindrance as the only way to account for the low reactivity of the *ortho* isomer with the protein.

At present it is not clear whether the *ortho* effects demonstrated in the interactions of the *s*-triazines with fungus spores and the animal protein arise from a reduction in degree of coplanarity of the rings, or steric hindrance of hydrogen bonding at the imino group, or both. However, the possibility that *s*-triazines of this type can form hydrogen bonds with metabolic substrates is supported by the finding that the *o*-methyl isomer is significantly less reactive with tyrosine than the *meta* and *para* compounds, perhaps because hydrogen bonding of the imino groups of the latter molecules with the phenolic hydroxyl group of the tyrosine speeds up the reactions by a Michaelis–Menton type mechanism.

H. P. BURCHFIELD
ELEANOR E. STORRS

Boyce Thompson Institute,
Yonkers, New York.
April 6.

---

[1] Burchfield, H. P., and Storrs, Eleanor E., *Contrib. Boyce Thompson Inst.*, 18, 429 (1957).

[2] Storrs, Eleanor E., thesis, M.S., New York University (1958).

RADIOCHEMISTRY

Non-destructive Analysis of Selenium by Neutron Activation followed by Gamma-Ray Spectrometry

DETECTION of selenium by neutron irradiation and gamma scintillation spectrometry has been attempted. It is known that, when natural selenium is irradiated with neutrons, selenium-75 (121 days), selenium-77 *m* (17·5 sec.) and selenium-81 (18·2 min.) are formed with comparatively large cross-sections. When any one of them is used to detect selenium, irradiation must be continued for a period comparable to the half-life. Therefore, it was thought that the use of selenium-77 *m* offered a method for the rapid detection of selenium; this method has not been described in the literature examined.

In the present work, the sample (0·1–0·5 gm.) was irradiated at a neutron flux of 3×10^{11} neutrons per sq. cm. per sec. for 20 sec., cooled for 15 sec., counted for 20 sec., again cooled for 20 sec. and counted for 20 sec. The counting apparatus used was a 256-channel pulse-height analyser with a 2-in. thick, well-type sodium iodide crystal. A typical spectrogram thus obtained is shown in Fig. 1, from which it is seen that: (1) there is only one photopeak;

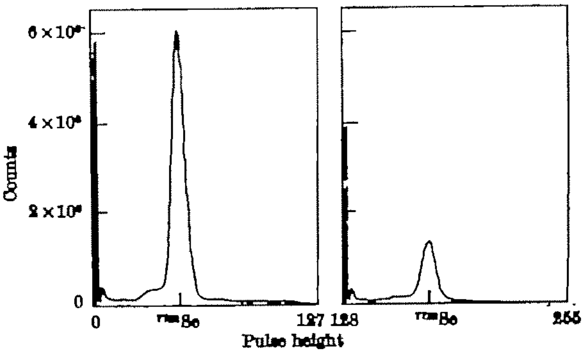


Fig. 1. Typical spectrogram. Sample, 0·109 gm. of sulphur powder. Energy scale ≃ 3·3 keV./pulse-height unit

Table 1. RADIONUCLIDES FORMED, THE GAMMA-RAY ENERGY OF WHICH IS ABOUT 0·16 MEV. (ARRANGED BY INCREASING HALF-LIFE)

Nuclide formed	Half-life	Nuclide formed	Half-life
^{183m}W	5·5 sec.	^{233}Th	22 min.
^{77m}Se	17·5 sec.	^{131}Te	25 min.
^{179m}Hf	19 sec.	^{123}Sn	40 min.
^{77m}Ge	54 sec.	^{111m}Cd	49 min.
^{165m}Dy	1·25 min.	^{139}Ba	84 min.
^{185m}W	1·62 min.	^{177}Yb	1·9 hr.
^{161}Gd	3·6 min.	^{85m}Kr	4·4 hr.
^{182m}Ta	16·5 min.	^{188}Re	17 hr.
^{70}Ga	21 min.		

(2) the corresponding gamma-ray energy is in the range 0·15$_5$–0·17 MeV.; (3) the half-life of the photopeak is about 17·5 sec.

Radionuclides formed by neutron irradiation from naturally occurring nuclides, and with gamma-ray energy of about 0·16 MeV., are shown in Table 1.

Of these radionuclides, those which show similar shapes of the gamma-spectra of Fig. 1 are selenium-77 *m*, tantalum-182 *m*, tin-123 and barium-139. Their half-lives are 17·5 sec., 16·5 min., 39·5 min. and 84 min., respectively.

By the comparison of observed half-life with the values given above, selenium can be identified, and it is confirmed that the observed photopeak is due to selenium.

Table 2. RESULTS OF ANALYSES

Sample	Selenium found (p.p.m.)
A (Sulphur)	68
B (Sulphur ore)	6·8
C (Ammonium thiocyanate)	< 0·02
D (Ammonium sulphate)	< 0·05

For the purpose of quantitative determination, the relation between photopeak height and the amount of selenium can be obtained by use of standards containing selenium in various amounts ranging from 0·1 to 100 μgm. (see Table 2).

I am indebted to Prof. Shozi Makishima for helpful suggestions, to Dr. Toshio Nakai for permission to use laboratory facilities, and to Dr. Seishi Yajima for help with the gamma-spectra.

MINORU OKADA

Government Chemical Industrial
Research Institute,
Shibuya-ku, Tokyo.
April 4.

BIOCHEMISTRY

Reactivity of the Disulphide Bond in Wool

THE permanent set which strained wool fibres acquire in steam or boiling water is due to breakdown of disulphide bonds; this promotes dissipation of stress, followed by linkage rebuilding, which fixes the relaxed structure in its deformed state. In such conditions oxidized fibres are more difficult to set than untreated, and it has been suggested that the formation of intermediate oxidation products, such as the sulphone, is sufficient to impair setting power[1]. This view has now been confirmed by taking advantage of the observation that sulphur dioxide can be reduced to sulphur by hypophosphorous acid[2].

Lincoln wool fibres were treated with a large excess of 2-vol. hydrogen peroxide for 3 hr. at *p*H 9·4 (borate buffer) and 50° C. After overnight washing in running water, the fibres were rinsed in several changes of distilled water, immersed in 0·05 *M* hypophosphorous acid at 50° C. for various times, and again washed to remove the acid. Fibres from each lot of wool were then stretched 40 per cent in cold distilled water, immersed in boiling distilled water for 1 hr., and finally released in boiling distilled water for 1 hr. Values for the set retained by the fibres are given in Table 1; corresponding values for unoxidised fibres, which had been treated with hypophosphorous acid under similar conditions, are also included. Each result is the average of the values obtained with at least three fibres.

Table 1

Time of treatment with hypophosphorous acid (min.)	Percentage set of.	
	Untreated fibres	Oxidized fibres
0	9·7	−6·2
75	—	3·4
150	—	6·2
180	17·0	—
270	—	7·2
400	—	9·4
660	17·8	12·9
960	19·4	16·8

It seems clear that the ability of hypophosphorous acid to restore setting power to oxidized fibres is due to the reduction of intermediate oxidation products to disulphide cross-linkages, because, whereas the oxidized wool failed to blacken during boiling for 40 min. in lead acetate solution at *p*H 4·9 (ref. 3), the same wool, after treatment with hypophosphorous acid for 16 hr., blackened rather more than untreated wool. This result cannot be due to the reduction of cystine cross-linkages to cysteine side-chains, because wool fibres do not supercontract, and strained fibres fail to acquire a set, on being boiled for 30 min. in 0·05 *M* hypophosphorous acid.

The effect of hypophosphorous acid in increasing the setting power of untreated fibres must likewise be due to the reduction of the intermediate oxidation products formed by the action of light and air on the cystine linkages during the growth of the fibres. The presence of such oxidation products to variable degrees in normal fibres, and to different extents in different wools, depending on the conditions to which they were exposed during growth, is one cause of the erratic results obtained in setting fibres under conditions (steam or boiling water) which are far removed from the optimum. Their presence may provide a reason, also, for the failure to account for the whole of the sulphur in keratin in terms of cystine, cysteine, lanthionine and methionine.

As regards the chemical mechanism of setting, the differences of behaviour between untreated and oxidized fibres provide a striking proof that the

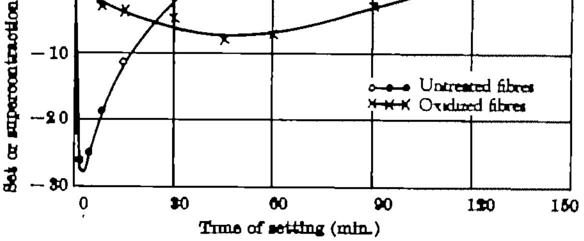


Fig. 1

breakdown of disulphide bonds is an essential first step. As before, the fibres were stretched 40 per cent, and after being immersed in boiling water for various times were released in boiling water for 1 hr. The amounts of set retained by untreated and oxidized fibres are shown in Fig. 1. As would be expected, in view of the greater stability of the intermediate oxidation products of cystine in boiling water[4], the oxidized fibres supercontract to a much smaller extent and are set much more slowly than the untreated fibres, which contain a high proportion of the more vulnerable cystine cross-linkages. In the light of these results, there can be little doubt that the failure of fibres treated with nitric acid to supercontract and set in boiling water[5] is due mainly to the oxidation of the cystine cross-linkages to more stable sulphones.

Finally, it should be mentioned that oxidized fibres can be set readily in boiling dilute solutions of sodium bisulphite, borax and sodium hypophosphite, in accordance with the fact that the intermediate oxidation products of cystine undergo fission readily in bisulphite and alkalis.

L. J. WOLFRAM
J. B. SPEAKMAN

Department of Textile Industries,
University, Leeds.
March 29.

---

[1] Speakman, J. B., *J. Soc. Dyers and Colourists*, 52, 335 (1936).

[2] Von Demes, O., *Ann. Chem.*, 440, 213 (1924).

[3] Smith, A. L., and Harris, M., *J. Res. Nat. Bur. Stand.*, 16, 309 (1936)

[4] Suter, C. M., "The Organic Chemistry of Sulphur" (J. Wiley and Sons, Inc., New York, 1945).

[5] Whewell, C. S., and da Silva, M. A., *J. Text. Inst.*, 48, T98 (1957).

Structures of Some Acetyl-serine Peptides from Acetyl-chymotrypsin

IN 1958, two of us[1] obtained, by enzymic degradation of acetyl-chymotrypsin labelled with carbon-14[2], five peptides containing labelled acetyl-groups. Subsequent sequence studies[3] have shown that the largest of these peptides has the amino-acid sequence, Gly·Asp·Ser·Gly·Gly·Pro·Leu, identical with that already found[4], by degradation of the di-*iso*propylphosphoryl-enzyme, to surround the reactive serine; it may reasonably be concluded that the other four peptides contain the sequences Ser·Gly·Gly·Pro·Leu, Asp·Ser·Gly·Gly, Gly·Asp·Ser·Gly and Ser·Gly·Gly, respectively.

Since such studies cannot, on their own, show whether the acetyl-group is attached to an amino- or a hydroxyl-group in the serine residue, two others of us[5] synthesized the four peptides, (I)–(IV): (I) Ac·Ser(OH)·Gly·Gly·OH, (II) H·Ser(OAc)·Gly·Gly·OH, (III) Ac·Ser(O·Asp·H)·Gly·Gly·OH, (IV) H·Asp·Ser(OAc)·Gly·Gly·OH, with the object of comparing them with two of the smaller peptides obtained from acetyl-chymotrypsin. We now report the results of our joint work; the details of the synthetic work and of the sequence studies will be published elsewhere[3,5].

Owing to the low yields in which the smaller peptides are obtained by degradation of acetyl-chymotrypsin, direct comparison with the synthetic products was not possible. However, the behaviour of the two synthetic acetyl-tripeptides on electrophoresis (Table 1) clearly shows that, as is to be expected, only the N-acetyl-tripeptide (I) resembles the acetyl-tripeptide from acetyl-chymotrypsin in being negatively charged at *p*H 3·6 as well as at *p*H 6·5. Clearly the acetyl-tripeptide from acetyl-chymotrypsin is N-acetyl-seryl-glycyl-glycine (I), and not the O-acetyl-compound (II).

Table 1. ELECTROPHORESIS OF SOME ACETYL-SERINE PEPTIDES

Peptide	*p*H 8·6	*p*H 6·5
(I)	+5·5	+17·8
(II)	−4·4	+5·2
(III)	+2·5	+15·0
(IV)	+2·4	+15·2
Glucose control	0·0	+3·5

Paper electrophoresis, in pyridine–acetate buffer, for 1 hr. at 2,000 V./40 cm. The figures are distances migrated, in mm., towards the anode (+) or cathode (−).

It will be seen, from Table 1, that the two acetyl-tetrapeptides (III) and (IV) are electrophoretically indistinguishable. They were equally indistinguishable by paper chromatography in a number of solvent systems, and recourse had, therefore, to be made to reaction with hydroxylamine as a method for distinguishing such isomeric pairs of acetyl-peptides; this reagent splits the O-acyl linkage, only O-acetyl peptides giving the readily detected acetohydroxamic acid.

The experimental procedure was as follows. A solution of hydroxylamine was prepared by mixing solutions of potassium hydroxide (560 mgm.) in methanol (5 ml.) and of hydroxylamine hydrochloride (347 mgm.) in methanol (5 ml.) and removing the precipitated potassium chloride by centrifugation. This reagent (10 µl.) was heated for 1 min. at 100° with 50 µl. of an aqueous solution containing the acetyl-peptide (0·1 µmole); after cooling, a few drops of methanol were added and the resulting solution acidified (*p*H 6). After paper chromatography, acetohydroxamic acid was detected by spraying with an alcoholic solution of ferric chloride (1 per cent) and hydrochloric acid (1 per cent), appearing as a red spot, $R_F = 0{\cdot}89$ (in t-BuOH : HCO_2H : H_2O; 70 : 15 : 15), 0·45 (in *n*-butanol saturated with water); in the case of acetyl-peptides labelled with carbon-14, the chromatograms were also kept in contact with Kodak X-ray film, material containing carbon-14 being detected by darkening of the developed film. Appropriate markers were run in all cases.

Under these conditions, the synthetic O-acetyl-peptides, (II) and (IV), gave acetohydroxamic acid; the N-acetyl-tripeptide, (I), gave no hydroxamic acid, while the O-aspartyl-N-acetyl-peptide, (III), gave a hydroxamic acid, $R_F = 0{\cdot}26$ and 0·06 (in the two solvent systems), which was undoubtedly aspartyl-α-hydroxamic acid. Treated in the same way, the acetyl-pentapeptide ($R_F = 0{\cdot}94$ and 0·06) from acetyl-chymotrypsin gave no acetohydroxamic acid, the only radioactive material in the reaction product being the unchanged pentapeptide which is, therefore, an N-acetyl-compound; the acetyl-heptapeptide ($R_F = 0{\cdot}80$ and 0·01), however, gave acetohydroxamic acid as the sole radioactive reaction product; clearly, this peptide is an O-acetyl-compound.

Summarizing our results, it appears that, of the acetyl-serine peptides obtained by degradation of acetyl-chymotrypsin, the two which have N-terminal serine residues are N-acetyl-compounds, whereas those with other N-terminal residues are O-acetyl-compounds.

At the outset of our work it was hoped that it might afford a crucial test of the oxazoline hypothesis concerning the nature of the reactive serine in chymotrypsin and other, similar, esterases[6], since it was thought that it was only by the hydrolysis of an N-acetyl-oxazoline that N-acetyl-serine peptides could arise. However, direct experiment[5] has shown that at pH 7·8 and 37°, conditions obtaining in the second stage of the enzymic degradation of acetyl-chymotrypsin[1], the O-acetyl-tripeptide (II), is converted, within 9 hr., into the N-acetyl-tripeptide (I), and that the N-acetyl-O-peptide (III) is broken down into aspartic acid and the N-acetyl-tripeptide (I). In consequence of these findings, our conclusions concerning the structures of the acetyl-serine peptides obtained from acetyl-chymotrypsin can be explained equally well on the basis of the oxazoline[6] and histidine-activation[7] hypotheses concerning the reactive serine. Thus, on the basis of the oxazoline hypothesis, the tautomeric acetylated oxazoline may be expected to break down, on hydrolysis, to give, initially, both N-acetyl-O-peptides, such as (III), and O-acetyl-N-peptides, such as (IV); the former will, however, under the degradation conditions, break down further to give N-acetyl-peptides containing N-terminal serine residues, which will, in agreement with our results, be the only isolabile N-acetyl-peptides. Likewise, although the histidine-activation hypothesis requires that only O-acetyl-peptides should be formed initially, those containing N-terminal serine will isomerize, under the degradation conditions, to N-acetyl-peptides, again in agreement with our findings. Our results cannot, therefore, be used to discriminate between the two hypotheses; for this purpose, different methods of approach are required, and work of this kind is in progress in both our laboratories.

We thank the University of Exeter for the award of an Imperial Chemical Industries Fellowship, and Shell Research, Ltd., for a grant, which enabled one of us (L. B.) to take part in this work.

LEO BENOITON
H. N. RYDON

Washington Singer Laboratories,
The University,
Exeter.

R. A. OOSTERBAAN
M. E. VAN ADRICHEM
J. A. COHEN

Medical Biological Laboratory,
RVO-TNO,
Rijswijk Z.H.,
The Netherlands.

[1] Oosterbaan and van Adrichem, *Biochim. Biophys. Acta*, 27, 423 (1958).

[2] Balls, *J. Biol. Chem.*, 219, 245 (1956).

[3] Janzs, Berends and Oosterbaan, *Rec. Trav. Chim.*, 78, 876 (1959). Cohen, Oosterbaan, Janz and Berends, *J. Cell. Comp. Physiol.*, 54, Supp. 1, 231 (1959).

[4] Oosterbaan, Jansz and Cohen, *Biochim. Biophys. Acta*, 20, 402 (1956). Oosterbaan, Kunst, van Rotterdam and Cohen, *ibid.*, 27, 549, 556 (1958).

[5] Benoiton and Rydon, *J. Chem. Soc.* (in the press).

[6] Porter, Rydon and Schofield, *Nature*, 182, 927 (1958). Rydon, *ibid.*, 182, 928 (1958).

[7] For references, see the review by Davies and Green, "Adv. Enzymol.", 20, 283 (1958).

Ultra-violet Absorption Spectra of Proteins in Deuterium Oxide

THE absorption spectra of proteins are characterized by two absorptions in the ultra-violet region, one at 2800 and the other near 2000 Å. The former has been ascribed to the phenol[1,2], indole[3] and phenyl groups[4] of tyrosine, tryptophan and phenylalanine. The other absorption at 2000 Å. may be attributed to peptide bonds[5]. Since the absorption at 2800 Å. is due to the chromophoric groups of aromatic amino-acids, this absorption is absent in proteins, such as clupein, which do not contain aromatic amino-acid, and they have only one absorption near 2000 Å.

The contribution of aliphatic amino-acid to the ultra-violet absorption spectrum of protein solutions has not been thoroughly investigated because they do not show conspicuous absorption, except that near 2000 Å. which may be due to the carbonyl group in the COOH group[5,6].

The purpose of this work was to study the ultra-violet absorption of proteins in deuterium oxide as well as in water and to examine whether the deuteration of proteins gives rise to a change in the absorption spectrum in this wave-length region. The absorption spectra of cytochrome *c* and myoglobin, which were purified from horse heart muscle, and also ovalbumin and clupein sulphate are illustrated in the figures. According to Fig. 1 (1), cytochrome *c* has distinct absorption in deuterium oxide at 2650 Å. while it is absent in water. Although the absorption at 2800 Å. is almost hidden behind that at 2650 Å., there is still a shoulder at 2800 Å. which indicates that the electronic transition of chromophoric groups of aromatic amino-acids is not affected by deuteration and that the unknown absorption might arise from entirely different electronic transition. As is obvious from Fig. 1 (2), ovalbumin has a double-peaked absorption curve in deuterium oxide, one maximum at 2650 and the other at 2800 Å. Distinct separation of both absorptions indicates more clearly that they have different origins. Myoglobin (Fig. 1 (3)) also shows absorption at 2650 Å. in deuterium oxide, however, to a lesser extent.

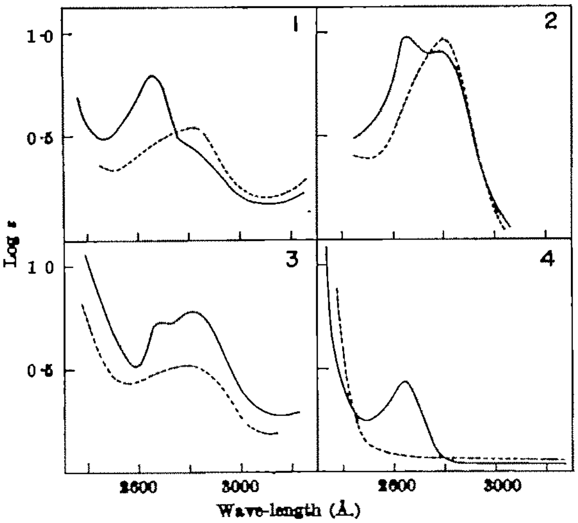


Fig. 1. Ultra-violet absorption spectra of protein solutions in deuterium oxide and water. 1, Cytochrome *c*; 2, ovalbumin; 3, myoglobin; 4, clupein, respectively. The ordinates show the relative absorption coefficients

Clupein is a protein which consists only of aliphatic amino-acids[7]. Accordingly the absorption at 2800 Å. which is characteristic of aromatic amino-acids is absent in this protein, as is shown in Fig. 1 (4) (broken line). However, this protein also shows absorption at 2650 Å. when it is dissolved in deuterium oxide, as is indicated by the solid line of Fig. 1 (4). This may be the evidence that the absorption at 2650 Å. in deuterium oxide has nothing to do with the electronic excitation of chromophores of aromatic amino-acids.

Further analyses with peptides indicate that the absorption cannot be attributed to the deuteration of the peptide bond and that it arises from the constituent simple amino-acids. Measurements with amino-acids revealed that valine, norvaline, aspartic acid, leucine, glycine and histidine showed strong absorption at 2650 Å. in deuterium oxide, but glutamic acid, alanine, aminobutyric acid and arginine and cystine did not show well-defined absorption. Measurement of tyrosine was obscured by the presence of strong absorption at 2750 Å., and I could not observe the appearance of the absorption at 2650 Å. These results indicate that some of the aliphatic amino-acids make a major contribution to the absorption of protein at 2650 Å. in deuterium oxide, rather than aromatic amino-acid, a phenomenon which has not been observed in water.

Although I have not been able to attribute this absorption to the electronic configuration of particular groups it is not likely to be due to the deuteration of dissociable groups, such as COOH, CONH or NH_2, which are capable of exchanging a hydrogen atom with deuterium atom very quickly, but may be due to the partial deuteration of non-polar groups such as hydrocarbon in α or β positions.

I am indebted to Dr. H. Tamiya for his continuous encouragement.

SHIRO TAKASHIMA

Department of Biochemistry and Biophysics,
University of Tokyo.

[1] Beaven, G. H., Holiday, E. R., and Jope, E. M., *Dis. Farad. Soc.*, 9, 406 (1950).

[2] Suzer, L. W., and Peacock, A. C., *J. Biol. Chem.*, 171, 767 (1947).

[3] Sponer, H., and Teller, E., *Rev. Mod. Phys.*, 13, 75 (1941).

[4] Loofbourow, J. R., *Rev. Mod. Phys.*, 12, 267 (1940).

[5] Blacet, J. C., Young, W. G., and Roof, J. G., *J. Amer. Chem. Soc.* 59, 608 (1937).

[6] Baba, H., *J. Chem. Soc. Japan*, 72, 74, 341 (1951).

[7] Block, R. J., Bolling, D., Borsbon, H., and Sober, H. A., *Proc. Soc. Exp. Biol. Med.*, 70, 494 (1949).

Structure of the Antibiotics *PA*114*B*-1 and *PA*114*B*-3

WE wish to report the partial structures of *PA*114*B*-1 and *PA*114*B*-3, members of the *PA*114 group of synergistic antibiotics obtained from a strain of *Streptomyces*[1]. Other reported synergistic antibiotic groups include streptogramin[2], staphylomycin[3], antibiotic *E*129[4], and mikamycin[5]. Bioautographic comparisons by us[6] and others[4,5] have indicated identities and close similarities between various members of the groups. Table 1 summarizes these comparisons and embodies a proposed universal system of designations.

Table 1. CLASSIFICATION OF SYNERGISTIC ANTIBIOTICS

Type	Specific compound	Synonyms
A	*A*1	*PA*114*A*-1 *E*129 Factor *A* Mikamycin *A* Streptogramin, main component Staphylomycin *MI*
	*A*2	Staphylomycin *MII*
B	*B*1	*PA*114*B*-1 *E*129 Factor *B* Mikamycin *B*
	*B*2	Staphylomycin *S*
	*B*3	*PA*114*B*-3
	Uncertain	Streptogramin, minor component

Antibiotics of the *A* group are neutral compounds giving a green ferric chloride test and a red colour with Ehrlich's reagent. The *B* antibiotics behave as weak acids, are negative to Ehrlich's reagent, and give a red ferric chloride test. One *A* antibiotic plus one *B* antibiotic constitute a synergistic pair having an antibacterial potency much higher than that of either component measured alone.

The characteristic properties of *PA*114*B*-1 and *PA*114*B*-3 clearly differentiate these antibiotics from staphylomycin factor *S* (Table 2).

Sealed-tube hydrolysis of *PA*114*B*-1 with 6 *N* hydrochloric acid at 120° was followed by two-dimensional chromatography. Butanol/acetic acid/water (5 : 1 : 4) and butanol/water/methylethyl ketone/diethylamine (10 : 10 : 5 : 1) gave the best separation of components. One ferric chloride-positive and seven ninhydrin-positive spots were observed. Displacement chromatography of a hydrolysate on 'Dowex 50' (partial separation) and quantitative paper chromatography using the butanol/acetic acid/water system was followed by aqueous elution. Vigorous hydrolysis (3 days, 120°) indicated that none of the compounds was a peptide. The following components were identified on the basis of R_F values, ninhydrin colours, specific rotations, and ultra-violet and infra-red spectra: L-threonine (Thr), L-phenylglycine (PhGly), L-proline (Pro), sarcosine (Sar), and D-α-aminobutyric acid (But). The optical configurations were confirmed by chromatography of a hydrolysate treated with D-amino-acid oxidase; only the spot corresponding to α-aminobutyric acid was lost.

From the initial aqueous wash of the 'Dowex 50' column chromatography an acidic component was isolated and identified as 3-hydroxy-picolinic acid (HyPic) on the basis of spectra and mixed melting point with an authentic sample.

Two additional ninhydrin-positive components were isolated from the paper chromatograms. Their characteristics are unlike those of any previously reported compounds. One of these unique amino-acids exhibited a yellow ninhydrin colour, a negative isatin test, and was displaced early from the 'Dowex 50' column. It had no characteristic ultra-violet absorption; analysis indicated no C-methyl, N-methyl, or alkoxyl. The properties are consistent with 5-hydroxymethylhydroxyproline-type compound (HMHyPro). Calculated for $C_6H_{11}O_4N$: C, 44·71; H, 6·88; N, 8·69; found: C, 44·98; H, 6·99; N, 8·58.

The second unique component gave a typical purple ninhydrin colour and exhibited ultra-violet and infra-red spectra indicative of an aromatic (dimethyl) amino-derivative of an α-amino-acid. These properties, together with elemental and group analyses, indicate a dimethylamino (methyl) phenylalanine-type structure (DMAMPhe). Direct concentration of an acid hydrolysate of *PA*114*B*-1 led to the isolation of this amino-acid as its dihydrochloride; m.p. 207°, $[\alpha]_D + 33°$. Calc. for $C_{11}H_{18}N_2O_2Cl_2$: C, 48·82; H, 6·83; N, 9·49; Cl, 24·02, C-CH_3(1), 5·0; N-CH_3(2), 19·7; found: C, 48·80; H, 6·89; N, 9·41; Cl, 22·93; C-CH_3, 1·52; N-CH_3, 20·18.

Treatment of *PA*114*B*-1 with 0·1 *N* sodium hydroxide for 30 min. at 25° and extraction at *p*H 3 with chloroform led to the isolation of a dibasic acid. Complete acid hydrolysis indicated that it contained all the components of *PA*114*B*-1. Hydrazinolysis of this new acid indicated that phenylglycine was C-terminal; *PA*114*B*-1 contains no C-terminal amino-

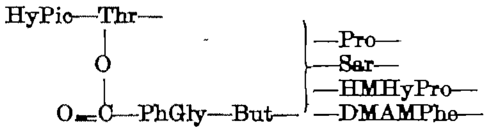
Table 2. PROPERTIES OF *PA*114*B*-1, *PA*114*B*-3 AND STAPHYLOMYCIN *S*

	*PA*114*B*-1	*PA*114*B*-3	Staphylomycin factor *S*
Melting point	265°	208°	240°
Optical activity, $[\alpha]_D^{25°}$	−59·7°	−37·2°	−28·0°
Elemental analysis C	62·07	62·77	62·80
H	6·21	6·52	6·57
N	12·77	12·61	11·46
Ultra-violet maxima (MeOH)	260 mμ (*E*(1%, 1 cm.) = 217) 305 mμ (*E*(1%, 1 cm.) = 105)	258 mμ (*E*(1%, 1 cm.) = 204) 305 mμ (*E*(1%, 1 cm.) = 95)	207 mμ (*E*(1%, 1 cm.) = 590) 304 mμ (*E*(1%, 1 cm.) = 86)
Neutral equivalent	1,000	1,070	790
pKa (MeOH)	8·5		9·0

acid. The generation of a terminal group by mild alkaline hydrolysis indicated the presence of a peptide chain closed by means of a lactone linkage—the carboxyl of phenylglycine to the hydroxyl of one of the hydroxyamino-acids. The similarity between *PA*114*B*-1 and staphylomycin factor *S* (ref. 7) makes a phenylglycine to threonine linkage, as in the latter, probable. Hydroxypicolinic acid, being incapable of forming a peptide via the nitrogen, must be N-terminal.

Partial hydrolysis of *PA*114*B*-1 (1 *N* hydrochloric acid, 37°, 1 week) and paper chromatography led to the isolation of two fluorescent peptides. After complete hydrolysis and two-dimensional chromatography on the systems described above, one of these peptides was found to have all the components of *PA*114*B*-1 except phenylglycine, confirming its C-terminal nature. The other peptide lacked only phenylglycine and α-aminobutyric acid.

At this stage we postulate the structure of *PA*114*B*-1 as:



This compares favourably with the analysis of Table 2 (calc. for $C_{48}H_{61}N_9O_{12}$: C, 60·33 ; H, 6·60 ; N, 13·11).

*PA*114*B*-3[6], a minor antibiotic of the *PA*114 complex, contains all the components of *PA*114*B*-1 except sarcosine. A new component (negative ninhydrin and ferric chloride tests) is also present ; a positive *p*-nitrobenzoyl chloride test[8] indicates that it is probably an N-methyl amino-acid.

Work on the structures of *PA*114*B*-1 and *PA*114*B*-3 are continuing.

D. C. HOBBS
W. D. CELMER

Biochemical Research Department,
Chas. Pfizer and Co., Inc.,
Research Laboratories,
Groton,
Connecticut.

---

[1] Celmer, W. D., and Sobin, B. A., "Antibiotics Annual 1955–1956", 437 (Medical Encyclopedia, Inc., New York).

[2] Charney, J., Fisher, W. P., Curran, C., Machlowitz, R. A., and Tytell, A. A., *Antibiotics and Chemother.*, 3, 1283 (1953).

[3] Vanderhaeghe, H., Van Dijck, P., Parmentier, G., and De Somer, P., *Antibiotics and Chemother.*, 7, 606 (1957).

[4] Ball, S., Boothroyd, K. A., Lees, K. A., Raper, A. H., and Smith, E. L., *Biochem. J.*, 68, 24 (1958).

[5] Arai, M., Okabe, K., Yonehara, H., and Umezawa, H., *J. Antibiotics*, 11, A, 21 (1958).

[6] Hobbs, D. C., and Celmer, W. D., *Fed. Proc.*, 18, 246 (1959).

[7] Vanderhaeghe, H., and Parmentier, G., *Bull. Soc. Chim. Belg.*, 68, 716 (1959).

[8] Sheehan, J. C., Zachau, H. G., and Lawson, W. B., *J. Amer. Chem. Soc.*, 80, 3349 (1958).

Presence of Immunologically Active Fragments after Proteolytic Degradation of Human γ-Globulin

ACCORDING to Lapresle, Kaminski and Tanner[1], degradation of human serum albumin with trypsin or chymotrypsin yields several components with retained ability to give precipitation reactions with anti-human albumin antibodies. One of these components has been isolated by column electrophoresis in an agar medium and partially characterized by ultracentrifugation[2]. Porter[3] isolated and characterized a similar component after chymotryptic hydrolysis of bovine serum albumin. After degradation of rabbit γ-globulin with papain, Porter also isolated a component showing inhibitory properties when added to a rabbit γ-globulin–anti-γ-globulin system[4].

We have carried out immunological analyses of human γ-globulin after degradation with trypsin and chymotrypsin, respectively. Immunologically pure γ-globulin (as shown with anti-human plasma sera in immune electrophoresis), supplied by AB Kabi, Sweden, was used. Amounts of 0·1–1·0 gm. γ-globulin were hydrolysed at *p*H 8·2 and 25° C. with commercial preparations of crystalline enzymes, using enzyme/substrate ratios of 1 : 50. After 24 hr. the reaction was interrupted by the addition of diisopropyl fluorophosphate[5]. The hydrolysates were analysed by means of immune electrophoresis[6].

The results of these analyses are shown in Fig. 1. After tryptic hydrolysis, the γ-globulin gave rise to two crossing lines when analysed with anti-γ-globulin immune sera (Behringwerke, Germany). The chymotryptic hydrolysate showed by similar analysis a dense precipitate which resembled the regular γ-globulin line. In addition two other lines

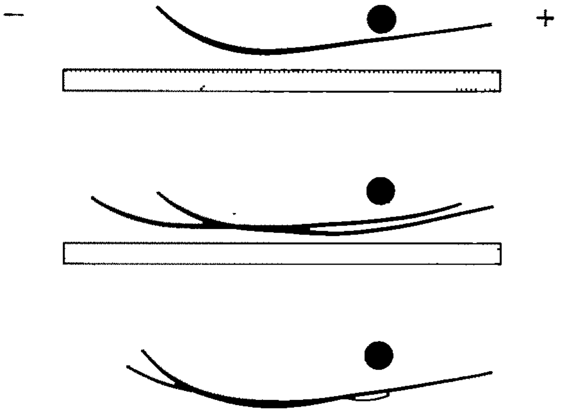


Fig. 1. Immune electrophoresis of human γ-globulin (top basin), γ-globulin degraded by trypsin (middle basin) and γ-globulin degraded by chymotrypsin (lower basin). Immune serum: anti-human γ-globulin

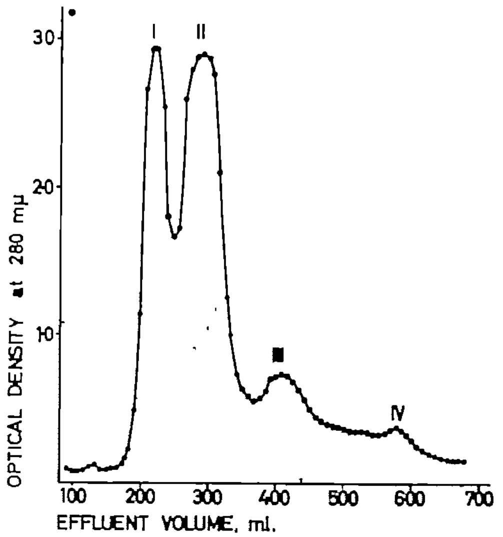


Fig. 2. Gel filtration of a tryptic hydrolysate of human γ-globulin on 'Sephadex G-75'. Eluant: 0·05 *M* sodium chloride

were formed, one farther out in the γ-globulin region and the other near the starting basin. All three lines were interconnected.

Preliminary experiments to separate the breakdown products demonstrated immunologically were carried out by the gel filtration method described by Porath and Flodin[7]. A dextran gel with a water regain of 4·9 ('Sephadex G-50', manufactured by AB Pharmacia, Sweden) was first tried. It was found, however, that more than 80 per cent of the degraded γ-globulin passed through the column without any retention. Therefore a gel with a lower degree of cross-linking was tried ('Sephadex G-75' with a water regain of 8·0). The column (4 cm. × 85 cm.) was equilibrated with 0·05 *M* sodium chloride, and the uniformity of the packing was tested by passing a hæmoglobin solution through the column. 500 mgm. of a tryptic hydrolysate of γ-globulin in 5 ml. of 0·05 *M* sodium chloride was then put on the column and eluted with a rate of flow of 20 ml. per hr. The effluent was collected in 7–8 ml. fractions, and the optical density of each fraction at 280 mμ was determined. The resulting curve is seen in Fig. 2. Immune electrophoretic analyses were carried out on fractions I–III, and the results are shown in Fig. 3. Fraction I showed one dense precipitate with its maximum mainly in the β_2- but extending into the γ-globulin region, where a confluent precipitate, farther out in the γ-globulin region, joined it. Fraction II showed two crossing lines, one with its maximum in the β-globulin region and the other with a maximum corresponding to slow-moving γ-globulin. With fraction III only a very faint precipitate was formed in the β_2-globulin region. Analogous results were obtained by gel filtration of a chymotryptic hydrolysate of γ-globulin (Cederblad, G.; Hanson, L. Å., and Johansson, B. G., unpublished work).

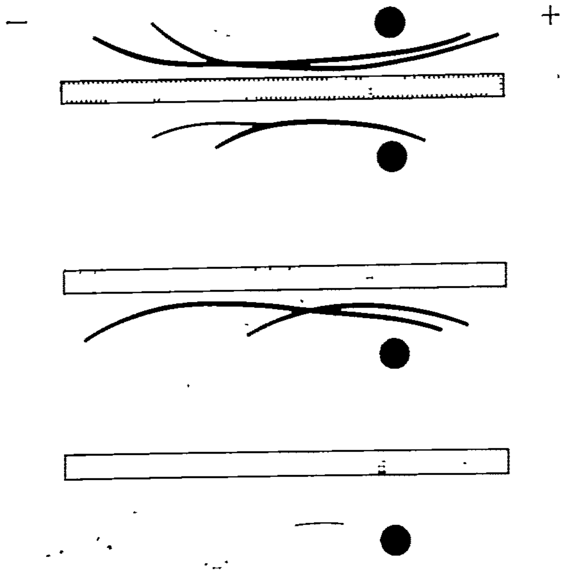


Fig. 3. Immune electrophoresis of human γ-globulin degraded by trypsin (top basin) and of fractions I, II and III obtained by gel filtration of this degraded γ-globulin. Immune serum: anti-human γ-globulin

From these results it can be concluded that normal human γ-globulin contains different antigenic groupings, with the ability to react with anti-γ-globulin antibodies. Corresponding findings concerning pathological γ-globulins have been presented by Scheidegger and Buzzi[8].

Further work on the isolation and characterization of immunologically active degradation products from immune globulins is in progress.

We are grateful to the Misses M. Wikström and A. Wallin for skilful technical assistance. The work was supported by grants from the Medical Faculty, University of Gothenburg, and the Swedish Dairies' Association.

L. Å. HANSON

Department of Bacteriology,

B. G. JOHANSSON

Department of Medical Biochemistry,
University of Gothenburg.

April 11.

[1] Lapresle, C., Kaminski, M., and Tanner, C. E., *J. Immunol.*, 82, 94 (1959).

[2] Lapresle, C., Webb, T., Kaminski, M., and Champagne, M., *Bull. Soc. Chim. Biol.*, 41, 695 (1959).

[3] Porter, R. R., *Biochem. J.*, 66, 677 (1957).

[4] Porter, R. R., *Nature*, 182, 670 (1958).

[5] Gorini, L., and Felix, F., *Biochim. Biophys. Acta*, 11, 535 (1953).

[6] Grabar, P., and Williams, C. A., *Biochim. Biophys. Acta*, 17, 67 (1955).

[7] Porath, J., and Flodin, P., *Nature*, 183, 1657 (1959).

[8] Scheidegger, J.-J., and Buzzi, C., *Rev. franç. Ét. clin. biol.*, 2, 895 (1957).

Starch-Gel Electrophoresis of Wheat Proteins

IT has been claimed that starch-gel electrophoresis may have a higher resolving power than that of the Tiselius apparatus for serum proteins[1]. In spite of its potential value, there have been no reports in the literature of the application of this technique to the study of wheat proteins. Wheat gluten has been separated into at least six components by Jones *et al.*[2], using the Tiselius apparatus, and Zentner[3] has reported the presence of seven proteins, using continuous paper electrophoresis. The present communication describes some preliminary experiments in which starch-gel electrophoresis has been used to examine the proteins of the gluten complex of wheat.

10 gm. of wet gluten were prepared from wheat flour by hand kneading in distilled water and were dispersed in 200 ml. *N*/100 acetic acid in a high-speed

stirrer, fitted with sharp steel blades, in 5 min. After centrifuging for 30 min. at 2,000 r.p.m., the liquid was subjected to starch-gel electrophoresis. Both horizontal and vertical[4] techniques were used. Connaught starch was used, 12·2 gm. mixed with 100 ml. of an aluminium lactate buffer[3]. The sample slot (1–2 mm. wide) was filled with protein solution mixed with starch granules, but in later work the starch was omitted without affecting the quality of the patterns. Runs were normally made for 2–4 hr. at a potential gradient of 4–6 V. cm.$^{-1}$. The gels were sliced and the cut surfaces stained with naphthalene black 10*B*.

Centrifugation at 2,000 r.p.m. does not remove colloidal particles, which migrate into the gel for several mm., and tend to obscure some of the slower-moving bands. They stain strongly, but can be distinguished from a true band by the characteristic irregular appearance. Under a low-power microscope the 'band' can be seen to consist of dyed particles. When a dispersion was cleared by ultracentrifugation at 20,000*g*, the 'band' no longer appeared on electrophoresis.

Table 1

Mobility (cm.^{2} V.$^{-1}$ sec.$^{-1}$)	Intensity of band			
	Bison	Flamingo	Rescue	Witchita
2·6	*m*	?	?	*m*
3·5	*s*	*m*	?	*m*
4·2	*s*	*s*	*s*	*s*
6·4	*f*	*m*	*m*	*f*
8·3	*m*	*s*	*m*	*m*
9·2	*f*	*m*	*m*	*f*
10·2	*vf*	*f*	*f*	*f*
12·7	*vf*	*f*	*f*	*f*

vf, very faint; *m*, medium; *s*, strong; ?, partially obscured.

Table 1 gives an example of electrophoresis patterns obtained on a four-channel vertical apparatus[4] for glutens from four wheat varieties of widely differing baking characteristics (Table 2). It is interesting to note that each of the four varieties examined shows patterns of similar electrophoretic mobilities, and the patterns differ only in the distribution of intensities. It should be pointed out that the presence of eight distinct and separate bands in the electrophoresis patterns does not necessarily prove that eight different proteins are present, since some of the bands could conceivably arise as a result of complex formation.

Table 2

Wheat	Source	Type	Baking strength
Bison	U.S.A.	Hard red winter	Strong
Flamingo	England	White winter	Very weak
Rescue	U.S.A.	Hard red spring	Weak
Witchita	U.S.A.	Hard red winter	Medium

The pattern of mobilities quoted in Table 1 is typical of the results of a large number of experiments, in all of which at least eight distinct bands have been found, but variations of the order of 20 per cent in mobility are found when comparing individual runs. This is probably due principally to the difficulty in preparing gels of precisely reproducible properties. The mobilities reported here are higher than those obtained for wheat proteins by Jones *et al.*[2] at 1° C. The highest value obtained by them was 6·5 × 10^{-5} cm.^{2} V.$^{-1}$ sec.$^{-1}$. Our experiments were carried out at approximately 25° C., and the increase in conductivity, due to the use of a higher temperature, would be enough to account for the increased mobilities, since the presence of starch up to concentrations of 12·5 per cent does not significantly affect the electrical conductivity of salt solutions (Collison, R., private communication).

The work reported here demonstrates that starch-gel electrophoresis is a valuable method for investigating wheat proteins, as complete resolution of the eight bands reported was obtained. Further studies of the protein components in wheats of different origin are in hand, using this method in conjunction with column chromatography and immuno-techniques.

Thanks are expressed to Mr. E. N. Greer of the Research Association of British Flour Millers for milling the wheats used in these experiments.

G. A. H. Elton
J. A. D. Ewart
British Baking Industries Research Association,
Chorleywood, Herts.

April 25.

---

[1] Smithies, O., *Biochem. J.*, 61, 629 (1955).

[2] Jones, R. W., Taylor, N. W., and Senti, F. R., *Arch. Biochem. Biophys.*, 84, 363 (1959).

[3] Zentner, H., *Chem. and Indust.*, 317 (1960).

[4] Smithies, O., *Biochem. J.*, 71, 585 (1959).

Activity of Bovine Pancreatic Ribonuclease *A* in Mixed Solvent Systems

It has been shown that bovine pancreatic ribonuclease may be dissolved in organic solvents with full recovery of the activity after removal of the solvent[1]. We have found that ribonuclease *A* retains its activity in the presence of high concentrations of many organic solvents and have utilized this property for investigating its mode of action. If the solvent used is methanol then the products of the action of ribonuclease on cytidine-2′,3′-phosphate are cytidine-3′-phosphate and cytidine-3′-phosphate methyl ester as previously observed by Heppel and Whitfeld[2]. As the mole fraction of methanol is raised, methanolysis increases and hydrolysis decreases as shown in Fig. 1. This behaviour is consistent with competition between methanol and water for a site on the enzyme.

The effect of solvents on enzyme-catalysed reactions is due to many causes including shifts in *pK*'s of buffers, substrate and protein as well as direct effects on the binding and catalysis. Thus solvent effects have contributed little to our understanding of enzyme catalysis. However, for ribonuclease it is possible to observe simultaneously the effect of addition of solvent on methanolysis and hydrolysis. This has been achieved by keeping a constant ratio of water : methanol while varying the concentration of another, inert, organic solvent (dioxane, formamide and dimethyl formamide). Under these conditions the solvent will have widespread effects but those involving the cyclic phosphate probably do not influence the relative rates of hydrolysis and methanolysis. Thus any changes in the relative rates which are observed may be attributed to the effects of the solvent on the interaction of water or alcohol with the protein. In Fig. 2 are shown the effects of dioxane and formamide on the ratio of the initial rates of esterification and hydrolysis. While formamide has little effect on this ratio, hydrolysis is very much favoured by increasing amounts of dioxane. This effect is not due to alteration of *pK*'s since the ratio esterification : hydrolysis was found to be substantially independent of *p*H when this was varied over a range covering any likely *pK* change. It is

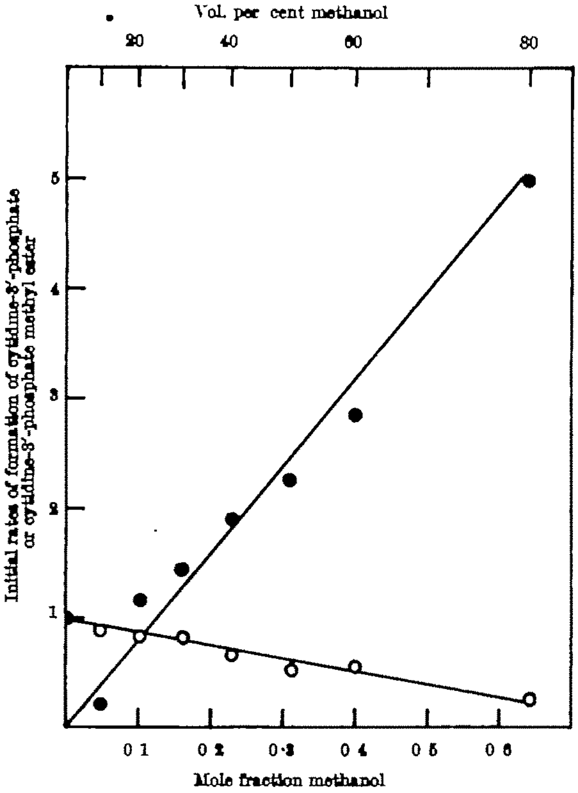


Fig. 1. The effect of methanol on the initial rates of formation of cytidine-3'-phosphate methyl ester (●) and cytidine-3'-phosphate (○). Rates are relative to hydrolysis of cytidine-2',3'-phosphate in absence of methanol. Cytidine-2',3'-phosphate, 0·05 *M* in citrate buffer at *p*H 6·9. Temperature, 25° C.

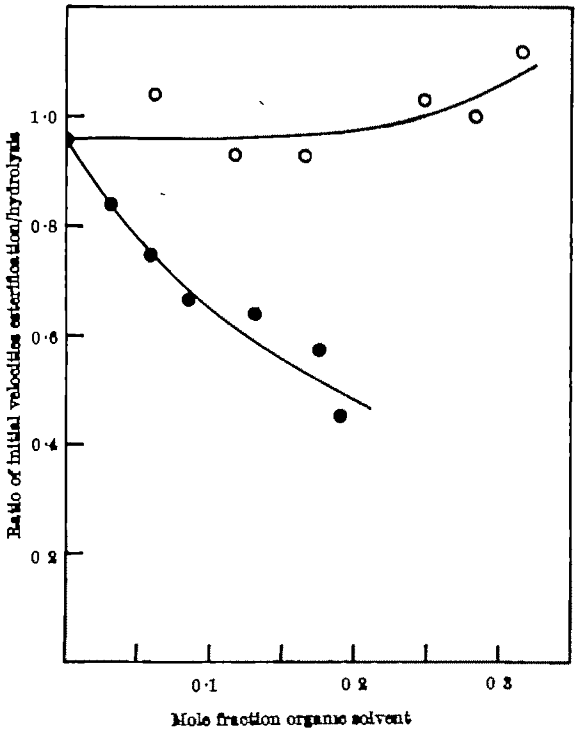


Fig. 2. The effect of formamide (○) and dioxane (●) on the ratio of the initial velocity of esterification to the initial velocity of hydrolysis of cytidine-2',3'-phosphate. Ratio water : methanol constant and equal 3 · 1 v/v

evident that there is a site on the enzyme surface which binds either water or methanol. The superiority of methanol as an attacking reagent (Fig. 1) and the effect of dioxane suggest that there is a Van der Waals interaction between methanol and the protein. Dioxane favours hydrolysis relative to methanolysis by interfering with the Van der Waals interaction.

It can be seen that considerable information can be obtained by measuring the activity of enzymes in mixed solvent systems. By investigating the effect of organic solvents on the *p*H activity curves using buffers of both types of charge, it should be possible to determine the type of charge of the ionizing groups controlling the enzyme activity.

One of us (D. F.) is indebted to the Ontario Research Foundation for a personal grant.

Dorothy Findlay
A. P. Mathias
B. R. Rabin

Department of Biochemistry,
University College,
London.

---

[1] Sage, H. J., and Singer, S. J., *Biochim. Biophys. Acta*, 29, 663 (1958).

[2] Heppel, L. A., and Whitfeld, P. R., *Biochem. J.*, 56, 1 (1954).

Action of Tetrakis(Hydroxymethyl)Phosphonium Chloride on Wool

In an investigation of the action of tetrakis(hydroxymethyl)phosphonium chloride (THPC) on wool the following interesting observations have been made.

When wool treated with tetrakis(hydroxymethyl)phosphonium chloride is dyed together with a sample of untreated wool with acid or premetallized dyes, the treated wool absorbs much more dye than the untreated. Uptake of the basic dye methylene blue is, however, less for the treated than for the untreated wool. The addition of tetrakis(hydroxymethyl)phosphonium chloride to the dye liquor greatly accelerates the rate of dye absorption.

When wool fibres, stretched 40 per cent, are boiled for various times in tetrakis(hydroxymethyl)phosphonium chloride solution (2 per cent) and afterwards relaxed for 1 hr. in boiling water, the results shown in Fig. 1 are obtained. It is evident that the amount of

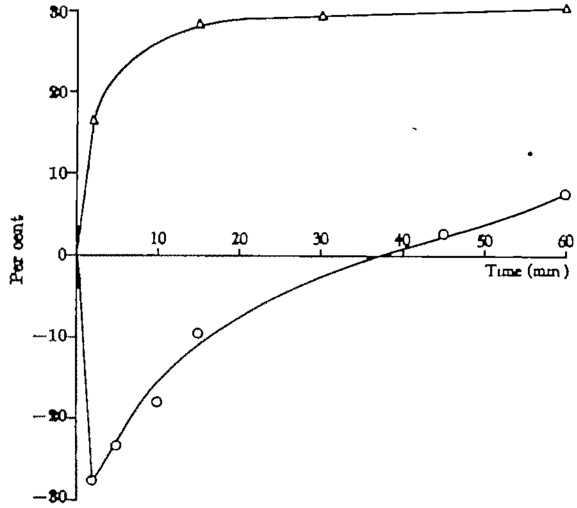


Fig. 1. Variation of set with time of treatment at the boiling point. ○, In water; △, in THPC

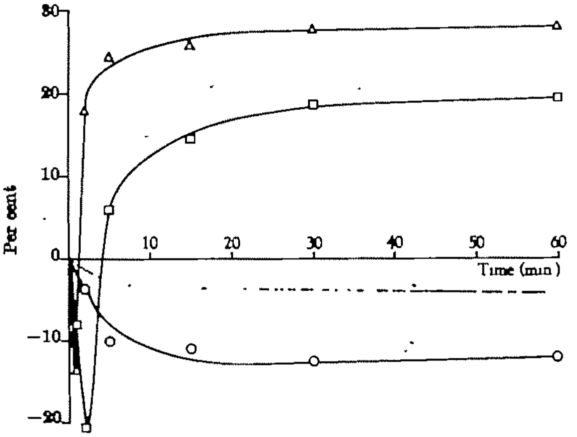


Fig. 2. Variation of set with time of treatment at the boiling point. ....., Deaminated, iodinated and potassium cyanide-treated fibres in water; △, iodinated fibres in THPO; □, deaminated fibres in THPO; ○, potassium cyanide-treated fibres in THPO

set retained by the fibres after they have been afterwards boiled freely is much greater than after a similar treatment of stretched fibres in boiling water. The effect of tetrakis(hydroxymethyl)phosphonium chloride depends on the strength of the solution, but is marked even at a concentration of 0·1 per cent. In dilute solutions the supercontraction characteristic of stretched fibres in boiling water is observed. Typical results are shown in Table 1.

Table 1

Concentration of THPO solution (per cent)	Set (+ve sign) or supercontraction (−ve sign) after relaxing the fibres, treated in the stretched state for 2 min.	120 min.
0·1	−17·8	28·6
0 5	+4·9	22·9
1·0	13 0	22·5
2 0	17·1	24·5

It is not possible to set stretched fibres which have been previously iodinated or deaminated in boiling water, but these materials are readily set in a solution of tetrakis(hydroxymethyl)phosphonium chloride (2 per cent). It is not, however, possible to set stretched fibres which have been previously treated with potassium cyanide, either in water or tetrakis (hydroxymethyl)phosphonium chloride solutions. These results are shown in Fig. 2.

When slack fibres are boiled in a solution of tetrakis(hydroxymethyl)phosphonium chloride (1 per cent) for 1½ min. at pH 7, supercontraction occurs to the extent of 38 per cent.

The reaction of tetrakis(hydroxymethyl)phosphonium chloride with wool is no doubt complex; but at present it is considered to involve reduction of the disulphide bond as the primary process, accompanied by the absorption of the phosphonium ion, thus increasing the number of positive sites in the fibre. Work on this topic is proceeding and will be reported in full elsewhere.

We wish to thank the Wool Textile Research Council for financial support, and Messrs. Albright and Wilson, Ltd., for supplies of reagents.

L. S. Bajpai
C. S. Whewell
J. M. Woodhouse

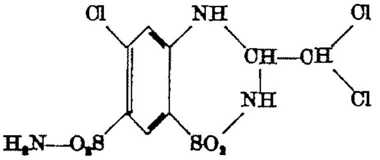
Department of Textile Industries,
The University,
Leeds, 2.

PHYSIOLOGY

A Potent New Benzothiadiazine Diuretic

Since the discovery of chlorothiazide by Beyer *et al.*[1], a number of chemically related compounds have been shown to possess similar natriuretic and chloruretic actions[2-4]. Some of these agents, notably 3,4-dihydrochlorothiazide and its derivatives, differ from chlorothiazide primarily in a greater milligram potency, which may be associated with a longer duration of action[5]. These agents also inhibit carbonic anhydrase to a lesser extent than the unsaturated analogues, resulting in a lower urinary pH and generally a greater chloruretic response[5,6].

In an effort to determine how further structural modifications of the chlorothiazide nucleus might alter the renal actions, we have undertaken an investigation of derivatives substituted in the 3 position of the dihydro analogue[7]. This is a preliminary report of pharmacological studies on one of these compounds, trichlormethiazide (*NAQUA*^{TM} is the Schering brand of trichlormethiazide), which has been characterized by marked diuretic activity at very low doses. The chemical formula of this agent is as follows:



3-dichloromethyl-6-chloro-7-sulphamyl-3,4-dihydro-1,2,4-benzothiadiazine-1,1-dioxide (trichlormethiazide).

The effect of trichlormethiazide on urine and electrolyte excretion was studied in anæsthetized dogs in which the ureters were cannulated and total urine was collected every 5 min. Urine samples were analysed for sodium, potassium and chloride. Typical results of intravenous administration of 1·0 µgm./kgm. are presented in Table 1.

Table 1. Effect of Trichlormethiazide on Urine Output and Electrolyte Excretion in an Anæsthetized Dog

Time (min.)	Urine (ml./min.)	Sodium	Potassium	Chloride
		Microequivalents per min.		
−15	0 26	98	43	68
−10	0·26	101	39	65
−5	0·24	100	31	62
0	1·0 µgm./kgm. trichlormethiazide (intravenous)			
5	0·28	112	32	68
10	0·32	136	34	85
15	0 34	134	30	98
20	0·32	128	30	96
25	0·30	122	30	88
30	0·28	126	31	82
35	0·24	97	25	67

These results demonstrate that a significant natriuretic and chloruretic response can be elicited at doses as low as 1·0 µgm./kgm. and that the sodium and chloride increases are equimolar. Potassium excretion increased slightly but considerably less than sodium and chloride. The maximum natriuretic response occurred approximately 10 min. after administration. Duration of action was 30 min.

The relative activities of trichlormethiazide in terms of chlorothiazide, and trichlormethiazide in terms of 3,4-dihydrochlorothiazide, by the oral route have been determined in unanæsthetized dogs using a modified cross-over design (32 animals for each assay). Dose-levels (2) and compounds (2) were both crossed over on two experimental days set one week apart. The doses were selected on the basis of previous experimental data to elicit approximately the same natriuretic response. Urine and sodium excretion-rates were determined for a 5-hr. period after treatment. Relative activities of trichlormethiazide were obtained by comparing the dose-response curves and analysing the results by statistical methods. The results are summarized in Table 2.

Table 2. COMPARATIVE ACTIVITY OF THREE THIAZIDE DIURETICS ON URINE OUTPUT AND SODIUM EXCRETION IN DOGS

Compound	Dose µgm./kgm.	Urine output ml./5 hr.	Urine output Relative activity	Sodium excretion m.eq./5 hr.	Sodium excretion Relative activity
Chlorothiazide versus trichlormethiazide					
CT	500	54	1·0	14·3	1·0
CT	3,000	73		16·6	
TCM	15	54	58·9	11·4	72·0
TCM	90	97	(25·2–168·0)*	27·2	†
3,4-Dihydrochlorothiazide versus trichlormethiazide					
HCT	100	50	1·0	12·8	1·0
HCT	600	84		18·4	
TCM	15	62	7·9	16·6	13·6
TCM	90	79	(7·1–9·4)*	19·6	(6·5–34·0)*

* 95 per cent confidence limits.

† Confidence limits could not be calculated since analysis showed significant non-parallelism between curves at P 0·01.

On a dose basis, trichlormethiazide was found to be 72·0 times more active than chlorothiazide and 13·6 times more active than 3,4-dihydrochlorothiazide in promoting the excretion of sodium. Potency values for urine output were 58·9 and 7·9, respectively. Average urine output in the same animals, untreated, was found to be 30–40 ml./5 hr. while control sodium excretion averaged 4–8 m.equiv./5 hr. These findings suggest that the minimally effective oral dose of trichlormethiazide is less than 15 µgm./kgm., and that this agent, like chlorothiazide and 3,4-dihydrochlorothiazide, is well absorbed through the gastrointestinal tract.

RICHARD M. TAYLOR
MARTIN M. WINBURY

Department of Pharmacology,
Scientific Research Division,
Schering Corporation,
Bloomfield, New Jersey.

[1] Beyer, K. H., Baer, J. E., Russo, H. F., and Haimbach, A. S., *Fed. Proc.*, 16, 282 (1957).

[2] Sprague, J. M., *Ann. N.Y. Acad. Sci.*, 71, 328 (1958).

[3] Logemann, W., Giraldi, P. N., and Parenti, M. A., *Nature*, 182, 1510 (1958).

[4] Renzi, A. A., Chart, J. J., and Gaunt, R., *Toxicol. and App. Pharmacol.*, 1, 406 (1959).

[5] Barrett, W. E., Rutledge, R. A., Sheppard, H., and Plummer, A. J., *Toxicol. and App. Pharmacol.*, 1, 333 (1959).

[6] Jones, J. H., and Jones, J. V., *Brit. Med. J.*, ii, 928 (1959).

[7] Taylor, R. M., and Winbury, M. M., *Pharmacologist*, 1 (2), 53 (1959).

Effect of Cocaine on the Disposition of Noradrenaline labelled with Tritium

COCAINE potentiates the responses of sympathetically innervated organs to adrenaline, noradrenaline and sympathetic nerve stimulation, and several explanations have been offered for this. Cannon and Rosenblueth[1] suggested that cocaine might act by preventing the destruction of injected adrenaline, or of transmitter substance released from adrenergic nerves, and Torda[2] and Trendelenburg[3] obtained evidence in support of this hypothesis. Macmillan[4] suggested that cocaine might prevent the uptake of catecholamines into tissue stores, and block their release from these stores, but his evidence was only indirect.

O-methylation is a major route for the inactivation of circulating catecholamines[5], and, more recently, binding by many tissues has been shown to be important for the inactivation of circulating adrenaline[6] and noradrenaline[7]. This communication describes the influence of cocaine on the uptake into tissues of noradrenaline labelled with tritium, and the formation of ^{3}H-normetanephrine by O-methylation.

Male cats (1·7–3·6 kgm.) were anæsthetized with pentobarbitone sodium (35 mgm./kgm.) intraperitoneally and a tracheostomy performed. The right femoral artery was cannulated for recording the blood-pressure and the left femoral artery for the withdrawal of blood samples. Cocaine (5 mgm./kgm.), dissolved in 5 ml. 0·9 per cent (w/v) sodium chloride solution, was injected intravenously over a period of 5–10 min. When the blood-pressure had returned to a steady level, *dl*-β-^{3}H-noradrenaline (1·72 mc./mgm.) was injected intravenously (dose, 25 µgm./kgm.) within 5–10 sec. Blood samples were withdrawn periodically and the animals were decapitated 1 hr. after the injection of noradrenaline. Adrenal glands, heart, liver, abdominal wall muscle and spleen were removed immediately, homogenized and analysed for ^{3}H-noradrenaline and ^{3}H-normetanephrine[8].

Table 1. EFFECT OF COCAINE ON THE TISSUE CONTENT OF ^{3}H-NORADRENALINE AND ^{3}H-NORMETANEPHRINE

Results are expressed in mµgm. ^{3}H-noradrenaline or ^{3}H-normetanephrine per gm. of tissue (mean value ± *S.E.*), and were obtained with seven untreated and four cocaine-treated cats (for details of dosage see text). Cats were injected intravenously with ^{3}H-noradrenaline (25 µgm./kgm.)

Tissue	^{3}H-Noradrenaline		^{3}H-Normetanephrine	
	Untreated	Cocaine-treated	Untreated	Cocaine-treated
Adrenal gland	121 ± 17	26 ± 9·0	9·0 ± 1·2	5·5 ± 0·5
Heart	165 ± 20	29 ± 5·8	16·4 ± 3·2	5·2 ± 0·4
Spleen	151 ± 21	22·5 ± 1·9	17 ± 1·9	7·1 ± 0·5
Liver	18·7 ± 3·9	8·0 ± 0·7	8·0 ± 1·1	6·3 ± 1·2
Skeletal muscle	4·6 ± 0·7	3·0 ± 0·5	5·2 ± 1·1	8·1 ± 0·7

The effect of cocaine on the concentrations of ^{3}H-noradrenaline and ^{3}H-normetanephrine in tissues is shown in Table 1. Adrenal glands, heart and spleen are three tissues in which uptake and retention of injected noradrenaline has been shown to be greatest[7]; in these organs administration of cocaine has resulted in a marked reduction in their content of ^{3}H-noradrenaline. The quantity of ^{3}H-noradrenaline in liver and skeletal muscle 1 hr. after the injection was also reduced, but to a smaller extent. The effect of cocaine on the tissue-levels of ^{3}H-normetanephrine was less marked; reductions were observed in heart and spleen and an elevation in skeletal muscle. Because of its bulk, muscle accounts for most of the ^{3}H-noradrenaline and ^{3}H-normetanephrine remaining in the animals at the end of the experiments.

Table 2 shows the plasma-levels of ^{3}H-noradrenaline and ^{3}H-normetanephrine at various times after the injection of ^{3}H-noradrenaline. In the cocaine-treated animals the level of ^{3}H-noradrenaline exceeded the control-levels during the first 3 min. after the injection, confirming the observations of Trendelenburg[3], but in later blood samples there was no significant difference between the two groups.

These experiments show that cocaine markedly reduces the uptake of circulating noradrenaline into

Table 2. INFLUENCE OF COCAINE ON PLASMA LEVELS OF ^{3}H-NORADRENALINE AND ^{3}H-NORMETANEPHRINE

Results are expressed in mμgm. ^{3}H-noradrenaline or ^{3}H-normetanephrine per ml. of plasma (mean value ± *S.E.*)

Time after injection (min.)	^{3}H-Noradrenaline		^{3}H-Normetanephrine	
	Untreated	Cocaine-treated	Untreated	Cocaine-treated
1	80·3 ± 9·5	212 ± 19	3·9 ± 0·5	5·5 ± 0·7
2	49·3 ± 5·8	89·5 ± 9·0	5·7 ± 1·0	6·4 ± 0·9
3	31·1 ± 3·1	51·7 ± 7·5	5·6 ± 0·7	8·4 ± 1·1
5	21·5 ± 1·7	25·1 ± 2·8	5·5 ± 0·8	8·3 ± 1·2
10	13·8 ± 1·3	13·3 ± 0·9	3·6 ± 0·5	4·8 ± 0·6
30	8·5 ± 1·4	7·3 ± 0·5	1·5 ± 0·1	1·9 ± 0·1
60	5·4 ± 0·5	3·9 ± 0·4	1·1 ± 0·2	0·8 ± 0·05

certain tissues, presumably by interfering with binding of the hormone. This interference with the uptake raises the amount of circulating catecholamine, and this is reflected in the increased plasma noradrenaline-levels observed in the early stages after an intravenous injection. Noradrenaline therefore exists in a free and active state for a longer period than in untreated animals, and these observations may be sufficient to explain the effect of cocaine in increasing the sensitivity of sympathetically innervated organs to circulating catecholamines.

It is unlikely that cocaine is acting by interfering with the enzymic inactivation of injected noradrenaline, since we have found that it does not inhibit O-methyl transferase *in vitro*. Furthermore (Table 1), cocaine has had little effect on the content of ^{3}H-noradrenaline, and no significant effect on the concentration of ^{3}H-normetanephrine in the liver, which is the organ having the highest concentration of catechol-O-methyl transferase[9].

We have found that reserpine also reduces the tissue content of ^{3}H-noradrenaline, and elevates the plasma-levels (unpublished observations). Both reserpine[10] and cocaine[1] cause supersensitivity of sympathetically innervated organs, but reserpine releases catecholamines from tissue stores[11], whereas cocaine prevents both their release[10,12] and uptake in the tissues. Although acting by different mechanisms, both drugs produce a common end-result, that is, lower tissue concentration of administered catecholamine, elevated plasma-levels of the free hormone, and consequently supersensitivity.

L. G. WHITBY*
G. HERTTING†
J. AXELROD

Laboratory of Clinical Science,
National Institute of Mental Health,
National Institutes of Health,
Bethesda, Maryland.

---

* Fellow of the Rockefeller Foundation. Present address: Biochemistry Department, University of Cambridge, England.

† Visiting scientist.

[1] Cannon, W. B., and Rosenblueth, A., "Autonomic Neuro-effector Systems" (The Macmillan Co., New York, 1937).

[2] Torda, C., *J. Pharmacol. and Exp. Therap.*, 78, 331 (1943).

[3] Trendelenburg, U., *J. Pharmacol. and Exp. Therap.*, 125, 55 (1959).

[4] Macmillan, W. H., *Brit. J. Pharmacol.*, 14, 385 (1959).

[5] Axelrod, J. Inscoe, J. K., Senoh, S., and Witkop, B., *Biochim. Biophys. Acta*, 27, 210 (1958).

[6] Axelrod, J., Weil-Malherbe, H., and Tomchick, R., *J. Pharmacol. and Exp. Therap.*, 127, 251 (1959).

[7] Whitby, L. G., Weil-Malherbe, H., and Axelrod, J., *Fed. Proc.*, 19, 295 (1960).

[8] Whitby, L. G., Weil-Malherbe, H., and Axelrod, J. (in preparation).

[9] Axelrod, J., and Tomchick, R., *J. Biol. Chem.*, 233, 702 (1958).

[10] Burn, J. H., and Rand, M. J., *J. Physiol.* (Lond.), 144, 314 (1958).

[11] Carlsson, A., Rosengren, E., Bertler, A., and Nilsson, J., "Psychotropic Drugs", 363 (Elsevier Pub. Co., Amsterdam, 1957).

[12] Bejrablaya, D., Burn, J. H., and Walker, J. M., *Brit. J. Pharmacol.*, 13, 461 (1958).

Effect of Trypan Blue on Rat Embryos

THE teratogenic effect of trypan blue in pregnant rats has been well established[1-3]. The dye appears to be most active when injected at 8½ days of pregnancy and gives rise to a variety of abnormalities involving almost all the systems of the embryo. Of a number of chemically related azo dyes tested, trypan blue was found to be the most active teratogenic agent in rats[4] and it has also been shown to act as a teratogen in other rodents[5-7] and in chicks[8]. Three main hypotheses explaining its action have been proposed. The first assumed that a part, at least, of the dye enters the blastocyst and acts directly on the embryonic cells[9]; the second postulates a 'clogging' of the yolk sac epithelium with the large dye molecules, thus inhibiting the transfer of essential substances to the conceptus; the third suggests maternal metabolic changes resulting in the formation of substances which are responsible for the fœtal malformations.

During our own preliminary investigations into the action of trypan blue it was found that the commercial sample used was grossly impure.

A brief survey (Table 1) of the purity of various other commercial samples showed that the chief impurity was sodium chloride, which is used for the salting out of the dye during its manufacture. The actual amount of the azo dye in the samples varied from 19·8 to 85·6 per cent, and for this reason it is difficult to compare dosage-levels and to assess the results of previous workers who have used commercial sources of the dye.

Paper chromatography of the dye samples has revealed in all cases a number of chromogenic impurities, the main one being red in colour. The ratio of red impurity : trypan blue, in the various dye samples, has been determined spectrophotometrically after chromatographic separation (Table 1, col. 4). This impurity has been previously noted in trypan blue[10,11] and a similar red impurity has been found in Evans's blue (*T* 1824) (ref. 12). The latter dye is also to some extent teratogenic[4].

The main red impurity ($\lambda_{max.}$ 540 mμ in *N* hydrochloric acid) was separated from the first mother liquor obtained after the recrystallization of crude trypan blue (Grübler). A 'Solkaflock' cellulose column was used with water as the eluting agent. The mother liquor was de-ionized in a Wood's electro-dialyser[13] before being applied to the column, and the separated red fraction was dried *in vacuo* and dissolved in water to give a 0·5 per cent w/v solution. The red material, which is of unknown structure, diffused slowly through a 'Cellophane' membrane and when injected into rats was quickly excreted in the urine. It therefore seems feasible to assume that the red impurity of trypan blue can enter the blastocyst.

Recrystallization of trypan blue (Grubler) twice from hot water gave a blue dye ($\lambda_{max.}$ 590 mμ in *N* hydrochloric acid) which showed negligible chloride content and only a trace of the red impurity. Further purification of this material was not possible at this time due to the restricted supply of the sample available and the large losses consequent on recrystallization. The recrystallized trypan blue did not diffuse through a 'Cellophane' membrane, and when injected into rats it was not excreted in the urine; it was dried *in vacuo* and dissolved in water to give a 1 per cent w/v solution.

Table 1. ANALYSIS OF COMMERCIAL SAMPLES OF TRYPAN BLUE

Source	Chloride as NaCl*	Water†	Azo dye as‡ $C_{34}H_{24}O_{14}N_6S_4Na_4$	$\frac{E_{515}\text{ red impurity}§}{E_{600}\text{ trypan blue}}$
G. T. Gurr vital stain 1	52·6	6·9	38·2	0·21
G. T. Gurr vital stain 2	76·0	5·5	19·8	0·21
Michrome	76·0	6·7	19·8	0·18
Michrome, vital stain	13·1	9·5	¶	¶
Gerrard	5·3	13·9	80·4	0·08
Grubler	9·7	17·2	73·6	0·16
British Drug Houses, Ltd.	1·5	11·6	84·5	0·07
British Drug Houses, Ltd., vital stain	1·2	12·3	85·6	0·10
Flatters and Garnett, Ltd.	48·7	11·0	43·2	0·24

* By potentiometric titration. † Loss of weight after 6 hr. at 110°. ‡ By titanous chloride titration. § Measured after chromatographic separation. ¶ No value could be obtained since this dye contains another major impurity, blue in colour.

Table 2

Substance tested	No. of rats used	Total implantations	Total resorptions	Resorptions (per cent)	External abnormalities in survivors Normal	 Abnormal
M.R.C. hooded rats						
Control (uninjected)	14	148	10	6·7	138	0
1 per cent trypan blue (Grubler)	11	117	36	30·7	80	1
1 per cent recrystallized trypan blue	12	144	18	12·5	126	3
1 per cent mother liquor	14	148	46	31·8	102	2
0·5 per cent red impurity	19	224	47	20·9	176	1
Wistar rats						
Control (uninjected)	4	33	2	6·0	31	0
1 per cent crude trypan blue	7	48	27	56·2	9	12

The mother liquor from the first recrystallization of trypan blue (Grubler) was also dried *in vacuo* and dissolved in water to give a 1 per cent w/v solution. This solution was rich in the red impurity, the ratio of the respective $E_{max.}$ values (cf. Table 1) of the red and blue components being 0·95 compared with 0·16 in crude trypan blue (Grübler).

For testing the effect of trypan blue M.R.C. hooded rats of our laboratory strain were used. Rats in œstrous (determined by the vaginal smear) were mated overnight and pregnancy was timed from midnight if the morning smear showed spermatozoa. At 8½ days of pregnancy the rats were injected subcutaneously with 1 ml. of 1 per cent commercial typan blue (Grübler) or solutions of fractions derived from it (*vide supra*) and killed at 20½ days. The number of fœtuses and resorption sites was noted. Fœtuses were removed, fixed in formalin and examined for external malformations. A series of control animals remained uninjected.

Table 2 shows the results obtained.

The demonstration that recrystallized trypan blue gave a resorption-rate (12·5 per cent) that was not significantly different ($0·20 > P > 0·10$) from the control group (6·7 per cent) suggested that it was the impurities in the crude samples of the dye which were responsible for its high resorption-rate (30·7 per cent). This appeared to be borne out when it was shown that the mother liquor containing these impurities caused resorption (31·0 per cent) at the same rate ($0·95 > P > 0·90$) as the crude material.

Since the control animals were uninjected, injection trauma was considered as a factor responsible for the resorptions in the experimental series. This consideration could be ruled out, since the resorption-rates given by the series injected with recrystallized trypan blue and the controls do not differ significantly ($0·20 > P > 0·10$).

Since the main impurity in crude trypan blue (Grübler), apart from sodium chloride, was the red chromogenic material, it was considered that this compound might be the causative resorptive agent. Tests with the impurity showed that the resorption-rate (20·9 per cent) although significantly ($P < 0·01$) higher than that of the controls fell between that of recrystallized trypan blue and the crude trypan blue (Grubler) (Table 2).

All fractions—including the pure red fraction which contained no trypan blue at all—were found to cause gross abnormalities, but χ^2 tests of significance failed to show differences in abnormality-rates between the experimental groups due to the small number of externally malformed fœtuses. All fœtuses are now being dissected to demonstrate cardio-vascular abnormalities.

Although the activity of the recrystallized trypan blue cannot be considered to have been disproved, it would appear that the red impurity is more active so far as fœtal resorptions are concerned. An attractive explanation of why the mother liquor was more active than the red impurity itself is that the red compound, being diffusible, is rapidly excreted when injected alone and may not be present at an optimal concentration at the correct period of fœtal development. When, as in the mother liquor or crude trypan blue, the red compound and trypan blue are injected together, the excretion of the red compound may be delayed by partial 'blocking' of the reticulo-endothelial system by trypan blue. Another point that should be mentioned is that the red fraction, as eluted from the cellulose column, contained only the main impurity and that other, possibly more active, compounds which were present in the crude trypan blue or the mother liquor may have been left on the column. Finally, it should be pointed out that the amount of total dye injected into the group of rats receiving the red impurity was only a half that received by the other groups.

Recently, a Wistar strain of rat has been subjected to the experimental treatment outlined above using 1 ml. of 1 per cent crude trypan blue (Grubler) (Table 2). Whereas there is no difference in resorption-rates between control Wistar and M.R.C. hooded rats (P about 0·8) the Wistar rats show a significantly higher ($P < 0·01$) resorption-rate (56·2 per cent) (and also a very much higher abnormality-rate among survivors) than do the M.R.C. hooded rats (30·7 per cent). Experiments with the various fractions of crude trypan blue are now being repeated on the more susceptible strain especially with the view of examining the rates of congenital malformation in the survivors.

F. Beck
B. Spencer
J. S. Baxter

Departments of Anatomy and Biochemistry,
University College,
Cardiff.
March 22.

[1] Gillman, J., Gilbert, C., Gillman, T., and Spence, I., *S. Afr. J. Med. Sci.*, 13, 47 (1948).
[2] Fox, M. H., and Goss, C. M., *Anat. Rec.*, 124, 189 (1956).
[3] Wilson, J. G., *Anat. Rec.*, 130, 388 (1958).
[4] Wilson, J. G., *Anat. Rec.*, 123, 313 (1955).
[5] Hamburg, M., *Anat. Rec.*, 119, 409 (1954).
[6] Ferm, V. H., *J. Embryol. Exp. Morphol.*, 6, 284 (1958).
[7] Harm, H., *Z. Naturforsch.*, 9, b, 536 (1954).
[8] Beaudoin, A. R., and Wilson, J. G., *Proc. Soc. Exp. Biol. Med.*, 97, 85 (1958).
[9] Wilson, J. G., Beaudoin, A. R., and Free, H. T., *Anat. Rec.*, 133, 115 (1959).
[10] Hartwell, J. L., and Fieser, L. F., "Org. Syn.", 16, 12 (1936).
[11] Okuneff, N., *Biochem. Z.*, 193, 70 (1928).
[12] Leeson, D., and Reeve, E. B., *J. Physiol.*, 109, 170 (1949).
[13] Wood, T., *Biochem. J.*, 62, 611 (1956).

Antileukæmic Activity of Glycyrrhetinic Acid

Recently some pharmacologically interesting activities of glycyrrhetinic acid corresponding to those observed with the adrenal cortical hormones have been shown; for example, a DOCA-like effect on sodium and potassium metabolism in normal people[1] and an anti-inflammatory activity in different animal tests[2].

It seems that the drug acts through the adrenals, because no effect on the sodium and potassium balance in adrenalectomized rats has been established.

Investigations to obtain a substance like adrenal cortical hormone by transforming the carboxyl-group of glycyrrhetinic acid in a ketol group and the 3-OH group in an oxo-group did not enhance or change the activity[4].

Experiments carried out recently by L. M. Atherden[5] have contributed to the explanation of the mode of action of glycyrrhetinic acid. This author showed that a direct effect on the steroid enzyme system inhibits the metabolism of progesterone and 11-deoxycorticosterone. In this test 11-deoxoglycyrrhetinic acid inhibits to a small extent only. This demonstrates that the 11-oxo-group is required for inhibition.

The purpose of this communication is to describe a further parallel between the activity of adrenal cortical hormones and glycyrrhetinic acid.

E. R. Heilman and E. C. Kendall[6] have shown that cortisone retards growth of malignant lymphosarcoma in mice. Similar results have been obtained by J. B. Murphy and E. Sturm[7] with adrenal cortical hormones in oil: in rats, development of the disease after inoculation with leukæmic cells has been prevented. About 50 per cent of the rats survived while the survival among controls was less than 5 per cent.

Clinical investigations have also demonstrated the effectiveness of cortisone therapy in acute leukæmia, especially in the lymphoblastic variety of acute leukæmia[8].

We have found that glycyrrhetinic acid has a similar activity on the development of transplantable Oberling–Guérin myeloma in rats: α- and β-glycyrrhetinic acid react qualitatively in the same way (Table 1, *b* and *c*); but it seems that the α-compound is more active. Also the corresponding 3-oxo-compounds (*d* and *e*) behave analogously. With the 3-oxo-20-ketolacetate (*f*) of glycyrrhetinic acid we have obtained different results with different kinds of leukæmias: with the Oberling–Guérin myeloma some activity has been noted, whereas a lymphatic tumour of the mouse (leukæmia 1210) does not seem to be sensitive to the drug. The compound 3-oxo-

Table 1. Effect of Glycyrrhetinic Acid and Derivatives on the Development of Transplantable 'Oberling–Guérin' Myeloma in Rats

Compound	Daily dose (mgm./kgm.* intraperitoneally)	No. of animals	Mortality No. of animals	Average tumour weight treated / Average tumour weight controls	Change in body-weight after 12 days Treated / Controls
(*a*) Cortisone	50	9	0	0·45	$\frac{+0}{+20}$
(*b*) 18 α-Glycyrrhetinic acid	80	9	1	0·32	$\frac{+23{\cdot}1}{+25{\cdot}4}$
(*c*) 18 α-Glycyrrhetinic acid	80	25	0	0·47	$\frac{+15{\cdot}5}{+19{\cdot}8}$
(*d*) 3-Oxo-18 α-glycyrrhetinic acid	80	20	2	0·33	$\frac{+20{\cdot}2}{+18{\cdot}3}$
(*e*) 3-Oxo-18 β-glycyrrhetinic acid	80	17	2	0·46	$\frac{+12{\cdot}8}{+17{\cdot}5}$
(*f*) 3-Oxo-20-ketolacetate-18 β-glycyrrhetinic acid	50	5	0	0·42	$\frac{+17{\cdot}0}{+18{\cdot}8}$
(*g*) 11-Deoxo-18 β-glycyrrhetinic acid	100	10	0	0·88	$\frac{+17{\cdot}7}{+14{\cdot}6}$
(*h*) 3-Oxo-18 α-glycyrrhetinic-β-dimethylaminoethylester methansulphonic salt	50	10	1	0·91	$\frac{+19{\cdot}0}{+24{\cdot}5}$
(*i*) 3-Oxo-18 β-glycyrrhetinic-β-dimethylaminoethylester methansulphonic salt	50	10	4	0·94	$\frac{+8{\cdot}2}{+18{\cdot}3}$
(*k*) 3-Acid-hydrogen-succinate of α-glycyrrhetinic disodic salt	50	10	1	0·65	$\frac{+14{\cdot}40}{+23{\cdot}17}$
(*l*) 3-Acid-hydrogen-succinate of β-glycyrrhetinic disodic salt	50	10	2	0·70	$\frac{+21{\cdot}20}{+23{\cdot}17}$

* Duration of treatment: 11 days starting 24 hr. after tumour implantation.

18-α-glycyrrhetinic acid (*d*) was also active against leukæmia 1210.

A negative result was obtained with 11-deoxoglycyrrhetinic acid (*g*). In order also to carry out experiments with water-soluble compounds, which eventually could show a higher activity, we have tested the β-dimethylaminoethylester of 3-oxo-β-glycyrrhetinic acid (*i*), but it was inactive. Since the β-acid in comparison with the α-acid is much more difficult to hydrolyse[4], we have investigated also the corresponding α-acid ester (*h*): it has proved to be inactive as well. The β- and α-acid hydrogen succinates of glycyrrhetinic acid are also inactive. These 3-succinates have a high anti-inflammatory activity (R. S. H. Finney and G. F. Somers[2]).

It is of interest to note that the glycyrrhetinic compounds do not inhibit the increase in body-weight as in the case of cortisone (Table 1). We have not yet been able to establish whether this fact is in part due to retention of water.

With other tumours, for example, mouse sarcoma 180, no activity was observed with any of the listed compounds. Tumour growth was determined by weighing the localized excised tumours 12 days after subcutaneous implantation of a rat myeloma cell suspension or 8 days after transplantation of the mouse sarcoma 180. Adult Wistar rats or stock albino mice of both sexes were used throughout the experiments.

We are indebted to the Cancer Chemotherapy National Service Center, National Institutes of Health, Bethesda 14, Maryland, for carrying out the determinations on 1210 leukæmia-bearing mice.

W. LOGEMANN
F. LAURIA
Chemical Research Laboratory,
G. CUDKOWICZ
J. FRANCESCHINI
Biological Research Laboratory,
Istituto 'Carlo Erba' per Ricerche Terapeutiche,
Milan.

[1] Molhuysen, J. A., Gerbrandy, J., De Vries, L. A., De Jong, J. C., Lenstra, J. B., Turner, K. P., and Borst, J. G. G., *Lancet*, ii, 381 (1950).

[2] Logemann, W., Lauria, F., and Tosolini, G., *Chem. Ber.*, 90, 601 (1957). Somers, G. F., *Brit. Med. J.*, i, 463 (1957). Finney, R. S. H., and Somers, G. F., *J. Pharm. and Pharmacol.*, 10, 613 (1958).

[3] Galal, E. E., *Brit. J. Pharmacol. and Chemother.*, 10, 305 (1955).

[4] Logemann, W., Lauria, F., and Tosolini, G., *loc. cit.* Lauria, F., *Gazz. chim. Ital.*, 87, 1407 (1957).

[5] *Biochem. J.*, 69, 75 (1958).

[6] Heilman, F. R., and Kendall, E. C., *Endocrinol.*, 34, 416 (1944).

[7] Murphy, J. B., and Sturm, E., *Science*, 99, 303 (1944).

[8] See Fessas, P., Wintrobe, M. M., Thompson, R. B., and Cartwright, G. E., *Arch. Int. Med.*, 94, 384 (1954).

[9] Beaton, J. M., and Spring, F. S., *J. Chem. Soc.*, 3126 (1955).

Protective Effect of Cysteine against Retinal Degeneration induced by Iodate and by Iodoacetate

ACUTE degenerative lesions of the neuro-epithelium and of the pigment layer of the retina can be readily induced in the rabbit by a single intravenous injection of five different agents, namely, sodium iodate[1], sodium iodoacetate[2], dithizone[3], the primary phenoxyalkanes[4] and sodium fluoride[5]. To be effective, sodium iodoacetate and sodium fluoride have to be given in sub-lethal doses, and only some 66 per cent and some 20 per cent, respectively, of animals treated with these agents show ophthalmoscopic lesions. With the remaining substances, well-tolerated doses produce retinal lesions in all rabbits treated. The severity of the lesion produced by an agent varies from animal to animal, so that it is difficult to be sure whether there is a fundamental difference between the reactions produced by these five agents; however, dithizone probably gives the most severe and rapidly developing lesion, while sodium fluoride gives the most localized reaction ophthalmoscopically and histologically. Ophthalmoscopic lesions are occasionally seen within a matter of a few hours, but more often not until about 48 hr.; fully established lesions are present almost always within 5 days.

These five agents do not seem to have very much in common chemically, nor apparently biologically; iodoacetate is a versatile enzyme inhibitor, dithizone produces experimental diabetes, and sodium fluoride is known mainly as an inhibitor of glycolysis. The mode of action of these five agents in producing retinotoxic damage is therefore obscure, and failure to obtain a protective effect from the use of possible protective substances—ascorbic acid[6] and vitamin E[7]—has not helped to clarify matters. In the rat, malic acid is protective against the lethal effect of iodoacetate, but enhances the retinal damage[8].

In the course of some work on possible protective substances, there was some suggestion that methionine might prove protective against the retinotoxic effect. The results were, however, not convincing, and as methionine is regarded as breaking up in the body into cystine and choline, and these two substances are antagonistic in experimental liver damage, it was thought best to study them separately. A preliminary trial with choline and cystine in the fasted rabbit suggested that cystine 50 mgm. intravenously 90 min. before and 90 min. after the administration of sodium iodate 17·5 mgm./kgm. intravenously was protective in 3 out of 4 animals treated. In contrast, choline in doses of 30 mgm. similarly administered was ineffective. Further work was continued with cysteine instead of cystine as it is more soluble and larger doses could be readily given intravenously. The procedure employed was to administer intravenously L (+) cysteine hydrochloride 300 mgm./kgm. (using 1 ml. of water per 100 mgm. of cysteine) on 5 days: twice on the day of the injection of the retinotoxic agent (90 min. before and 90 min after the injection) and once daily on the two previous days and the two subsequent days. The results obtained are shown in Table 1.

Table 1. EFFECT OF REPEATED DOSES OF CYSTEINE INTRAVENOUSLY IN RABBITS TREATED WITH FIVE DIFFERENT RETINOTOXIC AGENTS

Retinotoxic agent	Dose (mgm./kgm.)	No of animals treated	No died	Retinal lesions: Expected*	Present	Absent
Sodium iodate	25	10	0	10	0	10
Sodium iodoacetate	25	13	2	5–6	1†	10
" "	30	16	8	5	5†	3
" "	35	5	4	1	0	1
Dithizone	45	6	1	5	5	0
1 : 5 Di(p-amino-phenoxy)-pentane	5	10	1	9	9	0
Sodium fluoride	50	12	3	2	2	7

* In the case of sodium iodoacetate some 50 per cent are expected to show ophthalmoscopic lesions with doses of 25 mgm./kgm., 66 per cent with doses of 30 mgm./kgm., and almost all survivors with doses of 35 mgm./kgm. With sodium fluoride 50 mgm./kgm. some 20 per cent of survivors should show lesions With the other agents 100 per cent of treated animals should be affected with the dosage employed.

† These lesions were exceptionally mild both ophthalmoscopically and histologically compared to controls not treated with cysteine.

It will be seen that cysteine is fully protective against the retinotoxic effect of sodium iodate; the protective effect is only slightly less with sodium iodoacetate, judged by the fact that even with the larger doses of iodoacetate the ophthalmoscopic and histological reactions were very much milder in cysteine-treated animals than in controls. It would seem that cysteine has no protective effect against the remaining three retinotoxic agents listed.

These results suggest that the five retinotoxic agents known do not all exert their effect through the same mechanism, or that fuller doses of cysteine, and more effective methods of administration, might give control of the three agents uncontrolled in the present observation. Bearing on this latter possibility is the fact that protection appeared to be less effective when cysteine was given less intensively (either intravenously on the day of the injection of iodate only, or in the drinking water for several days).

ARNOLD SORSBY

Wernher Research Unit on
Ophthalmological Genetics
(Medical Research Council),
Royal College of Surgeons,
W.C.2.

RONALD HARDING

Royal Eye Hospital,
S.E.1.

[1] Sorsby, A., *Brit. J. Ophthal.*, 25, 58 (1941).
[2] Schubert, G., and Bornschein, J., *Experientia*, 7, 461 (1951). Noell, W. K., *J. Cell. Comp. Physiol.*, 40, 25 (1952).
[3] Butturini, U., Grignolo, A., and Baroncelli, A., *G. Clin. Med.*, 34, 1253 (1953).
[4] Sorsby, A., and Nakajima, A., *Brit. J. Ophthal.*, 42, 563 (1958).
[5] Sorsby, A., and Harding, R., *Brit. J. Ophthal.*, 44, 213 (1960).
[6] Sorsby, A., *Brit. J. Ophthal.*, 25, 62 (1941).
[7] Babel, J., *Ophthalmologica*, 107, 102 (1944). Babel, J., and Ziv, B., *ibid.*, 132, 65 (1956).
[8] Graymore, C., and Tansley, K., *Brit. J. Ophthal.*, 43, 177 (1959).

Influence of 5-Hydroxytryptamine on Renal Function in Extracorporeal Circulation

A REDUCED renal blood flow and glomerular filtration-rate, despite a mean aortic pressure over the filtration-level, is a feature inherent to cardiopulmonary by-pass operations. Yet the maintenance of an adequate renal circulation is of primary importance in preventing ischaemic damage to the kidneys[1], and much research has been directed toward this special problem in the use of heart-lung machines. Accurate measurements on the critical flow-rate in various forms of by-pass were recently reported by Morris *et al.*[2].

Another harmful event in the use of current heart-lung machines is the destruction of thrombocytes. This seems to happen without regard to the type of oxygenator used[3] and can reach considerable dimensions. Recently my colleagues and I reported our observations on the humoral blood trauma in extracorporeal circulation[4]. The destruction of platelets was followed by a release of 5-hydroxytryptamine into the blood stream, resulting in elevated levels of this substance in the plasma and in its appearance in the urine. The changes in the urinary output, not earlier reported, had the same trend as during the use of heart-lung machines. Table 1 shows the actual values and the amount of 5-hydroxyindoleacetic acid, the main excretory product of 5-hydroxytryptamine, in the urine in periods before and during the extracorporeal circulation. The urinary output decreased in three dogs of four, from an average of 0·15 ml./min. before extracorporeal circulation to 0·07 ml./mm. during this circulation. In one dog the reverse was observed. Despite the elevated levels of 5-hydroxytryptamine in the plasma (on the average from 0·025 μgm./ml. to 0·045 μgm./ml.), the 5-hydroxyindoleacetic acid excretion measured per time unit showed a decreasing trend. This can scarcely be explained on any basis other than a renal factor. There is evidence that the renal excretion of 5-hydroxyindoleacetic acid parallels that of para-aminohippuric acid[5,6]. If this theory is correct, the 5-hydroxyindoleacetic acid excretion is dependent on both glomerular filtration and tubular excretion, and the changes in renal perfusion conditions in extracorporeal circulation explain as such the change under consideration. This concept is confirmed by the observation of a low urinary content of 5-hydroxyindoleacetic acid in the oligouric phase after open cardiac surgery[7] and it indicates that the urinary excretion of 5-hydroxyindoleacetic acid can give an unreliable impression of the decomposition of 5-hydroxytryptamine in conditions with a renal suppression. The possible role of renal pathology is discussed elsewhere[8].

Table 1. URINARY OUTPUT AND 5-HYDROXYINDOLEACETIC ACID (5-HIAA) EXCRETION IN EXTRACORPOREAL CIRCULATION

	Before extracorporeal circulation		During extracorporeal circulation	
	Urine flow	5-HIAA	Urine flow	5-HIAA
Dog 1	0 14 ml./min.	1·0 μgm./min. 7·1 μgm./ml.	0·09 ml /min.	0 4 μgm./mm. 4·0 μgm./ml.
Dog 2	0·22 ml./min.	0·7 μgm./min. 3·1 μgm./ml.	0·07 ml./min.	0·4 μgm./mm. 5·0 μgm./ml.
Dog 3	0 09 ml./min.	0·6 μgm./min. 6·5 μgm./ml.	0 04 ml./min.	0 4 μgm./min. 9 0 μgm./ml.
Dog 4	0 11 ml./mm.	0·8 μgm./min. 7 3 μgm./ml.	0·28 ml./min.	0·3 μgm./mm. 0 9 μgm./ml.

Considering together the reduced urinary flow and the release of 5-hydroxytryptamine from disintegrated platelets, it seems reasonable that these two phenomena are to some degree interrelated, especially in view of the antidiuretic properties of 5-hydroxytryptamine. There is no general agreement with the original concept of Erspamer[9] that the physiological role of 5-hydroxytryptamine is that of a renal hormone. There are, however, several studies, well controlled to avoid the interference of hypotension, that show a clear-cut antidiuretic effect of exogenous 5-hydroxytryptamine[10,11]. According to these studies, infusions of 5-hydroxytryptamine at dose-levels of 5–15 μgm./kgm./min. had a definite antidiuretic effect in dogs and rats. Also, 5-hydroxytryptamine infused into normal people reduced the renal blood flow and glomerular filtration-rate[12]. The same antidiuretic effect certainly applies to endogenously released 5-hydroxytryptamine. Of special interest in this connexion are the findings of Watkins[13]. He observed that the renal suppression began already within 5 min. after the start of a dog by-pass at an adequate perfusion and arterial pressure and with minimal acid-base change. This type of a rapid renal suppression is rather to be related with some humoral agent in the circulating blood than with perfusion and pressure conditions.

Several factors in the use of heart-lung machines, many of them common in major surgery in general, can affect the renal function, perfusion rates clearly playing a central part. The release of 5-hydroxytryptamine, a substance with antidiuretic properties, in extracorporeal circuits, with a simultaneously reduced urinary output, suggests that this substance may also play a part in the renal hæmodynamics of by-pass operations and major surgery in general. Also the liberation of adenosine triphosphate[4] has to be taken into account since this substance releases antidiuretic hormone from the posterior pituitary[14]. Clinical studies are in progress to clarify further the problem under consideration.

The 5-hydroxyindoleacetic acid was generously supplied by Upjohn Co., Kalamazoo, Mich.

M. H. Frick

Wihuri Research Institute,
Helsinki.

[1] Beall, A. C., Cooley, D. A., Morris, G. C., and Moyer, J. H., *Ann. Surg.*, 146, 190 (1957).

[2] Morris, G. C., Awe, W. C., Bender, H. W., Cooley, D. A., and De Bakey, M. E., in "Extracorporeal Circulation", edit. by Allen, J. G. (Charles C. Thomas, Springfield, Illinois, 1958).

[3] Perkins, H. A., Osborn, J. J., and Gerbode, F., "Extracorporeal Circulation", edit. by Allen, J. G. (Charles C. Thomas, Springfield, Illinois, 1958).

[4] Sarajas, H. S. S., Kristoffersson, R., and Frick, M. H., *Amer. J. Physiol.*, 197, 1195 (1959).

[5] Despopoulus, A., *Fed. Proc.*, 15, 48 (1956).

[6] Despopoulus, A., and Weissbach, H., *Amer. J. Physiol.*, 189, 548 (1957).

[7] Sullenberger, J. W., Anlyan, W. G., and Weaver, W. T., *Surgery*, 46, 22 (1959).

[8] Sarajas, H. S. S., and Saure, L., *Nature*, 185, 768 (1960).

[9] Erspamer, V., *Arch. Internat. Pharmacodyn.*, 93, 293 (1953).

[10] Del Greco, F., Masson, G. M. C., and Corcoran, A. C., *Amer. J. Physiol.*, 187, 509 (1956).

[11] Spinazzola, A. J., and Sherrod, J., *J. Pharmacol. and Exp. Therap.*, 119, 114 (1957).

[12] Schneckloth, R., Page, I. H., Del Greco, F., and Corcoran, A. C., *Circulation*, 16, 523 (1957).

[13] Watkins, E., in "Extracorporeal Circulation", edit. by Allen, J. G. (Charles C. Thomas, Springfield, Illinois, 1958).

[14] Dexter, D., Stoner, H. B., and Green, H. N., *J. Endocrinol.*, 11, 142 (1954).

PATHOLOGY

Anti-Inflammatory Activity of Salicylate

Salicylate uncouples oxidative phosphorylation reactions[1], and the possible relation of this major action on cellular metabolism to other effects of the drugs is of great interest[2]. One of the most important properties of salicylate is its anti-inflammatory actions, both in rheumatic disease and in experimental inflammatory states[3]. Adams and Cobb[4] observed a general parallelism between uncoupling activity and the inhibition of erythema in the guinea pig by a series of non-hormonal anti-rheumatic drugs, including salicylate. They suggested a possible connexion between uncoupling ability and therapeutic activity but found that 2 : 4-dinitrophenol, which is a more powerful uncoupling agent than salicylate, failed to affect the erythema test. We have observed that salicylate, but not 2 : 4-dinitrophenol, also modifies the response to the passive cutaneous anaphylaxis test in the guinea pig.

In this test, the animals, after depilation, were given an intradermal injection of antibodies to pneumococcal type III polysaccharide, followed 24 hr. later by the intravenous injection of the antigen and pontamine blue. A progressive formation of œdema and leakage of the circulating dye then occurs in the areas of skin in which the antibodies have been injected. Animals given an intraperitoneal injection of salicylate (500 mgm./kgm. body-weight), 2 hr. before the injection of the antigen and dye, showed a reduced leakage of the circulating dye, but the area in which the extravasation of dye occurred was not changed. Similar treatment with 2 : 4-dinitrophenol (20 mgm./kgm. body-weight) had no effect compared to corresponding control animals.

These observations suggest that the anti-inflammatory action of salicylate, as exerted in the erythema and passive cutaneous anaphylaxis tests, does not result from an uncoupling action on oxidative phosphorylation processes and must be produced by another mechanism.

Full details of the experiments described above will be published elsewhere.

V. Marks
M. J. H. Smith

Chemical Pathology Department,
King's College Hospital Medical School,
Denmark Hill,
London, S.E.5.

[1] Brody, T. M., *J. Pharmacol.*, 117, 39 (1956).

[2] Smith, M. J. H., *J. Pharm. Pharmacol.*, 11, 705 (1959).

[3] Smith, W., and Humphrey, J. H., *Brit. J. Exp. Path.*, 30, 560 (1949). Spector, W. G., *Pharmacol. Rev.*, 10, 475 (1958).

[4] Adams, S. S., and Cobb, R., *Nature*, 181, 773 (1958).

Fate of Homologous Adult Spleen Cells Injected into New-born Mice

During a series of experiments involving radiation chimæras, it became increasingly evident that it would be necessary to consider the results in terms of immunological tolerance of the actively acquired type. At the time a cytological marker was being used for tracing donor cells in the radiation chimæras, following the technique of Ford, Hamerton, Barnes and Loutit[1]. It was decided to use the same marker in tracing cells injected into new-born animals in order to determine, by a direct method, to what extent chimærism is a necessary adjunct to tolerance. There is considerable circumstantial evidence that this is indeed the case[2,3].

5×10^6 spleen cells of the *T6/T6* strain were injected intravenously into either C^- or *CBA* litters within 24 hr. of birth. In three cases C^- cells were injected into *T6* babies. At various time-intervals after injection, animals were killed and the spleens were prepared for cytological analysis by a modification of the technique of Ford and Hamerton[4]. Table 1 records the results of preliminary experiments. Injection of homologous adult spleen cells into the new-born animals resulted in splenomegaly and runting, a well-known phenomenon[2,5,6].

The rates of division in all spleens investigated, except that of the six-months-old animal, were abnormally high and there were other signs of an

Table 1. A Cytological Analysis of the Spleens of Animals Injected at Birth with Adult Spleen Cells, Chromosomally Marked

Donor	Recipient	Age of recipient in days, at death	No. of donor cells found	No. of host cells found
T6	*CBA*	4	0	22
T6	*CBA*	4	0	20
T6	*CBA*	6	0	73
T6	*CBA*	6	0	57
*T6**	C^-	8	3	120
T6	*CBA*	10	0	367
T6	*CBA*	10	0	20
T6	*CBA*†	180	0	20
C^-	*T6*	8	4	34
C^-	*T6*	6	0	54
C^-	*T6*	21	0	74

* Hyperimmune to C^-
† Bearing a *T6* skin graft.

immunological activity which is thought to be basically a graft-versus-host attack. The only thing lacking in the spleens analysed (Table 1) was the high proportion of dividing donor type cells which has been postulated[3]. Contrary to expectation, splenomegaly in young mice injected at birth with homologous adult spleen cells does not appear to be due primarily to proliferation of the donor cells. Recently, Isacson[7] came to the same conclusion on rather less-direct evidence. Biggs and Payne[8] reported that enlarged spleens in nineteen-day-old chick embryos injected with homologous spleen cells at 14 days of incubation contained roughly equal proportions of donor and host cells.

A more comprehensive series of experiments will be published when the results have been fully analysed.

The work has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the Medical Research Council, the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

A. J. S. DAVIES
SHEILA M. A. DOAK

Chester Beatty Research Institute,
Fulham Road,
London, S.W.3.

[1] Ford, C. E., Hamerton, J. L., Barnes, D. W. H., and Loutit, J. F., *Nature*, 177, 452 (1956).

[2] Simonsen, M., *Acta Path. Microbiol. Scand.*, 40, 480 (1957).

[3] Billingham, R. E., *Ann. N.Y. Acad. Sci.*, 73, 782 (1958).

[4] Ford, C. E., and Hamerton, J. L., *Stain Tech.*, 31, 247 (1956).

[5] Billingham, R. E., and Brent, L. B., *Transp. Bull.*, 4, 67 (1957).

[6] Van Alten, P. J., and Fennell, R. A., *J. Embryol. and Exp. Morph.*, 7, 459 (1960).

[7] Isacson, P., *Yale J. Biol. and Med.*, 32, 209 (1959).

[8] Biggs, P. M., and Payne, L. N., *Nature*, 184, 1594 (1959).

Proliferative Capacity of Acute Leukæmia Cells

SEVERAL investigations have been carried out with the purpose of detecting some peculiarities in the deoxyribonucleic acid of leukæmic cells, particularly its content, its base composition and several of its physico-chemical characteristics. It can be expected that more valuable information might be obtained from the study of deoxyribonucleic acid metabolism than from the simple analysis of its static properties. The incorporation of several precursors of deoxyribonucleic acid in the total leucocyte pool has been investigated with chemical methods[1–3]. An increased uptake has been detected in leukæmic marrows as compared with normal ones[1,2]. However, such a study does not allow a direct comparison between normal and pathological marrows since with these techniques the importance of different leucocyte populations of various degree of maturation is necessarily overlooked. That holds particularly for acute leukæmia cells, of which the normal counterparts (that is, normal myeloblasts) represent only about 4 per cent of the whole cellular population in a normal bone marrow.

Radioautography is considered at present as the best technique for an investigation at a cellular level. With this technique Lajtha[4] has studied the incorporation of phosphorus-32 and of adenine-^{14}C into the deoxyribonucleic acid of human bone marrow cells *in vitro* and obtained valuable results concerning the kinetics of cellular division.

In the past few years the availability of thymidine labelled with tritium has allowed the use of the most specific precursor of deoxyribonucleic acid (thymidine) and, at the same time, it has enormously increased the resolution of the technique (tritium labelling)[5–8].

The present investigation deals with the incorporation of tritium-labelled thymidine, as studied with a radioautographic technique in bone marrow cells of five normal individuals and of 13 patients with acute leukæmia.

Bone marrow was obtained by sternal puncture and aspiration into a heparinized syringe, diluted 1/1 with Eagle medium and transferred into siliconized test tubes. ^{3}H-thymidine (specific activity 890 mc./m*M*) was added to a final concentration of 2·5 μc./ml. Incubation was carried out in a rotating system at 37°. After 1, 3 and 5 hr. smears were made on gelatine-coated slides. The smears were fixed in Carnoy's solution and, after several washings in distilled water, radioautographic preparations were obtained according to the current technique[9]. The percentage of labelled cells was determined, in each case, counting at least 100 myeloblasts for the normal and 2,000 blast cells for the leukæmic marrows.

The strikingly lower incorporation of thymidine labelled with tritium in acute leukæmia cells as compared to that detected in normal myeloblasts is shown in Table 1. No significant variations in the percentage of labelled cells were observed among the different normal bone marrows. In all cases, between the first and the fifth hour of incubation, the percentage of labelling did not significantly increase.

Table 1. PERCENTAGE OF LABELLED MYELOBLASTS AFTER 1 HR. INCUBATION

Normal bone marrows	Acute leukæmias			
	Stem cells	Myeloblastic	Monoblastic	Lymphoblastic
50	1·0	0·2	5·4	1·5
45	1·4	9·4		
35	3·3	4·0		
40	2·7	7·0		
35	9·1			
	2·8			
	1·0			
Mean value 41 ± 6·5	3·0 ± 2·3	5·1 ± 4		

It is well known that the incorporation of thymidine, as evidence of synthesis of deoxyribonucleic acid, occurs only as a preparation for later mitosis. It is therefore considered to be the most reliable index of the proliferative capacity of a tissue. The low percentage of labelling detected in acute leukæmia cells therefore indicates an extremely low proliferative capacity of these elements. Our results are in good agreement with those previously suggested by other investigators utilizing bone marrow cultures and the stathmokinetic test[10,11].

These results are in contrast with the current opinion of a high mitotic activity of leukæmic tissues, and suggest that in acute leukæmia elements, as compared to their normal counterparts, another important functional defect is present associated with the well-known incapacity to differentiate. This consideration might be of some importance in regard to a more rational therapeutic approach in acute leukæmia.

We wish to thank Prof. G. C. Dogliotti for his helpful suggestions.

FELICE GAVOSTO
GIOVANNI MARAINI
ALESSANDRO PILERI

General Medical Clinic,
Turin Medical School.

[1] Hamilton, L. D., "The Leukemias: Etiology, Pathophysiology and Treatment", 181 (Academic Press, Inc., New York, 1957).
[2] Wells, W., and Winzler, R. J., *Cancer Res.*, 19, 1086 (1959).
[3] Eidinoff, M. L., Cheong, L., Gambetta Gurpide, E., Benua, R. S., and Ellison, R. R., *Nature*, 183, 1686 (1959).
[4] Lajtha, L. G., Oliver, R., and Ellis, F., *Brit. J. Cancer*, 8, 367 (1954).
[5] Cronkite, E. P., Fliedner, T. M., Bond, V. P., Rubini, J. R., Brecher, G., and Quastler, H., Second U.N. Int. Conf. on the Peaceful Uses of Atomic Energy, Geneva (1958).
[6] Bond, V. P., Fliedner, T. M., Cronkite, E. P., Rubini, J. R., Brecher, G., and Schork, P. K., *Acta Haematologica*, 21, 1 (1959).
[7] Gavosto, F., Pileri, A., and Maraini, G., *Nature*, 184, 1691 (1959).
[8] Gavosto, F., Maraini, G., and Pileri, A., *Blood* (in the press).
[9] Pelc, S. R., *Nature*, 160, 749 (1947).
[10] Astaldi, G., and Mauri, C., *Rev. Belge Path. et Méd. Exp.*, 23, 59 (1954).
[11] Sacchetti, C., and Bianchini, E., *Le Sang*, 25, 490 (1954).

RADIOBIOLOGY

Removal of Internally Deposited Americium by Chelating Agents

DURING recent years there has been considerable interest in the use of chelating agents to remove certain radioelements deposited in the body. Ethylenediamine tetraacetic acid has been investigated extensively, and more recently there have been reports that diethylenetriamine pentaacetic acid is more effective than ethylenediamine tetraacetic acid for the removal of deposited plutonium[1], and that it also increases the excretion of thorium from the body[2]. We have studied the effect of these two chelating agents on the removal of americium-241 from the rat. Preliminary experiments showed that both reagents significantly increased the excretion of this nuclide and that diethylenetriamine pentaacetic acid was approximately twice as effective as ethylenediamine tetraacetic acid.

Groups of three young male hybrid rats of the F_1 generation bred from Marshall and August parents were injected intravenously with 0·2 μc. americium-241 as the citrate complex. Treatment with 0·3 m.mole diethylenetriamine pentaacetic acid and 0·2 m.mole calcium gluconate, given by intraperitoneal injection in 2 ml. of solution, was started at times varying from 1 hr. to 7 days after the injection of americium-241 and repeated at weekly intervals. The rats were killed 21 days after the injection of americium-241 and the alpha activities of the liver, femur, carcass and excreta were measured by the technique described by Turner, Radley and Mayneord[3].

In Fig. 1 the distribution of americium-241 twenty-one days after administration to a normal animal is compared with that in animals treated with diethylenetriamine pentaacetic acid at various intervals. The untreated animals contain approximately 40 per cent of the injected activity in the skeleton, 25 per cent in the soft tissues, and excrete about 35 per cent. When treatments with diethylenetriamine pentaacetic acid were commenced at 1 hr., 6 hr. and 7 days after the administration of americium-241, the levels in the skeleton were 7, 10 and 20 per cent, respectively, and the amounts in the soft tissues were reduced to less than 1 per cent of the injected activity. Most of the americium-241 that was removed was excreted in the urine.

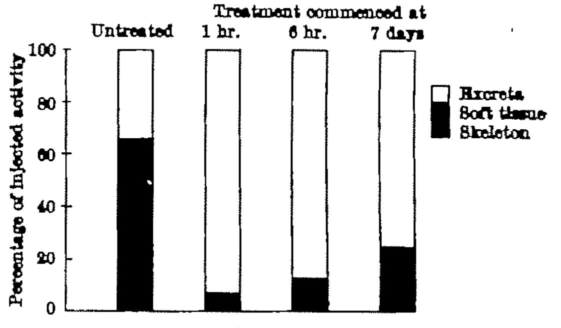


Fig. 1. Effect of diethylenetriamine pentaacetic acid on the distribution and excretion of americium in rats

It is concluded that diethylenetriamine pentaacetic acid can remove americium-241 from the skeleton and soft tissues, and that an appreciable reduction in the body burden can be achieved, particularly when the agent is administered within a few hours after exposure.

This work will be more fully reported in a later publication, which will include a comparison of the effects of multiple and single doses of chelating agent, and the effects of oral and intraperitoneal administration.

We wish to thank Prof. W. V. Mayneord and Dr. L. F. Lamerton for their help and encouragement, and the Geigy Company, Ltd., which generously supplied the diethylenetriamine pentaacetic acid.

F. D. SOWBY*
D. M. TAYLOR

Department of Physics,
Institute of Cancer Research,
Royal Cancer Hospital,
London, S.W.3.

* Permanent address: Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada.

[1] Smith, V. H., *Nature*, 181, 1792 (1958).
[2] Schubert, J., and Fried, J. F., *Nature*, 185, 551 (1960).
[3] Turner, R. C., Radley, J. M., and Mayneord, W. V., *Brit. J. Radiol.*, 31, 397 (1958).

Radiosensitivity of Mouse Kidney undergoing Compensatory Hypertrophy

WE have been interested in assessing the degree or extent of acute radiation damage to the kidneys, particularly as it may relate to late radiation effects on this organ, namely nephrosclerosis[1,2]. Significant acute changes in renal morphology (that is, during the first month), following whole-body irradiation in the lethal dose-range, have not in general been observed[3,4]. In this connexion, it is well known that the kidney of the normal adult exhibits only minimal mitotic activity. Therefore it was thought of interest to ascertain whether the kidney becomes radiosensitive when mitotic activity is stimulated by unilateral nephrectomy. Mitotic activity of the kidney following unilateral nephrectomy has been shown by Rollason[5] and by Sulkin[6] to be largely restricted to the period 48–72 hr. post-surgery.

Female mice of the $(C57L \times A)F_1$ hybrid strain were employed. A total of eighty 10-week-old animals were subjected to left unilateral nephrectomy under ethyl ether anaesthesia. The left adrenal gland was dissected free from the kidney with its blood supply intact, and spared. The excised kidney was gently blotted and weighed in a glass-stoppered weighing bottle to the nearest milligram. In a series of normal mice, comparison of the left and right kidney weights in each animal showed no more than 5 per cent difference—the right kidney being the larger in every case. These mice were divided into four sub-groups, approximately 15 each. One sub-group was X-irradiated in a single whole-body exposure to 690 r. (a high sublethal dose) 3 hr. after surgery. Another sub-group constituted a non-irradiated control group. A third sub-group of nephrectomized mice was X-irradiated similarly (690 r.) 48 hr. after surgery, with the fourth sub-group serving as the non-irradiated controls. A fifth sub-group was irradiated (690 r.) 1 hr. prior to unilateral nephrectomy. Of the 80 original mice, 75 were killed three weeks after surgery (a time at which compensatory hypertrophy of rat kidney has been shown to reach a plateau[6]), and the remaining right kidney removed and weighed. Kidneys from four of the original mice were removed 48 hr. after nephrectomy, and fixed in formalin for histological examination. One mouse of the 80 died 7 days post-irradiation. For determination of mitotic activity, kidney sections were stained with Feulgen reagent, and mitoses per 50 high-power fields were calculated. The X-radiation source was a Westinghouse therapy unit, operated at 250 kVp. The radiation factors were: 15 m.amp.; filter 0·5 mm. copper plus 1 mm. aluminium; half-value layer 1·5 mm. copper; target-skin distance 100 cm.; dose-rate 30 r. per min., in air.

A summary of the results showing the percentage increase in kidney weight in each animal, relative to the initial left kidney weight, is presented in Fig. 1. It is evident that in the group irradiated (690 r.) 48 hr. post-nephrectomy, compensatory hypertrophy of the right kidney was not inhibited, as compared with that of non-irradiated, nephrectomized controls. Many of the kidneys in both these groups showed increases in weight up to 50 per cent. By contrast, unilaterally nephrectomized mice exposed to 690 r. 3 hr. post-surgery showed only a minimal increase in weight of kidney—only one kidney showing increase in weight of as much as 21 per cent, the bulk of the remainder showing weight increases of 10 per cent or less.

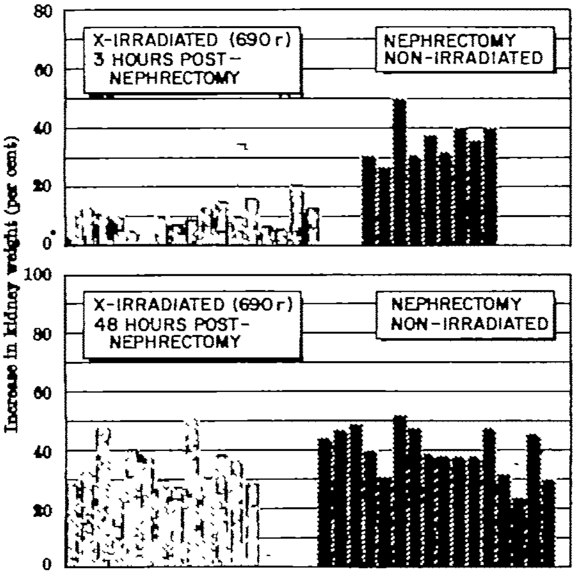


Fig. 1. Inhibition of compensatory hypertrophy of mouse kidney by X-irradiation (690 r.) 3 hr. post-nephrectomy

The weights of the normal left kidneys ranged from 86 mgm. to 159 mgm., with a mean of 121 mgm. The corresponding weights of the right kidneys extirpated from the non-irradiated mice 3 weeks post-surgery ranged from 127 mgm. to 203 mgm., with a mean of 167 mgm. By contrast, weights of the right kidney of mice irradiated 3 hr. post-surgery ranged from 114 mgm. to 170 mgm. (mean of 137 mgm.), as compared to weights of the right kidney of mice irradiated 48 hr. post-surgery with a range of 120–205 mgm. (a mean of 167 mgm.).

Mitotic counts were determined on the right kidneys removed from two non-irradiated control mice 48 hr. after left unilateral nephrectomy, and also on corresponding kidneys from two 690 r. irradiated mice (3 hr. post-nephrectomy), killed 48 hr. after surgery. In the non-irradiated mice, 136 and 147 mitoses, respectively, per 50 high-power fields were observed. By comparison, the kidneys of the irradiated mice (irradiated 3 hr. post-nephrectomy) showed only 7 and 5 mitoses per 50 high-power fields 48 hr. after surgery. (One high-power field contains approximately 400 cells.) The mitotic figures were distributed proportionately between cortex and medulla. Corresponding values for normal, non-irradiated kidneys were 5 and 8 mitoses per 50 high-power fields, respectively.

When 690 r. X-radiation was delivered 1 hr. prior to nephrectomy, no inhibition of capacity of the kidney to undergo compensatory hypertrophy could be detected. The weights of the left kidney from this group (that is, at the time of unilateral nephrectomy) ranged from 98 mgm. to 140 mgm., with a mean of 118 mgm. The weights of the right kidney, that is, three weeks post-nephrectomy, ranged from 129 mgm. to 205 mgm., with a mean of 168 mgm. The percentage weight increase of right kidney over left kidney varied from 30 to 54 per cent, with a mean increase of 42 per cent.

The foregoing results indicate that the mouse kidney is radiosensitive during a critical time period following a stimulus to cell division, namely unilateral nephrectomy. If the irradiation (690 r.) is carried out 2–3 hr. post-nephrectomy, there is a marked inhibition both of mitotic activity at 48 hr., and of compensatory hypertrophy, as measured at 3 weeks post-surgery. By contrast, when irradiation (690 r.) is carried out 48 hr. post-surgery, the capacity of the kidney to undergo compensatory hypertrophy is not impaired. It seems evident that the radiosensitivity of the kidney 3 hr. post-unilateral nephrectomy is somehow related to its cellular activity following upon the stimulus which leads to cell division—presumably preparation for deoxyribonucleic acid synthesis, since Becker and Ogawa[7] have demonstrated an increase in the amount of deoxyribonucleic acid per nucleus under these conditions of mitotic activity in the kidney. Recent studies by Beltz and Applegate[8] on regenerating liver would appear to shed further light on this problem, at the biochemical level. These workers subjected rats to partial hepatectomy, exposed them to 1,500 r. at 12–13½ hr. post-surgery, and killed them 25 hr. after surgery; assay for incorporation of thymidine labelled with tritium into deoxyribonucleic acid by the liver supernatant fractions *in vitro* was then carried out[8]. It was found that the liver supernatants from the irradiated partially hepatectomized rats possessed only 10 per cent of the capacity of the same tissue fractions from non-irradiated controls to incorporate labelled thymidine into deoxyribonucleic acid. They conclude that the effect of irradiation "is to prevent the synthesis, or the production of zymogen activation of one or more enzymes in the group of enzymes functioning to incorporate thymidine into deoxyribonucleic acid". It is tempting to speculate on the radiation-inhibition of compensatory hypertrophy in the kidney, presented in this report, in terms of similar mechanisms.

This investigation has been supported in part by funds from the Bureau of Medicine and Surgery, U.S. Navy Department, and from the Office of Civil and Defense Mobilization. The opinions and assertions contained herein are not to be construed as official or as reflecting the views of the Navy Department.

V. J. Rosen, jun.
L. J. Cole

Biological and Medical Sciences Division,
U.S. Naval Radiological Defense Laboratory,
San Francisco 24, California.

[1] Furth, J., Upton, A. C., Christenberry, K. W., Benedict, W. H., and Moshman, J., *Radiology*, 63, 542 (1954).
[2] Cole, L. J., Nowell, P. C., and Ellis, M. E., *J. Nat. Cancer Inst.*, 17, 435 (1956).
[3] Patt, H. M., and Brues, A. M., in "Radiation Biology", 1, Pt. 2, edit. by Hollander, A., 959 (McGraw-Hill, New York, 1954).
[4] Warren, S., *Arch. Path.*, 34, 1079 (1942).
[5] Rollason, H. D., *Anat. Rec.*, 104, 263 (1949).
[6] Sulkin, N. M., *Anat. Rec.*, 105, 95 (1949).
[7] Becker, N. H., and Ogawa, K., *J. Biophys. Biochem. Cytol.*, 6, 297 (1959).
[8] Beltz, R. E., and Applegate, R. L., *Biochem. Biophys. Res. Communications*, 1, 298 (1959).
[9] Bollum, F., and Potter, V. R., *Cancer Res.*, 19, 561 (1959).

Uptake of Thymidine and Synthesis of Deoxyribonucleic Acid in Mouse Ascites Cells

Recent studies of the synthesis of deoxyribonucleic acid have suggested that the radiation-sensitive period may occur at a stage in the cell-cycle before the polymerization of new deoxyribonucleic acid begins, that is, during the G1 period[1–3]. It therefore appeared to be of interest to study, in more detail, the assimilation of the precursors into cells and their subsequent incorporation into deoxyribonucleic acid. With this object we have examined the uptake of thymidine labelled with tritium into mouse Ehrlich and Landschutz ascites cells *in vitro*, measuring the total activity present in the cell and the activity incorporated into deoxyribonucleic acid, as a function of time. The distribution of the precursor among the cells of the population was determined by autoradiography. 2 ml. aliquots of suspension containing about 10^8 cells were incubated at 37° in a medium containing 50 per cent ascitic fluid and 50 per cent fortified Hanks' medium[4] (5 gm. glucose/l.). At the end of the incubation the cells were washed five times with ice-cold Hanks' medium and finally suspended in 4 ml. of the medium. Autoradiographs were prepared in the usual manner, the cells being air dried, fixed with 2 per cent acetic acid or with 45 per cent acetic acid in alcohol and washed before the application of the stripping film. Deoxyribonucleic acid was prepared from 2 ml. of the cell suspension using the detergent method of Kay, Simmons and Dounce[5], the final product being dissolved in 2 ml. of water. The solutions of deoxyribonucleic acid and the cell suspensions were homogenized by treatment with ultrasonics before plating on aluminium planchettes. Determinations of tritium activity were made using a windowless flow counter working in the proportional region with an efficiency of about 15 per cent. Deoxyribonucleic acid contents of the cell suspensions and acid solutions were determined using the modified diphenylamine method of Burton[6].

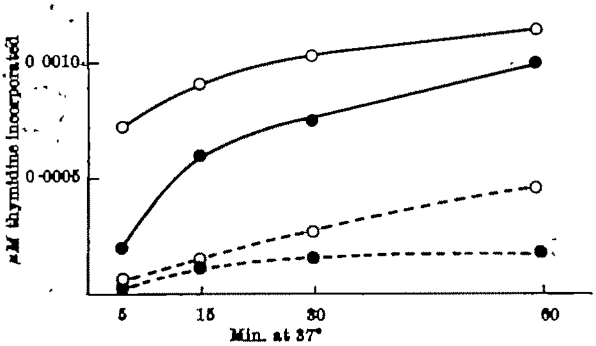


Fig. 1. Incorporation of tritium-labelled thymidine into cells and deoxyribonucleic acid. *a*, 0·001 μM, 2 μc. ^{3}H-thymidine, ●—● cells, ●- - -● deoxyribonucleic acid; *b*, 0·01 μM, 5 μc. ^{3}H-thymidine, ○—○ cells, ○- - -○ deoxyribonucleic acid

The general pattern of the results obtained for both types of cells is illustrated in Fig. 1. Thymidine is rapidly taken up by the cells, but the rate of incorporation into deoxyribonucleic acid is much slower. The amount of thymidine which the cells can take up is limited. For example, when 0·001 μM of thymidine is added to a suspension containing about 10^8 cells, nearly all of it is taken up by the cells in 1 hr., but when ten times this amount of thymidine is added the amount taken up in 1 hr. is only slightly increased. The amounts of tritium-labelled thymidine in the cells and in the deoxyribonucleic acid are not increased appreciably by longer periods of incubation (up to 3 hr.). Addition of the other three nucleosides does not influence the amounts taken up. The failure of the cells after 1 hr. to take up more thymidine or to synthesize more deoxyribonucleic acid is not due to a general stopping of the metabolic processes of the cells since the rate of incorporation of orotic acid into the ribonucleic acid continued at a constant rate for at least 2½ hr. Neither can the effect be attributed to damage caused by radiation from the labelled thymidine present in the cells, since the amount of precursor taken into the cells and incorporated into the deoxyribonucleic acid is the same if 0·01 μM of thymidine is added with an activity of 5 μc. or 0·5 μc. It appears that when the cells are incubated in this medium some changes occur or some metabolite is lacking which prevents them from either accumulating thymidine or synthesizing deoxyribonucleic acid for more than a short time.

We have also attempted to ascertain the nature and distribution of the precursor which is present in the cells but not polymerized into deoxyribonucleic acid. Nuclei were prepared using the method of Allfrey *et al.*[7], and the non-nuclear fraction was found to contain scarcely any activity. The autoradiographs also showed that the precursor was concentrated in the nuclei of the cells. Very little activity was lost from the nuclei on standing in Hanks' medium and no exchange was detected when inactive thymidine was added to the medium. It was, however, found that treatment of the cells or nuclei with ultrasonics and centrifuging for 20 min.

at 100,000g left considerable amounts of activity in the supernatant fraction. Chromatography of these supernatant fractions (*iso*butyric acid/ammonia solvent) obtained from cells incubated for 1, 5 and 16 min. showed that the activity of tritium was accounted for as 15 per cent thymidine di- and tri-phosphates (these two compounds were assayed together), 25 per cent thymidine monophosphate and 60 per cent thymidine in all cases. These results suggest that thymidine is taken up by the cells and transferred to the nucleus where an equilibrium is rapidly set up between thymidine, thymidylic acid and the di- and tri-phosphate derivatives. Although these compounds cannot be simply washed out from the cells or nuclei, it appears that they are not firmly bound within the nucleus since they can be liberated by destroying the nuclear structure. It seems probable that some part of the precursors may be even more firmly bound within the nucleus since the activity of the supernatant fractions obtained after ultrasonic treatment, added to the observed activity of the deoxyribonucleic acid, accounts, in some cases, for only 60 per cent of the total activity of the cells.

Table 1. COMPARISON OF THE TRITIUM ACTIVITY OF CELLS AND DEOXYRIBONUCLEIC ACID AND THE DEGREE OF LABELLING OBSERVED IN AUTORADIOGRAPHY EXPERIMENTS

Minutes incubated at 37° C.	C.p.m./μgm. deoxyribonucleic acid in the cell suspension	C.p.m./μgm. deoxyribonucleic acid in the isolated deoxyribonucleic acid	Average spots per cell in autoradiograph	Fraction of cells labelled in autoradiograph (per cent)
15	115	32	7·1	32
60	119	79	5·5	29

It has usually been considered that the activity observed, in the nucleus, by autoradiographic procedures after appropriate washing and fixing techniques can be ascribed to the thymidine incorporated into deoxyribonucleic acid[8]. The results of this work show that this is not necessarily valid. It can be seen, for example, in Table 1, that after 60 min. incubation the average amount of tritium-labelled thymidine assimilated per cell is little different from that observed after 15 min. incubation, though more than twice as much of the thymidine has been incorporated into deoxyribonucleic acid. The data from the autoradiographs suggest that the average activity per cell is roughly the same for the two periods of incubation and clearly bears no relationship to the activity of the deoxyribonucleic acid alone. It would therefore appear that the fixing procedure does not remove a significant part of the labelled thymidine, which is incorporated into the cell but not polymerized into deoxyribonucleic acid. To confirm this conclusion a suspension of washed cells was centrifuged and the cells resuspended in (*a*) 2 per cent acetic acid and (*b*) 45 per cent acetic acid in alcohol. After standing for 5 min. at room temperature the suspensions were centrifuged and the activity of the supernatant fractions assessed. In both cases the total activity of the fixing fluids was less than 10 per cent of the total activity of the cell suspension. Table 1 also shows that only one-third of the cells in the suspension have assimilated labelled thymidine. It would therefore appear that under the conditions used in our experiments, the autoradiographic process detects not only the cells which are actively polymerizing new deoxyribonucleic acid but also those which contain precursors in a form not easily removed by the washing and fixing procedures (cf. Harris)[9]. Other workers have attempted to assess mitotic activity from counts of the number of labelled cells in autoradiographs and have found an apparent index considerably greater than that obtained from experiments using colchicine to inhibit cell division[10]. The results described above could provide an explanation for this anomaly.

We are indebted to Prof. J. A. V. Butler for encouragement in this work. We also wish to thank B. Hunter and B. Wilson for technical assistance. This investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the Medical Research Council, the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

A. R. CRATHORN
K. V. SHOOTER

Chester Beatty Research Institute,
Royal Cancer Hospital,
Fulham Road,
London, S.W.3.

[1] Lajtha, L. G., Oliver, R., Kumatori, T., and Ellis, F., *Rad. Res.*, 8, 1 (1959).

[2] Holmes, B. E., Ciba Foundation Symp. "Ionizing Radiations and Cell Metabolism", 225 (1956).

[3] Bollum, F. J., Anderegg, J. W., McElya, A. B., and Potter, V. R., *Cancer Res.*, 20, 138 (1960).

[4] Paul, J., "Cell and Tissue Culture" (Livingstone, 1956).

[5] Kay, E. R. M., Simmons, N. S., and Dounce, A. L., *J. Amer. Chem. Soc.*, 74, 1724 (1952).

[6] Burton, K., *Biochem. J.*, 62, 315 (1956).

[7] Allfrey, V. G., Mirsky, A. E., and Osawa, S., *J. Gen. Physiol.*, 40, 451 (1956–57).

[8] Pelc, S. R., and La Cour, L. F., *Experientia*, 15, 131 (1959).

[9] Harris, H., *Biochem. J.*, 72, 54 (1959).

[10] Hughes, W. L., Bond, V. P., Brecher, G., Cronkite, E. P., Painter, R. B., Quastler, H., and Sherman, F. G., *Proc. U.S. Nat. Acad. Sci.*, 44, 476 (1958).

Effects of Whole-body Irradiation on the Breeding Plumage of the Weaver finch, *Quelea quelea*

THERE have been recent unsubstantiated reports that individuals of certain migratory species of birds have arrived in their African wintering grounds in breeding plumage instead of their normal eclipse condition[1]. Again, several migratory waders have been collected in Great Britain in unseasonal plumage. Some have been found to be radioactive; an examination has shown in some of the birds stimulation effects of the neuro-endocrine apparatus abnormal for the season (Harrison, J. M., personal communication). There is no evidence that the two factors are related, but the possibility that the anterior pituitary and sexual cycle, involving plumage changes, have been artificially disturbed by radiation could not be overlooked.

In order to investigate whether such phenomena can be produced by radiation, seasonally dimorphic weaver finches (*Quelea quelea*) were imported from Africa. In this species the male periodically assumes a vivid nuptial plumage, and after reproduction moults into non-breeding plumage which is indistinguishable from that of the permanently sombre female[2]. This cyclical assumption of a brilliant nuptial plumage is, as in certain other African weaver finches, under the direct influence of the adenohypophysis[3] and has been adopted by Witschi as a bio-assay test for gonadotrophins. He and his co-workers showed that

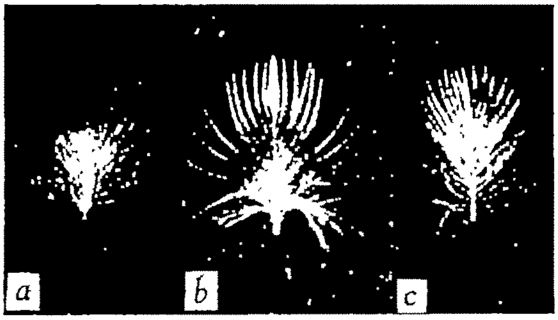


Fig 1. (a) Male feather regenerated after 1,000 r. Tip normal and pigmented but post-irradiation growth is unpigmented. (b) Female feather showing band of abnormal melanin deposition after whole-body irradiation of 200 r. (c) Unpigmented control female feather

the deposition of melanin in regenerating feathers is a specific reaction to luteinizing hormone[4].

In a preliminary experiment six groups each of 12 individuals (6 males and 6 females) were used. All these were in full breeding condition, all the males displayed the complete nuptial plumage of black facial mask and golden crown and breast, and all the females bright yellow beaks and drab plumage. Feathers were plucked from the black face-mask area of all birds, which were then left for four days, during which new feathers began to grow. Five of the six groups were then subjected to a single whole-body exposure of 15-MeV. X-rays at doses of 50 r., 200 r., 400 r., 800 r. and 1,000 r., respectively. The sixth was retained as a control group. The source of radiation was the 15-MeV. linear accelerator at St. Bartholomew's Hospital[5], and the dose-rate was about 500 r./min.

The feathers that regenerated in the plucked facial mask of male controls were identical with those removed before irradiation. In both cases they were black. In all the irradiated birds except those that received a dose of 1,000 r., the regenerated cock feathers were of the black type and indistinguishable from those of the controls. The regenerated plumage of the three survivors of the 1,000 r. exposure (approximately the *LD*50 for this species with this type of radiation), however, was unpigmented except at the feather-tips, which had been laid down in the four days before irradiation. No melanin was deposited in the parts of the feathers that had grown after irradiation (Fig. 1*a*).

Females of this species do not cyclically assume coloured breeding plumage, and so feathers removed from the facial mask area before irradiation were white and unpigmented. Regenerated feathers in female controls were unchanged, but those in the 50 r., 200 r. and 400 r. groups now displayed a black band of melanin deposition. The tips, which had developed before irradiation, were light and of normal hen colour. After irradiation, however, this normally coloured tip was succeeded by a band of melanin deposition of a kind that normally occurs only in cocks. The feather base was again hen-type and white (Figs. 1*b* and 1*c*). It is important to mention, however, that in the two higher-dosage groups melanin deposition did not occur and the regenerated plumage remained of the normal hen type.

All birds underwent a normal post-nuptial moult into the eclipse condition in July. By September, male birds were once again starting to assume their nuptial plumage.

A second experiment was performed on *Quelea* while the birds were in eclipse condition. Three groups of 24 such specimens were deplumed in the mask area and their feather follicles allowed to reorganize. One group was then given a dose of 100 r. of whole-body irradiation, another 800 r., and the third group was retained as a non-irradiated control. They were then left until the feathers had regenerated, when it was found that in all cases the new feathers were apparently normal, unpigmented and typical of the eclipse condition.

The abnormal deposition of melanin in the plumage displayed by female birds may be indicative of pituitary stimulation induced by the lower irradiations. This, however, appears to be only a temporary condition, for the birds soon reverted to their natural plumage and underwent normal moult cycles. Whether an exposure at a much lower dose-rate would have a prolonged stimulatory effect, and afterwards extend the period of melanin deposition, is not known and is under investigation.

We wish to thank the Nuffield Foundation for its support of this and allied studies.

B. Lofts

Department of Zoology and Comparative Anatomy,
St. Bartholomew's Hospital Medical College,
University of London.

A. J. Marshall

Department of Biology,
Monash University,
Melbourne.

J. Rotblat

Department of Physics,
St. Bartholomew's Hospital Medical College,
University of London.

---

[1] Williams, J., *The Times*, December 10, 1955.

[2] Disney, H. J. de S., and Marshall, A. J., *Proc. Zool. Soc. Lond.*, 127, 379 (1956).

[3] Witschi, E., *Wilson Bull.*, 47, 177 (1935); *Proc. Soc. Exp. Biol.*, 33, 484 (1936).

[4] Segal, S. J., and Witschi, E., *J. Clin. Endocr. and Metab.*, 15, 880 (1955).

[5] Rotblat, J., *Nature*, 175, 745 (1955).

BIOLOGY

Breeding Sites of Non-Cichlid Fishes in Lake Victoria

Breeding sites in Lake Victoria are known for three of the non-cichlid fishes. The lung-fish, *Protopterus aethiopicus* Heckel, constructs a nest in marginal swamp[1], and the cat-fish, *Clarias mossambicus* Peters[2], and the carp, *Labeo victorianus* Blgr.[3], spawn in temporary streams which flow into the lake after rain.

A study of the food of non-cichlid fishes in the Lake Victoria basin has recently been completed, and some of the findings, when considered in conjunction with other ecological facts, have indicated that in the lake two species, *Bagrus docmac* (Forskal) and *Mormyrus kannume* (Forskal), may breed on exposed rocky shores. The evidence is stated below.

The geological history of Lake Victoria[4] indicates that it has been colonized relatively recently by fishes of swamps and rivers[5]. Several non-cichlid fishes now inhabiting the lake periodically ascend affluent rivers *en masse*, presumably to breed[6]. *Bagrus* and *Mormyrus*, however, do not do this;

Table 1. NON-CICHLID FISHES COLLECTED FROM A ROCKY SHORE IN LAKE VICTORIA

Species	No. collected	Size-range (cm.)	Median (to nearest cm.)
Bagrus docmac (Forskål)	41	3–16	8
Clariallabes petricola Greenwood	34	3–11	6
Mastacembelus victoriae Boulenger	31	3–27	10
Clarias mossambicus Peters	15	3–14	11
Mormyrus kannume (Forskål)	8	11–20	14
Clarias werneri Boulenger	3	7–10	10
Engraulicypris argenteus (Pellegrin)	1	5	—
Synodontis afro-fischeri Hilgendorf	1	11	—

Bagrus takes part in the upstream migrations, but only in relatively small numbers[6], and therefore, like *Mormyrus*, must be assumed to breed within the lake itself. Juveniles of both these species had hitherto only been found in numbers in torrential reaches of the effluent Victoria Nile at Jinja, where they fed on lithophilic insects among the stones of the river bed. In the lake the habitat most resembling this environment is the exposed rocky shore, where many of the same insects (for example, *Afronurus*, *Neoperla*, *Metaonemis* and *Phanostoma*) typically occur. In the Victoria Nile juveniles of both fishes feed on lithophilic insects, but the adults on foods derived elsewhere. In the lake, individuals of these species below 15 cm. are scarcely ever found, but the food of fishes larger than this (of which more than 4,000 have been examined) changes according to their size, so that they feed progressively less on lithophilic organisms as they become older. Thus, although samples of fishes from the lake included no juveniles, they revealed ontogenetic changes in feeding behaviour which paralleled those observed in the river. This may therefore be regarded as additional evidence for supposing that in the lake exposed rocky shores provide the habitat for juveniles.

To test this supposition a small fish-poisoning operation was carried out on February 13 at Entebbe, along a short strip (about 50 m. × 3 m.) of rocky shoreline, exposed to unusually vigorous wave-action. The results (Table 1) confirm expectation in two important respects: they make it virtually certain that in the lake such a habitat provides a breeding site for *Bagrus*; and they emphasize the ecological similarity which exists between rocky shores in the lake and turbulent reaches in associated rivers. Whether or not *Mormyrus* also breeds on such shores must at present remain an open question, although the evidence given earlier indicates that this may be so. It should be noted that one Entebbe specimen of 20 cm. total length was a ripe female.

The presence of numerous *Clariallabes petricola* Greenwood is particularly informative, since not only is this the first record of this species from the lake proper but its type habitat[7] is the very spot where juvenile *Bagrus* and *Mormyrus* were found in the Victoria Nile. One female (6 cm. total length) from Entebbe had ripe gonads. Here it should be mentioned that another fish to be newly recorded from Lake Victoria, and also collected previously from the Victoria Nile site[7], is *Garra johnstoni* (Blgr.), which was found recently on an exposed loose-rock shore at Entebbe by Mr. J. P. C. Greenway.

Another significant feature of the results is the abundance of *Mastacembelus victoriae* Blgr., which was actually the commonest fish on the site. Like *C. petricola*, this species had previously been found to be very common on the bed of the Victoria Nile[2], but had hitherto been encountered only rarely in the lake, presumably because the appropriate habitat there had not been sampled. Thus, these observations correspond well with the report that in Lake Nyasa *Mastacembelus shiranus* Günther was encountered commonly only when fish-poisoning was carried out on rocky shores[9]. At Entebbe three *M. victoriae* (10, 16 and 26 cm. total length) were ripe females.

Although the specimens of *C. mossambicus* are too large to indicate that breeding was occurring in this site, it is perhaps significant that fishes of this estimated age (6–12 months) should be found in such an environment where, as in the temporary streams in which they are spawned[8], there is vigorous water movement.

From the observations recorded here it may be concluded that the fauna of wave-washed rocky shores in Lake Victoria closely resembles that of turbulent reaches in associated rivers (from which it presumably originated), and that consequently the rocky shore may be considered to constitute an important transition habitat able to accommodate the least-adaptable stages in the life-histories of those riverine fishes in process of becoming lacustrine. It follows that systematic studies of rocky shores may be expected to produce much valuable information concerning the ecology and evolution of non-cichlid fishes in the lake.

B. docmac is one of the non-cichlids caught most frequently by fishermen in Lake Victoria. That it should breed on rocky shores promises well for its future utilization, for it is likely that in the normal course of events neither man nor natural predators will interfere significantly with such a habitat.

I am grateful to Messrs. D. H. Rhodes and J. P. C. Greenway for assisting with the fish-poisoning operation, and to Mr. P. H. Greenwood for identifying and estimating the age of the Clariidae.

A full account of the work leading to these conclusions will be published elsewhere.

PHILIP S. CORBET*

East African Fisheries Research Organization,
Jinja, Uganda.

* Present address: Virus Research Institute, Entebbe, Uganda.

[1] Greenwood, P. H., *Proc. Zool. Soc. Lond.*, 130, 547 (1958).
[2] Greenwood, P. H., *Nature*, 176, 516 (1955).
[3] Fryer, G., and Whitehead, P. J. P., *Rev. Zool. Bot. Afr.*, 59, 33 (1959).
[4] Wayland, E. J., Summary Progress Geol. Survey Uganda (Entebbe 1931).
[5] Greenwood, P. H., *Nature*, 167, 19 (1951).
[6] Whitehead, P. J. P., *Rev. Zool. Bot. Afr.*, 59, 329 (1959).
[7] Greenwood, P. H., *Proc. Zool. Soc. Lond.*, 127, 555 (1956).
[8] Corbet, P. S., *Rev. Zool. Bot. Afr.*, 57, 73 (1958).
[9] Fryer, G., *Proc. Zool. Soc. Lond.*, 132, 153 (1959).

Occurrence of Free D-Serine in the Earthworm

LOMBRICINE was first isolated from the earthworm by Thoai and Robin[1]. Analysis of the crystalline material isolated in this laboratory[2] showed that the serine component was of the D-configuration[3]. Serine ethanolamine phosphodiester, which has been shown to be a precursor of lombricine in the earthworm[4], has been isolated in the crystalline form and shown to contain D-serine[5].

We now wish to report the finding of free D-serine in the acid-extractable free amino-acid pool of the earthworm.

The earthworms used were deep-frozen material of mixed species, but predominantly *Allobophora caliginosa* and *Octolasium cyaneum*. Extracts were prepared and fractionated as described[5] for the isolation of lombricine and serine ethanolamine phosphodiester; those fractions containing serine were identified chromatographically, collected and purified by repeated passage through 'Dowex-50' (NH_4-form).

The chromatographically pure serine was crystallized from a small volume of hot aqueous ethanol. Two crops were invariably obtained; the first crystallized easily on the addition of 2–3 volumes of ethanol to the aqueous solution, while the second usually required considerably higher ethanol concentrations, or the addition of ether, before crystallization occurred. 3 kgm. of frozen earthworms yielded 45 and 42 mgm. of the first and second crops, respectively. Both samples were shown to be pure serine by carbon, hydrogen and nitrogen analysis and by two-dimensional chromatography in ethanol/formic acid/water (7 : 1 : 2) and water-saturated phenol.

Examination of the optical rotation (in water) of the two samples showed crop 2 to be lævorotatory, while crop 1 was optically inactive.

In order to exclude the possibility of racemization during extraction and subsequent fractionation, a sample of authentic L-serine was dissolved in 1·5 *N* perchloric acid and the entire isolation procedure repeated with this solution. The serine was recovered in good yield and crystallized. It was found to be lævorotatory ($[\alpha]^{22^\circ}_{D} = -7\cdot37$ in water, $C = 4\cdot2$ per cent).

The optical purity of the serine samples was checked using a partially purified D-amino-acid oxidase preparation[6] which also contained a very active catalase. With crop 1 the oxygen uptake in 3 hr. was 88 per cent of that theoretically expected (1·0 µatom/µmole) for DL-serine in the presence of catalase. No oxygen uptake occurred with crop 2 or with the control L-serine re-isolated by the standard procedure. The possibility that the D-serine found in the perchloric acid extract of the earthworms was due to racemization can thus be excluded. In this connexion Minthorn *et al.*[7] have also shown, using the two serine enantiomorphs labelled with carbon-14, that the optical purity of serine was unaffected by techniques similar to those employed in the present experiments. Differential crystallization of DL-serine and one of the optically active enantiomorphs from a mixture has also been reported by these workers[8].

The present results thus establish the occurrence of D-serine in the free amino-acid pool of the earthworm, and, in view of the almost total recovery of the serine contained in the original extract, suggest that about 25 per cent of the free serine present is of the D-configuration. To the best of our knowledge this is the first occasion on which a free D-amino-acid has been unequivocally shown to be present in animal tissue. However, two unconfirmed early reports, on the finding of D-ornithine in fish liver[9], and of DL-alanine and DL-glutamate in goose and insect tissues, respectively[10], are referred to by Neuberger[11].

It would seem likely from the present findings that, in the earthworm, serine ethanolamine phosphodiester, and therefore lombricine, is synthesized from D-serine drawn selectively from the amino-acid pool.

A full account of this work will be published elsewhere.

H. ROSENBERG
A. H. ENNOR

Department of Biochemistry,
John Curtin School of Medical Research,
Australian National University,
Canberra.

[1] Thoai, N. v., and Robin, Y., *Biochim. Biophys. Acta*, 14, 76 (1954).
[2] Rosenberg, H., and Ennor, A. H., *Biochem. J.*, 73, 521 (1959).
[3] Beatty, I. M., Magrath, D. I., and Ennor, A. H., *Nature*, 183, 591 (1959).
[4] Rossiter, R. J., Gaffney, T. J., Rosenberg, H., and Ennor, A. H., *Biochem. J.* (in the press).
[5] Ennor, A. H., Rosenberg, H., Rossiter, R. J., Beatty, I. M., and Gaffney, T. J., *Biochem. J.*, 75, 179 (1960).
[6] Negelein, E., and Bromel, H., *Biochem. Z.*, 300, 225 (1939).
[7] Minthorn, jun., M. L., Mourkides, G. A., and Koeppe, R. E., *J. Biol. Chem.*, 234, 3205 (1959).
[8] Minthorn, jun., M. L., and Koeppe, R. E., *Nature*, 185, 459 (1960).
[9] Ackermann, D., and Mohr, M., *Z. Physiol.*, 98, 37 (1937).
[10] Fuchs, H., *Z. Biol.*, 98, 430 (1938).
[11] Neuberger, A., "Advances in Protein Chemistry", 4, 297 (1948).

Attachment of Immature Simuliidae to other Arthropods

AMONG biting flies of the family Simuliidae there are several species which, in their early stages, live in a remarkable association with other animals[1,2]. The larvæ and pupæ of the *Simulium neavei* complex, which includes an important vector of human onchocerciasis, are attached to freshwater crabs, and those of the *S. copleyi* complex to mayfly larvæ. The study of the association was interrupted by the extermination of *S. neavei* in a large area of Kenya[3], and the place of oviposition, the way in which the larvæ find their hosts, and the exact effect of the phenomenon are not yet known. The interest of the association is enhanced by its wide distribution; the *S. neavei* complex is represented in the Cameroons Republic[4] as well as in eastern and central Africa, and an unrelated species is associated with mayfly larvæ in the U.S.S.R.[5]. We now record the finding of Simuliids on dragonfly larvæ.

In January about forty crabs were examined near Salisbury, Southern Rhodesia, for larvæ of the *S. neavei* complex but without success. Seven dragonfly larvæ were collected in the Unwindsi stream, and a patch of Simuliid eggs was found on the abdomen, just behind the wing pads, of one of them which was 36 mm. long and belonged to a species of *Aeshna*, probably *rileyi* Calvert. The three hundred or so yellow eggs were placed in a wet tube and they hatched three days later after a journey by air. In the same district a small Simuliid larva was found on the side of a crab in the Ruwa stream. The hypostomium of this larva and first-stage larvæ from the eggs had three prominent apical teeth and was quite unlike that of the *S. neavei* complex, but resembled that of *S. lumbwanus* De Meillon. This character, combined with the presence of ventral papillæ, showed that the larvæ could be *S. adersi* Pomeroy, which was found in the larval stage on stones in the same stream, has a wide range of breeding places, and is probably related to the *S. neavei* complex. Two larvæ of another species, *S. medusaeforme* form *hargreavesi* Gibbins, probably in the third stage, were seen on the frons and the left wing pad of an 18 mm. Libellulid dragonfly larva which was found among a dense mass of these larvæ in the River Parmasea near Lokoja in Nigeria in August

1959. Other larvæ were found in similar circumstances in the River Hawal in the same country.

It seems unlikely that the eggs were laid on the larva by chance; but the significance of their presence is unknown. The finding on aquatic animals of larvæ of two species, at least one of which is outside the *S. neavei* complex and normally attaches itself to inanimate objects, may indicate how the Simuliid–crab association arose. Possibly larvæ attached themselves to crabs, received protection from certain natural hazards, and gave rise to a form which always behaved in this way. Whatever the reason for the findings, they suggest that it would be worth while to examine dragonfly larvæ and other aquatic animals in various parts of Africa and elsewhere in the hope of gaining more information about the association of immature Simuliids with larger animals. Young larvæ should, if possible, be kept alive in running water until they are large enough to be identified.

We are grateful to Mr. D. E. Kimmins of the British Museum (Natural History) for examining the dragonfly larvæ.

D. J. LEWIS

Scientific Staff,
Medical Research Council,
c/o British Museum (Natural History),
London, S.W.7.

E. T. REID

Malaria and Bilharzia Laboratory,
Salisbury,
Southern Rhodesia.

R. W. CROSSKEY

Commonwealth Institute of Entomology,
London.

J. B. DAVIES

Ministry of Health,
Kaduna,
Nigeria.

March 17.

[1] van Someren, V. D., and McMahon, J. P., *Nature*, 166, 350 (1950).

[2] Freeman, P., and De Meillon, B., "Simuliidae of the Ethiopian Region" (British Museum (Natural History), London, 1953).

[3] McMahon, J. P., Highton, R. B., and Goiny, H., *Bull. World Health Org.*, 19, 75 (1958).

[4] Grenier, P., and Mouchet, J., *Bull. Soc. Path. Exot.*, 51, 968 (1958).

[5] Rubtsov, I. A., *Priroda*, No. 10, 77 (1948).

Inhibition of Nodule Bacteria by an Antibiotic from Legume Seed Coats

THE loss of viability of *Rhizobia* on the surface of some legume seeds was described in early reports quoted by Fred, Baldwin and McCoy[1] and more recently by other workers. Greenwood (personal communication) found that survival of *Rhizobia* was better when applied in a peat-pumice carrier than in a milk suspension, and suggested that the white clover (*Trifolium repens*) "seed surface may have a toxic effect on rhizobia". Vincent[2] showed that survival on glass beads was superior to that on subterranean clover (*T. subterraneum*) seed. Lobb[3] suggested that an inhibitory substance may be present in lucerne (*Medicago sativa*) and white clover seed coats. However, in no case was it conclusively demonstrated whether reduced viability was due only to unsuitable physical conditions for survival or also to an inhibitory effect of the seed. Inhibition of organisms other than *Rhizobia*, by antibiotic substances in the seed of flowering plants, has been demonstrated by several workers[4-6].

Table 1. INHIBITION OF *Rhizobium trifolii* STRAIN *TA*1 ON PLATES BY SEED AND SEED EXTRACTS OF *Trifolium subterraneum* L. VAR. TALLAROOK

Seed treatment	Inhibition zones Mean distance – seed edge to zone edge (mm.)
Untreated	4·1
Autoclaved	4·7
Soaked and dried	0·1 *l.s.d.* 5 per cent = 3·4
Soaked, dried, and autoclaved	0·6
Autoclaved, soaked and dried	0·9
Autoclaved, soaked, dried and autoclaved	0·3
Source and treatment of water extract absorbed by filter paper disks	**Mean distance – disk edge to zone edge (mm.)**
Control—no extract	0·0
Extract of untreated seed	6·8
Extract of autoclaved seed	5·2 *l.s.d.* 5 per cent = 3·4
Extract of untreated seed autoclaved after absorption	4·0

Preliminary investigations showed that untreated and autoclaved seed of subterranean clover, and their extracts, inhibited *Rhizobia* in culture, but soaked seed did not. The following experiment was then carried out, using the direct plate method for testing seed[7] and the filter paper disk method for testing extracts[8].

Seed and seed extracts of *Trifolium subterraneum* L. var. Tallarook were treated as listed in Table 1. For soaking, 20 seeds were placed in 10 ml. of distilled water for 6 hr. This water was replaced with 10 ml. for a further 1 hr. before being poured off and the seed dried. Seed extracts were obtained by soaking 400 seeds in 10 ml. sterile water for 7 hr. Sterile filter paper disks (5 mm. diam.) were then immersed for 1 min., removed and dried. Disks were treated 3 times. Seed and filter paper disks were dried, at 50° C. in a sterile oven, to minimize variations between treatments due to differential uptake and loss of water during preparation of the treatments. Autoclaving of seed and extracts (15 lb. per sq. in. for 20 min.) prevented germination of seed, and antibiotic production by seed-borne organisms. Seed soaking and autoclaving treatments were combined to test whether any antibiotic from autoclaved seed formed only as a result of autoclaving was extractable, and, if so, whether it affected *Rhizobia* similarly to that from untreated seed.

Petri dishes, each containing 20 ml. of 1·4 per cent yeast mannitol agar, were surface inoculated with a suspension of 5×10^8 organisms (*Rhizobium trifolii* strain *TA*1). Three seeds or disks of each treatment were placed on the agar surface of each of 3 plates. Inhibition measurements were made after 93 hr. incubation at 27° C.

Inhibition was indicated by a clear zone, containing no visible colonies, surrounded by a zone of reduced colony size and number. Beyond these zones *Rhizobium* growth appeared normal. The distance of seed or disk edge to the zone of normal growth was measured.

Untreated seed was inhibitory. With soaked seed inhibition zones were very small but a seed extract strongly inhibited growth. Autoclaving of seed did not significantly affect the strength of inhibition whether the seed had been previously soaked or not, showing that no secondary inhibitory substances were formed due to autoclaving. Similarly autoclaving of the seed extract did not affect inhibition. The inhibitory substance in autoclaved seed was extractable with water and the extract of untreated seed retained its activity after autoclaving.

Further investigations showed that the antibiotic was associated with, and extractable from, the seed coat and not the embryo. Contrary to Ferenczy's findings[8], germination was not necessary for antibiotic production. In fact, recolonization of the inhibited zone was more rapid with viable germinating seeds than with autoclaved seeds.

Some variation occurred between individual seeds but variation between species was more marked. Autoclaved seed of three separate samples of three forage legume species were tested with *Rhizobium trifolii* strain *TA*1. Inhibition was strong with subterranean clover (mean 5·8 mm.), considerably less with white clover (1·5 mm.), and weak with lucerne (0·3 mm.). Differences in seed size do not adequately explain these differences, as lucerne seed is larger than that of white clover.

Field evidence, suggesting the presence in subterranean clover seed of substances inhibitory to *Rhizobia*, has been obtained at this laboratory. Spencer (personal communication) found that soaking of seed prior to inoculation and sowing resulted in greatly improved nodulation from the applied inoculum. On the other hand, when inoculum was applied to the soil there was no beneficial effect of soaking seed. I have found that physical separation of the seed coat and inoculum, by coating the seed with inert material before inoculation, improved nodulation of subterranean clover.

The results presented indicate that the seed coats of the subterranean clover investigated contain a thermo-stable, water-soluble antibiotic, active against a strain of *Rhizobium* normally incorporated in commercially prepared inocula. This substance could contribute to loss of viability of nodule bacteria on the seed both in storage and in field sowings.

J. A. Thompson

Division of Plant Industry,
Commonwealth Scientific and Industrial
Research Organization,
Armidale,
New South Wales.

[1] Fred, E. B., Baldwin, I. L., and McCoy, Elizabeth, "Root Nodule Bacteria and Leguminous Plants" (University of Wisconsin Press, Madison, 1932).

[2] Vincent, J. M., Proc. Univ. of Nottingham Fifth Easter School of Agric. Sci., 108 (Butterworths, London, 1959).

[3] Lobb, W. R., *N.Z. J. Agric.*, 96, 556 (1958).

[4] Ferenczy, L., *Acta Biol. Acad. Sci. Hung.*, 6, 317 (1956).

[5] Ark, P. A., and Thompson, J. P., *Plant Dis. Rep.*, 42, 959 (1958).

[6] Maruzzella, J. C., and Freundlich, M., *Nature*, 187, 972 (1959).

[7] Osborn, E. M., and Harper, J. L., *Nature*, 167, 685 (1951).

[8] de Beer, E. J., and Sherwood, Marion B., *J. Bact.*, 50, 459 (1945).

Effect of Autumn Applications of Potassium Gibberellate on Fruit Production of the Strawberry

In the autumn of 1957 at New Brunswick, New Jersey, single-row, 30-ft. replicated plots of Sparkle strawberries were treated with 20 and 50 p.p.m. of potassium gibberellate. Three applications were made, with the first application applied on September 13. An additional variable was added by using both a 1-week and 2-week interval between spray applications. No effect was noted in the autumn of 1957 from these sprays except for an occasional inflorescence observed on the plots sprayed with 50 p.p.m. The next spring the sprayed plots had a heavier bloom early in the flowering period as compared with the unsprayed plots. The harvest records for 1958 showed that the treated plots produced about a 30 per cent larger volume of early fruit than the unsprayed checks, with no difference due to interval between spray applications. Due to rains and fruit rots during the latter part of the 1958 harvest season, total yield records were not recorded.

In the autumn of 1958 another investigation was conducted using 30-ft. single-row plots of Sparkle strawberry plants. Each treatment was replicated five times. Treatments consisted of 0, 10, 20, 30, 40, 50 and 100 p.p.m. of potassium gibberellate (supplied by Merck and Co., Rahway, New Jersey, which supported this work with a grant-in-aid) applied as sprays on September 17, October 1 and October 15. Some inflorescences were observed later in the autumn on plots sprayed with 40, 50 and 100 p.p.m., and petiole elongation was observed at the 100 p.p.m. level.

Table 1. Effect of Potassium Gibberellate Sprays on Yield of Sparkle Strawberry Fruit

Spray concentration (p.p.m.)	Yields	
	Early harvest* (quarts/acre)	Total† (quarts/acre)
0	2,603	10,662
10	3,758	9,519
20	3,616	8,637
30	3,515	8,252
40	2,485	5,209
50	2,390	5,241
100	822	1,678
L.S.D. 0·05	958	1,882
L.S.D. 0·01	1,298	2,550

* Includes harvests of May 28, June 2 and June 5.
† Total yield was based on above three harvests plus an additional five completed by June 26, 1959.

The results obtained in the 1959 harvest season (Table 1) indicate that by June 5 (including three harvests) the 10 and 20 p.p.m. treatments had significantly increased the volume of fruit harvested as compared with the unsprayed checks: the 100 p.p.m. treatment, on the other hand, had significantly reduced yields. The total yields (including eight harvests) for these plots showed that there was no significant difference between the unsprayed checks and the 10 p.p.m. treatment, while all the other treatments showed a significant reduction in yield.

The application of three sprays of 10 p.p.m. of potassium gibberellate in the autumn may give the strawberry grower an economic advantage, since the early fresh market fruit commands a premium price.

Carter R. Smith

Department of Horticulture,
Rutgers—The State University,
New Brunswick,
New Jersey.

Viability and Germination Inhibitor of the Seed of Rice

The loss of viability of seeds within one year after harvesting has been reported by Grist[1] from varieties of rice grown in British Guiana and by Ramiah[2] in India, but no explanation has been offered. Germination tests of a winter variety 'Rupsail' recently carried out in this laboratory indicated peak germination

Table 1. Respiration-Rates of Rice Seeds without Husk

Year of collection	μl./O_2/hr./mgm. dry weight	μl./CO_2/hr./mgm. dry weight
1953	0·078	0·054
1957	0·078	0·080
1958	0·142	0·113

Table 2. ROOT AND SHOOT GROWTH (CM.) IN SOLUTIONS LEACHED FROM SEEDS OF RICE HARVESTED IN DIFFERENT YEARS

Growth (hr.)	Control (distilled water)		1958		1957		1953	
	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
24	0·25 ± 0·02	0	0·22 ± 0·02	0	0·26 ± 0·04	0	0·15 ± 0·01	0
48	3·08 ± 0·12	1·08 ± 0·30	3·50 ± 0·52	0·83 ± 0·14	3·45 ± 0·24	1·36 ± 0·12	1·83 ± 0·30	0·93 ± 0·18
72	4·18 ± 0·36	1·94 ± 0·21	5·89 ± 1·10	2·58 ± 0·23	4·98 ± 0·14	2·33 ± 0·48	4·02 ± 0·37	2·28 ± 0·07
96	6·28 ± 0·83	3·54 ± 0·45	7·25 ± 0·26	2·77 ± 0·29	6·38 ± 0·37	4·68 ± 0·46	4·89 ± 0·97	3·72 ± 0·31
120	9·76 ± 0·12	8·30 ± 1·0	9·88 ± 0·46	7·88 ± 0·80	7·33 ± 0·88	13·0 ± 2·80	5·10 ± 0·06	10·2 ± 0·41
144	11·20 ± 0·57	8·53 ± 0·53	12·23 ± 0·73	9·20 ± 1·40	8·83 ± 0·17	14·56 ± 0·93	5·36 ± 0·33	13·03 ± 1·70
168	15·43 ± 0·96	12·01 ± 1·10	12·43 ± 0·75	15·36 ± 0·95	8·90 ± 1·00	16·50 ± 0·76	5·56 ± 0·20	17·20 ± 1·90

Table 3. EFFECT OF LIGHT QUALITIES ON THE PERCENTAGE OF GERMINATION OF RICE SEEDS

	White	Blue	Green	Yellow	Red	Dark	Far-red	12-hr. period of white light + dark	8-hr. period of white light + red + dark	12-hr. period of red + far-red	12-hr. period of far-red + red
24-hr. exposure of soaked seeds	96·10 ±0·50	92·30 ±1·02	94·95 ±0·05	88·85 ±1·02	85·30 ±2·00	87·95 ±0·02	78·30 ±0·83	98·40 ±0·03	60·80 ±0·40	45·34 ±0·19	45·06 ±0·25

during March–June following harvesting in December; thereafter it declined and from November onwards the viability was lost. Seeds harvested in 1953 and 1957 failed to germinate in 1959. The excised embryos from fresh seeds of 1958 germinated only in White's nutrient agar media while those of one- or five-year old seeds did not grow. Respiration-rates measured by Warburg apparatus indicated higher rates in fresh seeds than the old ones (Table 1).

The results thus show that the failure of germination of old seeds of 1953 and 1957 is not due to the nature of the husk acting as a barrier with increasing carbon dioxide concentration inside or the old seeds becoming dead. The possibility of the presence of germination inhibitor and its formation was then investigated.

Tests were made on the basis that the inhibitor, if present, might be leached out of the seeds during soaking in water for 24 hr. Leachings from seeds of 1953, 1957 and 1958 were therefore used for the growth of viable seeds; 88–90 per cent seeds just sprouted but subsequent growth of root was inhibited in the leachings from the non-viable seeds of 1953 and 1957 and shoot growth accelerated in later periods (Table 2). Promotion of growth of the shoot and inhibition of growth of the root are suggestive of auxin action. Auxin assay of the embryo extracts by root inhibition tests showed that embryos from old seeds contained a higher amount of indoleacetic acid equivalent in comparison to that of viable seeds. The concentration was much increased in the embryos of 5-year-old seeds. From consideration of the presence of a large amount of auxin in the embryos of non-viable seeds and reduction of embryonic root growth in the leachings, it is presumed that there exists a close relation between auxin concentration and the formation of germination inhibitor.

Experiments performed on the effects of different light qualities indicated that white light increased germination over the percentage in the dark. But the percentage in red was not increased over darkness while far-red rays had the largest inhibiting effect (Table 3). In photoblastic seeds Toole *et al.*[3] have recorded stimulation in red over darkness, but infra-red following red inhibited germination. Inhibiting effect in rice seed was further shown when red was interpolated between white light and dark as the percentage of germination was considerably reduced in comparison with treatments of light and dark. It appears that the absorption of red and far-red rays leads to the formation of germination inhibitor in rice seeds.

We thank Miss Protima Datta Ray for assistance in the measurement of respiration-rates.

S. M. SIRCAR
MANJULA BISWAS

Department of Botany,
University of Calcutta,
Calcutta, 19.
March 18.

[1] Grist, D. H., "Rice" (Longmans, Green and Co., London, 1954).

[2] Ramiah, K., "Rice Breeding and Genetics", Sci. Mono. No. 19 (Indian Council of Agricultural Research, New Delhi, India, 1953).

[3] Toole, E. H., Hendricks, S. B., Borthwick, H. A., and Toole, Vivian K., "Ann. Rev. Plant Physiol.", 7, 299 (1956).

Foliar Application of Nutrients and Rhizosphere Microflora of *Camellia sinensis*

SUSCEPTIBILITY of plants to fungi causing root-rot is known to be conditioned by the rhizosphere microflora[1,2]. Changes in this microflora can result from derangement in plant metabolism caused by either foliar treatment with chemicals[3], fungal infection of the roots[2] or even systemic infection by plant viruses[4]. Therefore, it seems possible to stimulate artificially the multiplication of specific micro-organisms in the rhizosphere by selective plant treatment, such as foliar application of nutrients, designed to act directly on the plant without affecting the soil. Work on these lines, apart from a recent report[5], has received little attention. Observations on sprayed tea plants reported here support the basic concept of changing the pattern of the rhizosphere microflora by foliar sprays.

One-year-old monoclonal selections of tea plant, propagated from cuttings, were grown in tea field soil in earthenware pots, and each experimental plant was sprayed with an atomizer with 10 ml. aliquots of nutrient solutions (Table 1). Distilled-water sprayed plants formed controls. The soil was protected from run-off spray by a plastic cover. The plants were kept under a bell-jar for 24 hr. after each spray application, four of which were made at 2-day intervals. Four days after the completion of the last spray, rhizosphere soil from each treatment (three replicates) was sampled and dilutions plated in soil-extract, glucose, nitrate-agar for bacterial, and in peptone, dextrose-agar containing 1 : 10,000 crystal violet and 15 μgm./ml. each of streptomycin and dihydrostreptomycin for fungal, counts.

Table 1

Foliar spray treatments	Rhizosphere population in 1 gm. dry soil		
	Fungi (in thousands)	Bacteria (in hundred thousands)	Fungal genera and species occurring in the rhizosphere
(*A*) 0·76 *M* $(NH_4)_2SO_4$	125·0	32·3	(1), (2)*
(*B*) 0·04 *M* $MgSO_4.7H_2O$	93·5	12·3	
(*C*) 0·67 *M* KCl	256·5	27·0	(2)
(*D*) 1·47 *M* $NaNO_3$	176·5	33·0	(2)
(*E*) 0·28 *M* $Na_2HPO_4.12H_2O$	281·5	14·0	(2), (3)
(*F*) 0·83 *M* Urea	73·5	20·3	(1)
(*G*) Control: distilled water	193·5	44·0	(2)
Difference required for significance, *P* = 0·01	32·0 FBADGCE	6·3 BEFCADG	

* (1) *Stysanus* sp., (2) *Scopulariopsis brevicaulis* Bain., (3) *Myrothecium* sp.

Foliar spray with any of the inorganic or organic nutrients significantly reduced the bacterial population of the rhizosphere soil (Table 1). 0·67 *M* solution of potassium chloride and 0·28 *M* disodium hydrogen phosphate significantly increased the number of fungi in the rhizosphere soil over that in the control, whereas a significant reduction of fungal numbers was recorded with application of 0·04 *M* magnesium sulphate. The rhizosphere fungi responded differently to spray containing comparable amounts of nitrogen but from different nitrogen sources. With 1·47 *M* solution of sodium nitrate there was no significant difference in fungal numbers over control plants, but spraying with 0·76 *M* ammonium sulphate and 0·83 *M* urea significantly decreased the fungal population. Although spray application with urea markedly increased fungal population in the rhizosphere of rice plants[4], the reverse seems to be the case in tea plants.

Table 1 also summarizes specific differences in the genera and species of fungi occurring in the rhizosphere of plants sprayed with different nutrilites. Such differences in the occurrence of a species of *Penicillium* in the rhizosphere of urea-sprayed rice plants has recently been reported[5]. Roots of plants subjected to high temperature, high light intensity[6] or desiccation[7] are known to exude large amounts of amino-acids and these energy sources are presumed to be used up by micro-organisms[6]. Differences in the rhizosphere microflora resulting from foliar application of nutrients is probably due to qualitative and quantitative changes in the root exudates induced by the plant treatment. Further work on these lines is in progress and details will be published elsewhere.

I thank Prof. T. S. Sadasivan for helpful suggestions, the Director of the Commonwealth Mycological Institute, for identification of fungal cultures and the Chief Scientific Officer of this Department for facilities to carry out this investigation.

C. S. VENKATA RAM

Tea Experiment Station,
P.O. Devarshola,
South India.
March 7.

---

[1] Timonin, M. I., *Soil Sci.*, 52, 395 (1941).

[2] Katznelson, H., and Richardson, L. T., *Sci. Agric.*, 23, 293 (1943).

[3] Halleck, F. E., and Cochrane, V. W., *Phytopath.*, 40, 715 (1950).

[4] Lakshmi-Kumari, M., *Mem. Indian Bot. Soc.* (in the press).

[5] Ramachandra-Reddy, T. K., *Phytopath. Z.*, 36, 286 (1959).

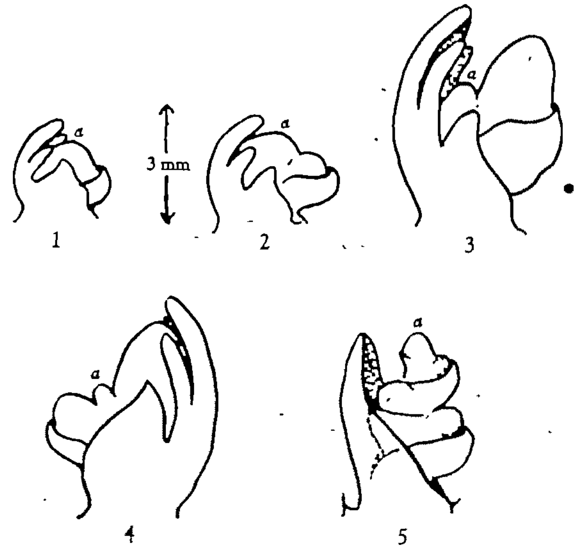
[6] Rovira, A. D., *Plant and Soil*, 11, 53 (1959).

[7] Katznelson, H., Rouatt, J. W., and Payne, T. M. B., *Nature*, 174, 1110 (1954).

Axial Origin of the Terminal Inflorescence in the Genus *Trifolium*

J. L. STODDART[1] states that floral initiation in red clover begins by the enlargement of the shoot apex. The following observations show that the actual shoot apex is absorbed by an adjoining lateral bud. The origin of the terminal inflorescence of this species as a lateral bud is therefore similar to that of the axillary inflorescence in other species.

In species with axillary inflorescences (for example, *T. subterraneum*[4] and *T. repens*), the change from the vegetative state (Fig. 1) to the reproductive begins at the shoot apex (*a*) with the formation of a bulge in the axil of the topmost leaf initial (Fig. 2). A similar bulge is formed in each further leaf initial, the bulge and leaf initial developing into the type of inflorescence and leaf typical of the species, and the tissue expanding between each leaf to make the lengthened internodes characteristic of the flowering stage of the shoot.



In species with terminal inflorescences (for example, *T. pratense* and *T. alexandrinum*), the reproductive state begins in the same way, but is followed by domination and absorption of the shoot apex by the first one or two lateral bulges. Usually the first bulge is the only one; it increases in size (Fig. 3) until the shoot apex disappears. Florets are differentiated from a series of small bulges formed over its surface. Sometimes a second bulge is formed in the axil of another leaf initial before the shoot apex stops growth. In this case, the apex can be seen for a short time between the two enlarging inflorescence primordia (Fig. 4). The younger inflorescence is usually the smaller of the two when fully developed.

It is interesting to note that the terminal inflorescences of well-known gramineous genera also originate from lateral bulges in leaf initials close to the shoot apex (for example, oat, Fig. 5). Apart from differences in floret structure peculiar to each family, the mature inflorescence of a grass or cereal therefore differs from that of a clover mainly by the number of 'fertile' leaf initials, and by the development of each such leaf initial to form a small ridge only instead of a leaf (for example, *Avena sativa*[2] and *Lolium perenne*[3]).

YVONNE AITKEN

School of Agriculture,
University of Melbourne.

---

[1] Stoddart, J. L., *Nature*, **184**, 559 (1959).

[2] Bonnett, O. T., *J. Agric. Res.*, **54**, 927 (1937).

[3] Cooper, J. P., *J. Ecol.*, **39**, 228 (1951).

[4] Aitken, Y., *Aust. J. Agric. Res.*, **6**, 212 (1955).

BACTERIOLOGY

A Growth Factor for *Haemophilus* Species secreted by a Pseudomonad

THE clustering of bacterial colonies of one species around those of another—satellitism—was first described for *Haemophilus influenzae* by Grassberger in 1897[1]. The interrelationship is probably due to the supply of critical nutrients by one micro-organism to the other. While the special nutritional requirements of *Haemophilus* species have been studied and some compounds essential for growth identified[2], the nature of bacterial substances responsible for the satellite phenomenon have not been investigated. In this communication we report on the isolation of such substances.

It is much easier to study excretory products of bacteria in a chemically defined medium than in a complex one. Therefore, only cultures able to grow in simple media were screened for their ability to stimulate growth of *Haemophili* on blood agar or support it on brain heart infusion (Difco Laboratories, Detroit) agar. Test organisms included seven strains of *Haemophilus* of animal origin, four strains of *H. influenzae*, and one strain each of *H. parainfluenzae*, *H. parahaemolyticus* and *H. gallinarum*. The cultures were streaked on test media and crossed with a single streak of the possible 'feeder'. A good 'feeder' was found to be a pseudomonad isolated from an emperor penguin and obtained from Dr. L. A. Page. This bacterium grew well in a solution of histidine (200 mgm. per cent), monobasic potassium phosphate (20 mgm. per cent), mineral mix No. 49 (supplied by Dr. J. H. Hunter, Haskins Laboratories, New York, and containing iron, manganese, zinc, cobalt, copper, vanadium and boron) (8 mgm. per cent) at *p*H 7·5 and 37° C. When grown in such a medium, the organism secreted growth factors essential for *Haemophilus* species, apparently the same as produced in the more complex media.

The penguin pseudomonad was grown in 1 litre of the above medium for 48 hr. After the cells had been removed by centrifugation, the supernatant was Seitz-filtered and lyophilized. The dried material was redissolved in 10 ml. of water and chromatographed, using ascending chromatography with a solvent system consisting of butanol, acetic acid, and water (4 : 1 : 5). Two ultra-violet-absorbing spots were observed under illumination with a 'Mineralight' (2537 *A*) (Ultra-violet Products, Inc., South Pasadena), of which one was much denser than the other. An additional spot was detected after spraying with ninhydrin—probably histidine from the growth medium, as shown by a reference sample.

The ultra-violet-absorbing material (*EP*) contained in the denser spot was eluted from the paper and added to brain heart infusion agar. This medium could then support the growth of *Haemophili*. *EP* was further purified by repeated partition on Whatman No. 1 filter paper and subsequent elution. The solvents, used in sequence, were: monobasic sodium phosphate, 5 per cent; *iso*propanol, ethanol, and water in the ratio of 7 : 2 : 1; and *iso*propanol and 0·2 *M* ammonium hydroxide in the ratio of 3 : 1. Prior to use, the filter paper had been washed for 24 hr. in distilled water.

Purified *EP* had ultra-violet absorption optima at 265 and 275 mμ at *p*H 1·0 and 11·0, respectively. On hydrolysis, with 2 *N* hydrochloric acid at 115° C. for 60 min., a carbohydrate was released which, in three different solvents, had the same R_F as ribose. *EP* was found to be free of phosphorus. In aqueous solution it could be heated at 100° C. for 30 min. and 120° C. for 5 min. without substantial loss of activity; heating at 120° C. for 10 min. resulted in complete inactivation.

Species of *Haemophilus* require for growth either *V* factor—replaceable with diphosphopyridine nucleotide, or its nucleoside[3]—*X* factor—replaceable with hæm, or both. Since most of our animal strains which were stimulated by *EP* showed no hæm requirement, a relationship between *EP* and diphosphopyridine nucleotide was suggested. *EP*, both before and after acid hydrolysis, had a different R_F value from niacin, niacinamide, niacinamide riboside, niacinamide mononucleotide, and diphosphopyridine nucleotide. It also differed from these in ultra-violet absorption spectra. Infra-red absorption spectra do not exclude *EP* from being a derivative of niacinamide.

EP could be replaced as a growth factor for *Haemophilus* by diphosphopyridine nucleotide and niacinamide mononucleotide but not by niacinamide, adenosine triphosphate or the products of acid hydrolysis of ribo- or deoxyribo-nucleic acids. Test organisms grew in brain heart infusion broth with either niacinamide mononucleotide or diphosphopyridine nucleotide in the concentration of 10γ per cent, whereas *EP* was required at the concentration of 1,000γ per cent. While it is possible that this amount reflects the true needs of the test species, the possibility of partial inactivation of the compound during the purification process cannot be disregarded. Dorfman *et al.*[4], working with *Shigella*—which requires nicotinic acid or niacinamide for growth—showed that N-substituents of niacinamide served as growth factors while substitution on the ring inactivated the molecule. In one case where quinolinic acid could be used to promote some growth, its effective concentration was 1,000 times that of niacinamide.

While the data on hand are insufficient to characterize *EP* completely, present information suggests that it might be a niacinamide riboside with unknown substitutions. Its implied biological significance would be consistent with such an interpretation. Work to elucidate further the structure and composition of *EP* is in progress.

This work was supported in part by a U.S. Public Health Service grant *E*–1726.

MOSHE SHIFRINE
ERNST L. BIBERSTEIN

School of Veterinary Medicine,
University of California,
Davis, California.

---

[1] Grassberger, R., *Z. Hyg. Infekt. Dis.*, **25**, 453 (1897).

[2] Lwoff, A., *Ann. Inst. Pasteur*, **61**, 580 (1938).

[3] Gingrich, W., and Schlenk, F., *J. Bact.*, **47**, 535 (1944).

[4] Dorfman, A., Koser, S. A., Reames, H. R., Swingle, K. F., and Saunders, F., *J. Infect. Dis.*, **65**, 163 (1939).

Antibody Responses of the Domestic Fowl to Two Soluble Bacterial Antigens

FOR some years now virologists have recognized the value of the domestic fowl as a means of obtaining high-titred antisera to viral and rickettsial antigens. Bacteriologists and immunologists have almost invariably preferred the rabbit, consequently little information is available about the responses of fowls to soluble bacterial antigens. While investigating the immunological tolerance of diphtheria alum-precipitated toxoid in the domestic fowl[1] I had the opportunity of collecting a limited amount of information about the primary and secondary antibody responses of White Leghorn fowls to both tetanus alum-precipitated toxoid (Wellcome series *W6874A*) and diphtheria alum-precipitated toxoid (Wellcome series *BA6403A*); though only one dosage of each antigen was used, the results may be of value to other workers.

Twenty birds between the ages of 10 and 14 months were used in the experiment. One group of ten was given a primary stimulus of 1·0 ml. diphtheria alum-precipitated toxoid (20L_f) intramuscularly; the other received 1·0 ml. tetanus alum-precipitated toxoid (50L_f) by a similar route. A sample of blood was taken from each bird immediately before primary challenge and then at 3- or 4-day intervals for 31 days. A second dose (1·0 ml.) of the respective antigens was given intramuscularly 34 days after the last bleeding (that is, 65 days after primary challenge). The fowls were bled immediately before this injection and then at intervals of 2 or 3 days for the next 15 days.

The serum was separated from these blood samples by centrifugation and the appropriate samples tested for their diphtheria antitoxin content (Romer and Sames[2], as modified by Glenny and Llewellyn-Jones[3]), or their tetanus antitoxin content[4].

Fig. 1 shows the average primary and secondary antibody response of ten fowls to diphtheria alum-precipitated toxoid. Antibody to this antigen was first detected 10 days after primary stimulation, reached a maximum in most cases on the fourteenth day and then gradually declined. After secondary stimulation, antibody was always detectable after 3 days and reached maximum concentration between the eighth and thirteenth day, the tenth day after injection being the most usual.

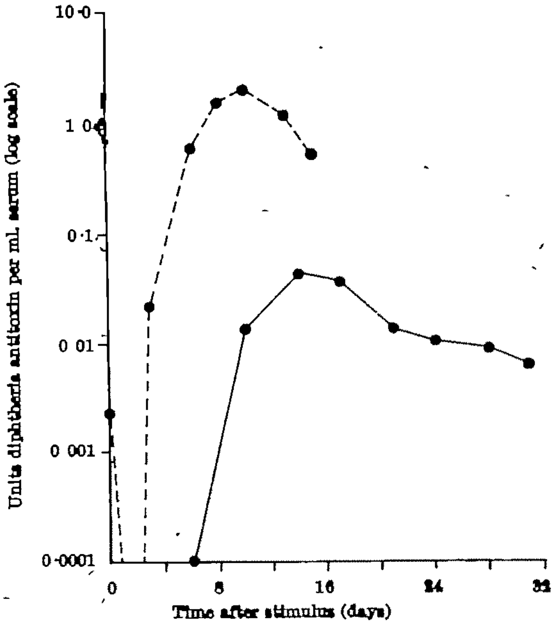


Fig. 1. Average antibody responses of 10 birds to the primary (●—●) and secondary (●– – –●) antigenic stimulus with diphtheria alum-precipitated toxoid

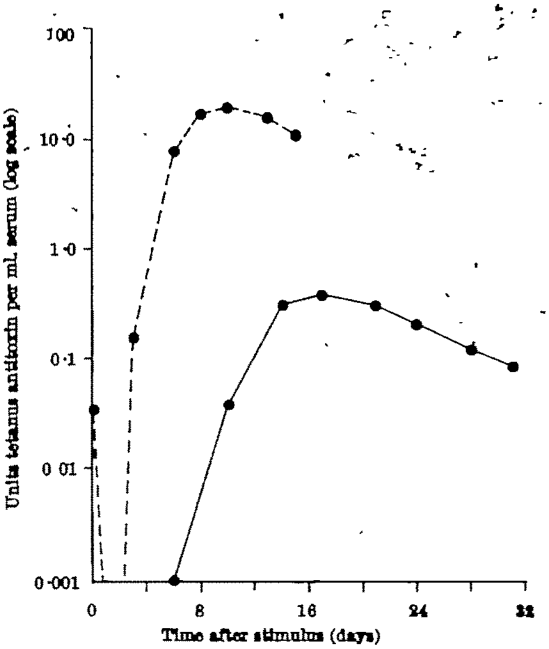


Fig. 2. Average antibody responses of 10 birds to the primary (●—●) and secondary (●– – –●) antigenic stimulus with tetanus alum-precipitated toxoid

Fig. 2 shows the primary and secondary antibody responses to tetanus alum-precipitated toxoid. These responses are similar in form to those with diphtheria alum-precipitated toxoid as the antigen, except that the maximum response to primary challenge with tetanus alum-precipitated toxoid appears to be delayed for about three days and is therefore not usually reached until the seventeenth day. This finding was general among the group.

The individual maximum antibody concentrations reached were 0·1 I.U. diphtheria antitoxin and 3·0 I.U. tetanus antitoxin per ml. of serum during the primary response, and during the secondary response 5·0 I.U. diphtheria antitoxin and 65 I.U. tetanus antitoxin. There was, of course, considerable individual variation in the amounts of antibody produced, but, as can be seen from the figures, the antibody responses in these birds compare favourably with those obtainable in the rabbit under similar conditions.

A number of fowls were also injected with both antigens simultaneously[1], one antigen being injected into each leg. Results similar to those described above were obtained and there was no evidence of any interference between the two antigens.

G. GOWLAND

Department of Bacteriology,
School of Medicine,
Leeds, 2.
March 17.

---

[1] Gowland, G., and Oakley, C. L., *J. Path. Bact.* (in the press).
[2] Romer, P. H., and Sames, T., *Z. ImmunForsch.*, 3, 384 (1909).
[3] Glenny, A. T., and Llewellyn-Jones, Mona, *J. Path. Bact.*, 34, 143 (1931).
[4] Glenny, A. T., and Stevens, Muriel, F., *J. Roy. Army Med. Corps*, 70, 308 (1938).

FORTHCOMING EVENTS

Tuesday, August 16

Institute of Metals (at 17 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. J. J. Gilman: "The Physical Nature of Plastic Flow".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Librarian (with a university degree)—The Secretary, The University, Aberdeen (August 20).

Radio Propagation Engineer (with an appropriate university degree with honours or equivalent, and experience in radio propagation research and meteorological physics) at the Research Laboratories, Australian Post Office, Melbourne, for the scientific investigation of tropospheric radio propagation as related to general meteorological phenomena—The Australian Post Office Representative, Australia House, Strand, London, W.C.2 (August 20).

Research Assistant, to perform theoretical investigations on various aspects of semiconductors—Prof. P. T. Landsberg, Department of Applied Mathematics, University College, Cathays Park, Cardiff (August 20).

University Demonstrator in the Department of Veterinary Clinical Studies, to assist in the teaching of clinical pathology—Dr. G. A. Gresham, The Medical School, The University, Tennis Court Road, Cambridge (August 25).

Senior Lecturer in Mathematics; and a Senior Lecturer in Mathematical Statistics at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 31).

Research Assistant (Plant Biochemist) to Dr. B. T. Cromwell, for work on biosynthesis of alkaloids in higher plants—The Registrar, The University, Hull (September 3).

Lecturer (Electron Microscopy), for integrated biochemical and cytological studies of cell division; and a Lecturer (Physical Biochemistry), for studies of proteins, particularly of wheat grain, in the Department of Agricultural Chemistry at the Waite Agricultural Research Institute, University of Adelaide, Australia, —The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 5).

Botanist, Scientific Officer grade (with a good honours degree and preferably postgraduate training or research experience), to study the development and anatomy of apples in relation to storage behaviour—The Secretary, East Malling Research Station, near Maidstone, Kent (September 7).

Lecturer (graduate in civil, mechanical or electrical engineering) in Engineering; and a Lecturer in Geology at Fourah Bay College, The University College of Sierra Leone—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 15).

Lecturer/Senior Lecturer (qualified in grassland management) in Animal Husbandry at the University of Sydney Animal Husbandry Farms, Camden, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 15).

Research Biophysicist (with a degree in medicine or biology, previous research experience, and preferably experience in the technique of electron-microscopy), to undertake an investigation into some aspects of industrial chest disease with special reference to asbestos, and to work either in the Department of Pathology or in the Cavendish Laboratory, or partly in both Departments—The Secretary of the Department of Physics, The Cavendish Laboratory, The University, Cambridge (September 15).

Senior Lecturer and Director (with high academic qualifications and experience of high-speed digital computers) of the Sub-Department of Computation—The Secretary and Registrar, The University, Southampton (September 15).

Lecturer/Senior Lecturer and a Lecturer in Psychology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 16).

Chair of Psychological Medicine—The Secretary, The University, Edinburgh (September 23).

Chair of Botany in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, September 30).

Reader in Mathematics—Prof. Titchmarsh, Mathematical Institute, The University, Oxford (October 15).

Scientific Officer (honours graduate, preferably with two to three years postgraduate experience) in the Entomology Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (October 15).

Assistant, Grade B, in the Architecture and Building Department, to teach Mathematics to G.C.E. "A" level standard to full-time students in the Land Surveying Section—The Clerk to the Governors, South-West Essex Technical College and School of Art, Forest Road, Walthamstow, London, E.17.

Assistant Principal (with a university degree in forestry and preferably experience in teaching and tropical forestry) of the Forest School, Uganda—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.61/9/08/01.

Education Officer (with a university degree or equivalent qualification and several years experience in a special library or information department, preferably in industry), to make a special study of the training requirements of special librarians and information officers and to organize frequent short courses in this field)—The Director, Aslib, 3 Belgrave Square, London, S.W.1.

Field Seismologist (with an honours degree in mathematics and physics, geophysics or a closely related science, plus experience in seismological field work) in the Department of Mines and Technical Surveys, Canada, to direct a group conducting long-range seismic observations on the Polar Continental Shelf and at sea with the most modern magnetic tape equipment—Dept. 1510, National Employment Service of Canada, 61 Green Street, London, W.1.

Game Officer (male, with a university degree in zoology) in Kenya, initially for normal Game Warden duties, but after experience of Kenya conditions, for research work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.152/7/04.

Graduate Research Assistant in Physics, to work on studies of the structure of diamonds by optical methods—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey.

Lecturer (with a degree in electrical engineering and appropriate professional qualifications, with teaching and industrial or research experience) in Electrical Engineering—The Principal, Kingston Technical College, Fassett Road, Kingston-upon-Thames, Surrey.

Lecturers (2) in Zoology, one to teach histology and microtechnique, and the other to teach ornithology (and, if possible, animal behaviour)—MacGill University, Montreal, Quebec, Canada.

Meteorologists (men or women, with a good honours degree in mathematics and/or physics, and preferably experience in a meteorological service, especially in analysis and forecasting) in the East African Meteorological Department, for duties which may include weather analysis and forecasting (including research); consultative meteorological work related to agriculture, hydrology, etc.; research into climatology, rain stimulation, evaporation control, and work in the field of geomagnetism or solar radiation—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.57/88/01/C1.

Professor of Physiology, and a Professor of Biochemistry at the University of Shiraz, Iran—The Director, Recruitment-Department, British Council, 65 Davies Street, London, W.1, quoting N.12/T (60).

Research Assistant (preferably with an honours degree, some experience of vacuum techniques, electronics, or a knowledge of dielectrics) in Physics in the Department of Natural Philosophy, for work on the properties of thin dielectric films—The Secretary, Royal College of Science and Technology, George Street, Glasgow, C.1.

Research Workers (2) (with an honours degree in biochemistry or zoology, and preferably with previous research experience) in the Department of Zoology, for the extension of fundamental work now in progress on (*a*) the mode of action of insecticides and (*b*) chemoreception of insects—Dr. A. B. P. Page, Imperial College Field Station, Ashurst Lodge, Sunninghill, Ascot, Berks.

Rexco Research and Development Company Research Students (with, or anticipating to have, a good honours degree in chemistry, Grad.R.I.C., or a Dip.Tech. in pure or applied chemistry), for the study of products from the low temperature carbonization of coal—Head of the Department of Applied Chemistry, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

Scientific Officers or Senior Scientific Officers (with a first- or second-class honours degree in an appropriate subject or equivalent) at Home Office Forensic Science Laboratories at Cardiff (Chemist), Preston (Chemist and Biologist) and Birmingham (Chemist or Biologist), for examination of material received from police and to give evidence in criminal courts—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. F.454/0A.

Senior Lecturer in Inorganic Chemistry; Lecturers (2) in Chemical Engineering; Lecturers (2) in Organic Chemistry; an Assistant, Grade B, in Applied Chemistry (Dyeing); and an Assistant, Grade B, in Metallurgy—The Registrar, Bradford Institute of Technology, Bradford 7.

Technical Officer (with a recognized degree or National Diploma in Agriculture, Horticulture or Agricultural Botany) in the Seed Production Branch, to specialize on root and vegetable seed crops—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 61: The Care and Management of Breeding Bulls. Pp. 8. Leaflet No. 110: Diseases and Pests of Tomatoes. Pp. 14. (Belfast: Ministry of Agriculture, 1960.) [235

Falkland Islands Dependencies Survey. Scientific Reports. No. 19. The Geology of South Georgia—II. By Dr. A. F. Trendall. Pp. 48+5 plates, 25s. net. No. 23: The King Penguin *Aptenodytes patagonica* of South Georgia. 1: Breeding Behaviour and Development. By Dr. Bernard Stonehouse. Pp. 81+7 plates. 25s. net. (London: H.M. Stationery Office, 1960.) [235

Institution of Gas Engineers. Publication No. 565: 97th Annual Report and Accounts of the Council of the Institution of Gas Engineers. Pp. 46. Publication No. 566: Presidential Address delivered at the 97th Annual General Meeting, Edinburgh, 31st May to 3rd June, 1960. By Duncan D. Melvin. Pp. 16. Publication No. 574: Official Programme, 97th Annual General Meeting, Edinburgh, 31st May to 3rd June, 1960. Pp. 12. (London: Institution of Gas Engineers, 1960.) [235

The National Gallery, July 1958–December, 1959. Pp. 75+10 plates. (London: The National Gallery, 1960.) 5s. [235

Royal Greenwich Observatory Bulletins. No. 18: Photographic Zenith Tube 1959. Pp. 25–50. (London: H.M. Stationery Office, 1960.) 4s. net. [235

Transactions of the Royal Society of Edinburgh. Vol. 64, No. 1: Glaucophane-Schist, Eclogite, and Associated Rocks from Knockormal in the Girvan-Ballantrae Complex, South Ayrshire. By Dr. T. W. Bloxam and Dr. J. B. Allen. Pp. 1–27+2 plates. 10s. 6d. Vol. 64, No. 2: On the Structure of *Calymmatotheca kidstoni* Calder (emended) and *Genomosperma latens* gen. et sp. nov. from the Calciferous Sandstone Series of Berwickshire. By Albert G. Long. Pp. 29–44+4 plates. 8s. 6d. (Edinburgh: Royal Society of Edinburgh, 1960.) [235

Colonial Office. Fishery Publications No. 13, 1960: The Plankton of Inshore Waters off Freetown, Sierra Leone. By V. Bainbridge. Pp. iv+48. (London: H.M. Stationery Office, 1960.) 35s. net. [235

Library Association. Annual Report, 1959. Pp. 27. (London: Library Association, 1960.) [245

An Introduction to the Anaesthesia of Laboratory Animals. By Dr. Phyllis G. Croft. Pp. 32. (London: Universities Federation for Animal Welfare, 1960.) 3s. 6d. [245

Department of Scientific and Industrial Research. Report of the Research Council for the year 1959. Pp. 75. (Cmnd. 1049.) (London: H.M. Stationery Office, 1960.) 4s. 6d. net. [275

Ministry of Agriculture, Fisheries and Food: Department of Agriculture for Scotland. Report on the Animal Health Services in Great Britain, 1958. Pp. iv+119. (London: H.M. Stationery Office, 1960.) 6s. net. [275

University of Glasgow Appointments Committee. Report for the year ended 31st December, 1959. Pp. 16. (Glasgow: The University, 1960.) [275

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 1018, Vol. 252 (26 May 1960). Geomagnetic Westward Drift and Irregularities in the Earth's Rotation. By M. G. Rochester. Pp. 531–555. (London: Royal Society, 1960.) 8s. [275

Forestry Commission. Forest Record No. 41: *Fomes annosus* in Great Britain: an Assessment of the Situation in 1959. By J. D. Low and R. J. Gladman. Pp. 22+20 plates. 4s. net. Leaflet No. 31: The Grey Squirrel: A Woodland Pest. Pp. 18. 1s. 6d. net. (London: H.M. Stationery Office, 1960.) [275

Westminster Press Provincial Newspapers Limited. Report of the Directors and Accounts, Year Ended 31st December, 1959. Pp. 10. (London: Westminster Press Provincial Newspapers, Ltd., 1960.) [275

Ciba (A.R.L.), Limited. Technical Notes No. 209 (May 1960): Strip Heating, Part 1. Pp. 8. (Duxford: Ciba (A.R.L.), Ltd., 1960.) [275

Recruits to Teaching: A Study of the Attainments, Qualifications and Attitudes of Students entering Training Colleges. By F. W. Land. Pp. 83. (Liverpool: The University Press, 1960.) 7s. 6d. net. [275

Standard Telephones and Cables, Ltd. Binary Counting Circuits Using Alloy Junction Transistors—Application Report. Pp. 44. (MK/144. Ed. 1). Some Temperature Compensation Problems Associated with Transistor Circuits—Application Report. Pp. 8. (MK/145. Ed. 1). Hermetic Seals. Pp. 8. (MK/153. Ed. 1). STC Microwave Tubes. Pp. 12. (MS/113. Ed. 1). (London: Standard Telephone and Cables, Ltd., 1960.) [275

The National Anti-Vivisection Society. Eighty-fifth Annual Report for the year 1959. Pp. 16. (London: The National Anti-Vivisection Society, 1960.) [275

Proceedings of the Society for Psychical Research. Vol. 53, Part 190 (May 1960): A Critical Review of Experiments with Mr. Basil Shackleton and Mrs. Gloria Stewart as Sensitives. By C. E. M. Hansel. A Reply to Mr. Hansel. By S. G. Soal. Pp. 82. (London: Society for Psychical Research, 1960.) 12s. 6d.; 2 dollars. [315

Colonial Office. Social Development through Family and Home: Report of a Conference held at St. Hugh's College, Oxford, 7th to 25th September, 1959. Pp. ii+94. (London: H.M. Stationery Office, 1960.) 4s. net. [315

A Look at Threatened Species: a Report on some Animals of the Middle East and Southern Asia which are Threatened with Extermination. By Lee Merriam Talbot. Pp. iv+137+18 plates. (London: The Fauna Preservation Society, c/o Zoological Society of London, 1960. Published for the International Union for the Conservation of Nature and Natural Resources.) 10s. [315

How TV Works: The Technical Story for Non-Technical People. Pp. 48. (London: Granada TV Network, Ltd., 1960. Distributed by Methuen and Co., Ltd.). 5s. [36

Ministry of Agriculture, Fisheries and Food. Technical Bulletin No. 10: Control of Rats in Sewers. By Dr. H. W. Bentley. Pp. iii+22+4 plates. (London: H.M. Stationery Office, 1960.) 2s. 6d. net. [36

Discovery Reports, Vol. XXX. Pp. 161–300: The Distribution of Pelagic Polychaetes in the South Atlantic Ocean. By Norman Tebble. (Issued by the National Institute of Oceanography.) (Cambridge: At the University Press, 1960.) 63s. net. [36

Library Association. Special Subject List No. 32: The English Newspaper Since 1900. Compiled by Frank Atkinson. Pp. 31. (London: Library Association, 1960.) 4s. [36

Bulletin of the British Museum (Natural History). Botany. Vol. 2, No. 6: *Allium* and *Milula* in the Central and Eastern Himalaya. By William T. Stearn. Pp. 159–191+plates 9–12. 16s. Entomology. Vol. 9, No. 2: A Revision of the Species of *Schizonycha* Dejean (Col.: Melolonthidae) from Southern Africa. By R. D. Pope. Pp. 63–218+plates 1–14. 50s. Historical Series. Vol. 2, No. 3: Darwin's Notebooks on Transmutation of Species. Part 2: Second Notebook (February to July 1838). Edited with an Introduction and Notes by Sir Gavin de Beer. Pp. 75–118. 15s. (London: British Museum (Natural History).) [36

General Post Office. Report of the Television Advisory Committee, 1960. Pp. 20. (London: H.M. Stationery Office, 1960.) 1s. net. [76

British Steel Castings Research Association. Data Sheets on Dust Collectors. Second, revised and enlarged edition. Pp. vii+39. (Sheffield: British Steel Castings Research Association, 1960.) 30s. [136

British Poultry Science, Vol. 1, No. 1 (April 1960). Pp. 72+xvi. Initially two numbers annually published in April and October. Annual subscription 30s.; U.S.A. and Canada 5 dollars. Single issues 17s. net.; U.S.A. and Canada 2.75 dollars. (Edinburgh and London: Oliver and Boyd, Ltd., 1960.) [136

Building Research Station Digest. No. 134 (May 1960): Questions and Answers on Underground Drainage. Pp. 6. (London: H.M. Stationery Office, 1960.) 4d. [136

An Edinburgh Occasion: an Account of the Sixth Lister Memorial Lecture and the First Duncan Flockhart Symposium, 1 and 2 October, 1959. Pp. 39. (Edinburgh: Duncan, Flockhart and Co., Ltd., 1960.) [136

Other Countries

Gradina Botanica a Universitatii "C. I. Parhon," Bucuresti. Lucrarile Gradinii Botanice din Bucuresti. (Acta Botanica Horti Bucurestiensis.) Impreuna cu Catalogul de Seminte Oferite in Schimb de Gradina Botanica din Bucuresti. (Unacum delectu Seminum quae Hortus Botanicus pro Mutua Commutatione Offert, 1959.) Pp. 223. (Bucuresti: Gradina Botanica a Universitatii "C. I. Parhon" din Bucuresti, 1960.) [235

United States Department of Agriculture. Leaflet No. 467: The Cotton Aphid: How to Control It. Pp. 8. (Washington, D.C.: Government Printing Office, 1960.) 5 cents. [235

Annual Report of the National Academy of Sciences—National Research Council, Fiscal Year 1958–1959. Pp. viii+224. (Washington, D.C.: Government Printing Office, 1960.) 70 cents. [235

University of California Publications in Botany, Vol. 32, No. 2: Phloem Structure in *Pyrus communis* L. and Its Seasonal Changes. By Ray Franklin Evert. Pp. 127–194+plates 15–25. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1960.) 1.50 dollars. [235

Canada. Meteorological Branch—Department of Transport. Monthly Bulletin—Canadian Radiosonde Data, April 1959. Pp. ii+61. (Ottawa: Queen's Printer, 1960.) 50 cents. [235

South Australia. Report of the Museum Board, 1st July, 1958, to 30th June, 1959. Pp. 15. (Adelaide: Government Printer, 1960.) [235

Canada. Department of Mines and Technical Surveys: Geological Survey of Canada. Memoir No. 302: Shubenacadie and Kennetcook Map-Areas, Colchester, Hants and Halifax Counties, Nova Scotia. By I. M. Stevenson. Pp. viii+88 (5 plates). 1 dollar. Economic Geology Series, No. 19: Mica Deposits of Canada. By J. W. Hoadley. Pp. xvii+141. 1 dollar. (Ottawa: Queen's Printer, 1959 and 1960.) [235

Bericht Über das Geobotanische Forschungsinstitut Rübel in Zürich für das Jahr 1958. Von E. Rübel und W. Lüdi. Pp. 140. (Zürich: Geobotanische Forschungsinstitut Rübel in Zürich, 1959.) [235

Berichte des Deutschen Wetterdienstes. Nr. 61 (Band 9): Turbulenz im Wolkenfreien Raum (Clear-Air Turbulence). Von Elmar R. Reiter. Pp. 42. 10.80 D.M. Nr. 62 (Band 9): Statistik der Meteorologischen Eignung West-, Nord- und Mitteleuropäischer Flughäfen als Gegenseitige Ausweichhäfen. Von Hans Guss. Pp. 62. 6.60 D.M. Nr. 63 (Band 9): Klimadaten von 1621–1650 nach Beobachtungen des Landgrafen Hermann IV, von Hessen (Uranophilus Cyriandrus). Von Walter Lenke. Pp. 51. 9.60 D.M. Nr. 64 (Band 9): Klimadaten für Bauwesen und Technik (Lufttemperatur). Von Rudolf Reidat. Pp. 72. (Offenbach a.M.: Deutschen Wetterdienstes, 1960.) [235

Union of South Africa: Department of Education, Arts and Science. Report of the Archaeological Survey of the Union of South Africa for the year 1st April, 1958, to 31st March, 1959. Pp. 8. (Annual Report No. 24.) (Pretoria: Government Printer, 1959.) [235

Neue Physik, Doppelheft 4/5 (1959): Das Atommodell der Photronentheorie: Die Verhältnisse in der Elektronenhülle und die Spektralterme. Von K. Nowak. Pp. 113–176. (Wien: *Neue Physik*, Mollardgasse 8, 1960.) 24 schillings; 4 D.M. [245

Museum of Applied Science of Victoria, Melbourne. Report of Activities for the year ended 30th June, 1959. Pp. 30. (Melbourne: Museum of Applied Science of Victoria, 1960.) [275

National Academy of Sciences—National Research Council. Nuclear Science Series. NAS–NS 3004: The Radiochemistry of Thorium. By E. K. Hyde. Pp. vi+70. 75 cents. NAS–NS 3005: The Radiochemistry of Fluorine, Chlorine, Bromine and Iodine. By Jacob Kleinberg and G. A. Cowan. Pp. vi+42. 50 cents. NAS–NS 3007: The Radiochemistry of Chromium. By J. Pijck. Pp. vi+34. 50 cents. (Washington, D.C.: Office of Technical Services, Department of Commerce, 1960.) [275

Parapsychology Foundation, Inc., New York. Parapsychological Monographs, No. 2: ESP in Relation to Rorschach Test Evaluation. By Gertrude Schmeidler. Pp. iii+89. (New York: Parapsychology Foundation, Inc., 1960.) [275

Wissenschaftliche Ergebnisse der Deutschen Atlantischen Expedition auf dem Forschungs- und Vermessungsschiff *Meteor*, 1925–1927. Herausgegeben im Auftrage der Deutschen Forschungsgemeinschaft von A. Defant. Band 16, Erster Teil: Ergebnisse der Aerologischen Beobachtungen. Die Höhenwinde Über dem Tropischen und Südlichen Atlantischen Ozean. (Messungen der Deutschen Seewarte bis Eingeschlossen.) Dritte Lieferung: Abschnitt C, Kapitel 1–3: Besprechung der Ergebnisse die Luftströmungen Über dem Tropischen Atlantik. Von Erich Kuhlbrodt. Pp. 169–254. (Berlin: Walter de Gruyter und Co., 1960.) 54 D.M. [275

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

PHLOGISTON OR ATOMS?

WE hear a great deal these days about the need for more scientific and technological education, both to produce more scientists and technologists and to give the layman some idea of what they are doing; but the method adopted for this form of education is comparatively neglected. It seems to be assumed by too many people that the present school courses are quite adequate and that it is simply a matter of pushing more people through them. A report* by Dr. Michael Bassey, on a survey he carried out recently on what some arts students at the University of London remembered and thought of the chemistry they had learned at school, strongly suggests that there is something seriously wrong with elementary school chemistry, as presented to the person who does not intend to do any more science in any event; and what is true of chemistry is probably true of the other sciences.

One of Dr. Bassey's questions was: "Which of air, water, clay and wood contains atoms?" One in five got the answer wrong. A few of them may have thought he was trying to find out if they knew the difference between elements, compounds and mixtures; even so, the proportion is far too high. All the people questioned had passed at least chemistry in general science of the General Certificate of Education (Ordinary Level) and they were all university students. Elementary chemistry obviously cannot cover a great deal of ground, yet surely it should manage to instil the basis of all chemistry, that is, the atomic theory.

Since all the people who replied to the questionnaire had passed some form of chemistry (Ordinary Level), their ignorance cannot be due simply to inattention. What, then, were they doing during the years they studied chemistry? Another of Dr. Bassey's questions provides the answer: Were you taught about aspirin, DDT, Lavoisier, phlogiston and the Law of Multiple Proportions? In Dr. Bassey's own words: "Lavoisier came out top of the poll, phlogiston and the Law of Multiple Proportions shared the second place, and DDT and aspirin would have lost their deposits in a parliamentary election". In fact, the teaching of elementary chemistry is apparently dominated by a historical approach which tends to exclude modern developments.

It can, of course, be argued that in the short time available the historical approach will give the best understanding of the subject. The phlogiston theory is an excellent example of a hypothesis that fitted most of the facts available at the time. Lavoisier's experiments are probably the most important series in the whole history of chemistry. The determination of the composition of water does illustrate the sort of approach that is used in all the sciences. But to grasp the significance of such things requires a great deal of background knowledge which the ordinary schoolboy is certain not to possess, and a feat of historical imagination of which he is most unlikely to be capable. If he does not grasp their significance he feels that they are irrelevant and dull. A youngster who knows the formula of water is H_2O is apt to be contemptuous of anyone who does not.

What should elementary chemistry, or for that matter elementary science, try to do? Obviously it has to provide some sort of grounding: the scientific equivalents of addition, subtraction, multiplication and division. It should also create interest, in the sense that even someone who only intends to do science for a few years to pass the necessary examinations should be able to see why others should want to devote most of their time to it. But it is essential that it should not create the hostility that comes from boredom, and bored most of the people who replied to Dr. Bassey's questionnaire certainly seemed to have been. Most of them put this down to chemistry, as taught to them, being a lot of unconnected, uninteresting facts, totally unrelated to everyday life.

This is not really surprising when one considers the present syllabus. Its attempts to include everyday and commercial applications look as though they were put in fifty years ago, which they probably were. Washing soda! Bleaching powder! An obsolete process for manufacturing sulphuric acid! Most of the important developments in chemistry in the past twenty years or so have come from the organic field—plastics, drugs, insecticides—yet organic chemistry does not even appear in the Ordinary Level syllabus. One needs a certain amount of basic knowledge before starting organic chemistry, of course, but there might at least be some hint of the fact that carbon forms long chains and rings and that these are the basis of life. The real trouble with the historical approach is not that it is there, but that it seems to displace everything else.

The criticism that chemistry is taught as an unconnected series of facts is all the more regrettable, since it can be taught in a way that makes it a coherent body of knowledge, developing logically from a few basic ideas, leading straight to many interesting and stimulating modern developments, and emphasizing the close connexion between chemistry and physics. The way is simply to start with the atom. The structure of the atom leads naturally to the periodic classification of the elements, and here some properties of the elements can be introduced not as isolated facts but to show how the elements are related to one another. Valency follows from atomic structure. Ionization, crystals, states of matter, can all be dealt with in terms of the atom. In fact, the whole subject can be brought together, and at each point items of everyday and topical interest can be introduced—the new metals, atomic energy, rocket fuels—things that stimulate interest instead of killing it.

---

* *New Scientist*, 7, 1594 (1960).

The atomic theory can be expressed quite easily in simple terms; so there is really no justification for saying that it is too advanced to be understood by children in their early teens. After all, the study of electricity nearly always begins with electrostatic attraction. The force that attracts the electrons to the nucleus can be demonstrated with a fountain pen rubbed on the sleeve and a bit of paper. There is the analogy with the solar system, and atomic structure lends itself very well to demonstration by diagrams and models. It is certainly a good deal easier to understand the elementary theory of the atom than to grasp the significance of the phlogiston theory.

Dr. Bassey's questionnaire was sent to arts students; but these arguments apply equally well in the case of people who intend to specialize in science. The fact that they have an interest in science is no excuse for a boring syllabus. The defects in school chemistry are particularly obvious at the elementary stage, but they persist right through the school. Is there any real justification for the amount of time devoted to the extraction of metals at General Certificate of Education (Advanced Level), for example? A good deal of irrelevant material could probably be found in university courses as well.

The teachers cannot be blamed for this state of affairs, although most people are reluctant to change a well-established routine, since they have to prepare their pupils for examinations based on an out-of-date syllabus. But they are represented on the committees that decide what shall be included, so they do have an opportunity to try to improve things. Books, too, tend to be written around a syllabus. In fact, there are a lot of vested interests that will probably oppose any far-reaching changes, and far-reaching changes are certainly due.

Every year there is more and more to be learned; if the new things are not to be neglected, as they tend to be at present, a continuing review of examination syllabuses will be necessary, to prune off things that have lost their importance. If no pruning is done the syllabus will grow so fast that it will soon become quite unrealistic. The historical approach should not be dropped automatically; in many cases it may be very suitable, but the question, "What is the best approach?", should always be asked before any approach is adopted.

LAND USE AND THE CYPRUS PROBLEM

The Evolution of the Rural Land Use Pattern in Cyprus

By Dr. Demetrious Christodoulou. With Land Use Map, 1 : 253,440, prepared by R. R. Rawson and Dr. K. R. Sealy. (The World Land Use Survey—Regional Monograph No. 2.) Pp. vi+230. (Bude, Cornwall: Geographical Publications, Ltd.; London: Ed. Stanford, Ltd., 1959.) 25s.

FOLLOWING the success of Dr. Tregear's monograph on "Land Use in Hong Kong" (1958), the World Land Use Survey, under Prof. Dudley Stamp's direction, has produced a valuable, and topical, explanatory account of the land use problem in Cyprus. This publication contains what are, in effect, two separate though complementary studies married together by careful editing.

One of these studies, the "Land Utilisation Map of Cyprus", on a scale of approximately 1 : 250,000, was first published in 1956, but it is a great convenience to have it for reference alongside Dr. Christodoulou's monograph. The map itself was prepared from some 10,000 air photographs by a team of workers at the London School of Economics directed by Mr. R. R. Rawson and Dr. K. R. Sealy and records nine categories of use.

Dr. Christodoulou's study reflects, in its form of publication, the earlier publications of the Land Utilization of Britain; in its methods, the author's geographical training in Britain at Southampton and at the London School of Economics; and in the quality and spirit of the writing, his own long experience in the country of his birth, of which he is now land consolidation officer. More recently he has become chairman of a Food and Agriculture Organization working party on the problems of administration of public and common grazing lands in southern Europe, and readers of his study of Cyprus will await his report with more than usual interest.

Though the third largest island in the Mediterranean, Cyprus is no bigger than two English counties, such as Norfolk and Suffolk. The land, and its water supplies, remain the main natural resources, largely supporting a population of 550,000, now increasing at a rate of 1·5 per cent per annum. Marked regional contrasts exist in the degree to which population presses upon land, but overall the mounting population pressure, coupled with an increasing expectation of improved standards of living, are vital factors in the island's social, economic and political life. On the whole, society remains close to the land: about half the adult population is engaged primarily in farming.

The land-use pattern is a varied and complex one. Cyprus presents an unusual variety of cultivations and crops, with rapid variations occurring within a small compass. The complex situation is analysed carefully by a systematic treatment of the principal crop and land-use distributions, by a discussion of the main farming types and through a synthetic examination, region by region, of land use characteristics.

Dr. Christodoulou's assessment of the physical conditions affecting crop production, based upon a nine-fold regional division of land-forms, is straightforward and generally clear. Climate is given special attention in view of the importance of water to the life of this thirsty island. The fundamental significance of winter rainfall, and the adjustment to it of the life-cycle of vegetation and the pattern of human endeavour, are forcefully driven home. The sad record of recurring droughts arising from rainfall variability is long, and a critical treatment is given of schemes to conserve and utilize "the most precious resource" of the island.

But the diverse pattern of village and farm bears also the ineradicable marks of centuries of human labour. Christodoulou shows that, in the final analysis, it is the human or institutional problems, rather than the physical conditions, that provide the most stubborn problems of land use. His chapters on these problems form the most interesting and original parts of the book, for in them Dr. Christodoulou's own personal feeling for the land and its people is most clearly revealed.

The gap between available scientific knowledge and the archaic practices of the mass of peasant farmers is seen to be at the core of the problem: technical education has scarcely begun to narrow the gap while, so long as agriculture remains the least remunerative occupation, there is little prospect of its attracting technically efficient and receptive farmers. Farming problems of to-day bear the burden of a complicated situation of land tenure, the antecedents of which are, in summary, unravelled. Christodoulou feels that much of "the malaise of the rural areas and a serious obstacle to modern agricultural techniques stem from the size and fragmentation of peasant holdings". Holdings are fragmented, plots dispersed and the pattern of ownership diffuse. The financial misfortunes of the Cyprus peasant are not overlooked, and, even if times are better than they were, capital is scarce, returns small and rural indebtedness is a continuing source of rural debilitation. Unfortunately, the section on the internal market is short, necessarily so in the absence of detailed studies, and the impact of town growth on the countryside, though many times suggested, is not separately considered. But there is an excellent account of the evolution and characteristics of the farm and of the main types of farm dwelling.

Dr. Christodoulou's work is critical and firmly based both on field work and on relevant British, Greek and Turkish sources. He is understandably cautious about the future. While not neglecting the many valuable contributions already made, he clearly feels that reorganization of the whole agrarian pattern is essential and that careful planning, based on a full appraisal of the human and natural resources of the island, is overdue.

Problems of land use are fundamental to the social, economic and political issues that beset this troubled island. It is a sad commentary that it is only in the closing days of British administration that such a study, and this from a private source, should become available. Christodoulou's work should quicken attention not only to these issues in Cyprus but also to the study of the use of land in other territories for which responsibility still lies in Britain.

M. J. WISE

SUBMARINE GEOLOGY

The Earth beneath the Sea

By Prof. Francis P. Shepard. Pp. xii+275. (Baltimore, Md.: The Johns Hopkins Press, 1959.) 5 dollars.

PROF. SHEPARD has made a lifelong study of submarine geology, but it is a rapidly advancing subject and he says he has obtained most of his education since he received his doctor's degree. He published his last book on submarine geology twelve years ago. It did not mention turbidity currents and now most students are convinced that they really do charge down continental slopes at the speed of express trains and carry silt hundreds of miles across the ocean floor. The book has much else that is new, largely in physical and geophysical treatment but also in topography. It is written for readers with little technical background though an elementary knowledge of geology or physical geography would be a help.

The author shows how every bit of the ocean floor from the shore lines to the greatest depth is likely to be influenced by currents, tides or some kind of oscillation, and deals successively with the beaches, continental shelves, slopes and the deep ocean floor. He maintains that the action of a lowered sea-level during glacial times was mainly responsible for the shelves, and that the canyons were cut at such times, or during periods of coastal elevation, and worked nowadays by turbidity currents. He is rather sceptical whether the trench of the mid-Atlantic ridge is as long and continuous a feature as recently claimed. In explaining flat-topped seamounts he favours the subsidence hypothesis, and that coral reefs occur where favourable growth conditions allowed the coral to keep pace with subsidence. He deals briefly with investigations using acoustic, seismic, gravity and heat-flow techniques and feels that the work is in too early a stage to allow much more than speculation about events below the ocean bottom.

When dealing with ripple marks, grading of sediments and other characteristics that have been used to date the past, he shows how many ideas have to be changed now that actual observations of what conditions are like on the sea bed have been made, and notes that we have been too much influenced by arguments that were largely philosophical.

G. E. R. DEACON

MINOR ELEMENTS IN SOILS

The Geochemistry of Rare and Dispersed Chemical Elements in Soils

By A. P. Vinogradov. Second edition, revised and enlarged. Translated from the Russian. Pp. ii+209. (New York: Consultants Bureau, Inc.; London: Chapman and Hall, Ltd., 1959.) 9.50 dollars; 80s. net.

THE behaviour of minor elements during the processes of rock weathering and soil formation is described and illustrated in A. P. Vinogradov's "The Geochemistry of Rare and Dispersed Chemical Elements in Soils", now in its second edition. The author assumes a sound knowledge of geochemistry and pedology, thereby limiting the use of the book to geochemists and soil scientists.

Chapter 3 on "General Geochemical Regularities" gives an outline of the various factors which control the distribution of elements in the zone of weathering. The following are briefly discussed: ionic radii, electromotive series, sorptive properties, ionic potential, pH, oxidation-reduction potentials, etc.

The major part of the book describes the distribution of the elements boron, fluorine, bromine, iodine, arsenic, selenium, lithium, rubidium, cesium, strontium, barium, rare earths, titanium, zirconium, vanadium, chromium, manganese, nickel, cobalt, copper, zinc, cadmium, lead and molybdenum in soil profiles which are developed over the sedimentary rocks of the eastern European plain. The soil types dealt with are tundra, podzol, grey forest, chernozem, chestnut, desert serozem, brown soils, and red earths. Comparisons are frequently made with data from similar profiles described in non-Russian literature.

A few generalizations concerning the element under discussion are made at the beginning of each chapter. These are followed by a description of its content in profiles from the various soil-types. Finally, conclusions of the behaviour of the element within the soil are given. Frequently these conclusions are not supported by the data quoted; for example, in Chapter 6 it is stated "in the majority of cases a tendency toward an increase in the content of fluorine in the subsoil was noted". However, in only two of the nineteen profiles presented (Table 20) is there an increase of fluorine in the subsoil. In the remaining seventeen examples quoted there is a decrease.

The behaviour of the elements tin, tungsten, radium, uranium, thorium, ionium, beryllium, scandium, gallium, indium, thallium, germanium, niobium, tantalum, antimony, bismuth, mercury, rhenium, gold, silver, platinum, tellurium and hafnium is briefly mentioned without introducing new data. A comprehensive bibliography contains 560 references, including many non-Russian papers.

Poor editing in the original Russian edition of the book is reflected in the English translation. Numerous errors appear in both the text and tables. Data have not been uniformly presented in some tables and often the units used are not clearly stated. The text on p. 170 should follow that on p. 167.

Despite the many editing errors, the extensive tables should prove useful sources of information on the normal contents of the minor elements in soils of the zonal types considered. A. H. Debnam

NUCLEAR RESEARCH IN THE U.S.S.R.

Atomic Energy in the Soviet Union

By Arnold Kramish. Pp. x+232. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1960.) 27*s*. 6*d*. net.

THIS book by Arnold Kramish performs a most useful task in a thoroughly interesting fashion. The writer traces the published evidence of Soviet activity in the field of nuclear studies since before the War, and indeed he pays rather special attention to the important time of development in the early part of the 1930–40 decade. With some hesitation in the mid-war years only, he is able to establish a consistency and breadth of Soviet effort in the field that is altogether impressive. Many scientists who have neglected until recently the original Soviet publications will find the volume a considerable help in tracing some of the important landmarks in Soviet achievement in this field during the past thirty years.

During this time, as the author demonstrates, there have been many vagaries in the policy of the Soviet Union regarding the extent to which publicity has been given to particular advances. The book removes much of this difficulty, and the picture that emerges is one of almost uninterrupted pressure on the large number of well-trained scientists and engineers to make full use of the generous provision of support in both money and materials. As the author points out, our picture is still far from complete because of the secrecy that still surrounds many of the ventures. He points to interesting differences in approach to certain topics for example to the subject of controlled thermonuclear research. It appears to be the policy to be frank in those areas where really fundamental difficulties are present and so to encourage help to come from any possible source. It is no doubt rewarding to ponder on some of these basic differences in approach.

If one has to make any general conclusion from the study it is probably that achievement by scientists and engineers in the Soviet Union, the United States, and Great Britain is more or less proportional to the support afforded and relatively independent of the political background, provided that original thinking or inventiveness is encouraged.

The style of the author is lively and fresh, and the book is very easily digested by those with some background knowledge of modern physics and atomic energy. Its value to scientists, engineers and administrators is obvious, and it can be highly commended. The price is relatively modest at 27*s*. 6*d*., and the volume does not suffer from the absence of illustrations. S. C. Curran

PHYSIOLOGY OF MARINE ANIMALS

The Biology of Marine Animals

By J. A. Colin Nicol. Pp. xi + 707. (London: Sir Isaac Pitman and Sons, Ltd., 1960.) 95*s*. net.

TO those, of whom I am one, who for the past generation and more have worked in the field of comparative physiology of marine animals, this book comes as a revelation of the extent of achievement during this period. Very few of the 1,700 odd references to literature which are among the many virtues of this volume deal with papers earlier than the mid-twenties. It was in that earlier post-war period that the attention of marine biologists began to turn from description, of structure or of life-history, to analysis of function and to the elucidation of physiological as well as of morphological adaptation. Increased knowledge of marine environments went hand in hand with greater understanding of the internal fluid medium in animals and of how problems of osmo-regulation had been solved. Interest extended from the properties of vertebrate hæmoglobin to those of hæmocyanin and of other invertebrate respiratory pigments, as well as to the wider general problems of animal pigments so wonderfully displayed in many marine animals. Then also knowledge of the complexities of the mechanisms of sensation and response began to include analysis of the sense organs and behaviour of marine invertebrates and fishes as well as of the nature of nervous and hormonal control particularly in fishes, cephalopods and crustaceans.

In this impressive volume of 700 pages, Dr. Nicol summarizes the results of these investigations, to which he has himself made very significant contributions. It is a major work of synthesis; it may well be the last time that anyone will attempt single-handed to cover so wide a field, in any event with that meticulous reference to the sources of knowledge here provided. It does not seem that this book could have been done better. It has been, one knew, years in preparation by an author living in the very atmosphere of marine biological research. It would appear, judging from the date of the introduction, to have been four years in process of publication. So, like all such books, it is a little out of date, a matter, however, that will only be apparent to active research workers and then only within their speciality.

Exception might be taken to the title, but then few people would agree about what precisely is meant by biology. Here it covers physiology, extending from body fluids to luminescence (on which the author writes with particular authority), but with final chapters on "Associations: Commensalism, Parasitism and Symbiosis" and "Skeletons, Shelters and Special Defences". There is no mention—and could not be without extension into a second volume—of reproduction, which one feels should be covered in any book dealing with biology. Dr. Nicol might have been better advised to restrict himself to his purely physiological chapters—with suitable change in title—because the final two chapters covering much wider, less-analysed fields are inevitably more condensed and less critical.

These, however, are very minor criticisms of a book that brings many into Dr. Nicol's debt. It is extremely well produced, containing some 300 figures as well chosen as they are reproduced. The publishers may well share some of the congratulations extended to the author but not, surely, when it comes to price. Was it, one may reasonably ask, really necessary to charge almost £5 for a book that should find a place in the library of every university and marine station in the world and be in the possession of everyone scientifically interested in marine animals? C. M. YONGE

A NEW STUDY OF THE BRITISH ODONATA

Dragonflies

By Philip S. Corbet, Cynthia Longfield and N. W. Moore. (The New Naturalist: a Survey of British Natural History.) Pp. xii+260+32 plates. (London: William Collins, Sons and Co., Ltd., 1960.) 42*s*. net.

WITH just over forty species of dragonflies recorded from the British Isles, one might at first question the necessity for another book on these insects, since for the purposes of identification the subject has already been dealt with in two recent publications. The present volume in the "New Naturalist" series is, however, intended more for the naturalist than for the collector and may be considered rather as supplementary to Tillyard's classic, "The Biology of Dragonflies," in which the external and internal morphology of the Odonata was dealt with in great detail, but classification, distribution, fossil history, bionomics, etc., only occupied about one-third of the book. As in other volumes of the "New Naturalist" series, this book is an indication of the changed attitude of the naturalist, with the emphasis on the living insect and its behaviour rather than on dissection and museum study.

Three of its fourteen chapters deal with the composition of the British dragonfly fauna, its history and distribution, and four are devoted to the life-history of the various stages. The behaviour of the adult dragonflies, dispersal and seasonal regulation in dragonflies are the titles of other chapters, and the fossil history of the order and the inter-relationships of dragonflies and other animals (including man) are discussed. Various appendixes include a key to the larvæ of the British dragonflies, a survey of the wing venation and its terminology, methods of preserving colours of dragonflies and of marking dragonflies for behaviour studies.

The three authors are all general naturalists as well as being specialists in different facets of the study of Odonata. Dr. P. S. Corbet made a three-year investigation into various aspects of the life-history of dragonflies the subject of a thesis for his Ph.D. degree. Miss C. Longfield worked for thirty years as an honorary associate in the Department of Entomology, British Museum (Natural History), where she identified and described dragonflies from many parts of the world, including material collected on her own expeditions abroad. Dr. N. W. Moore made his investigations into the ecology and behaviour of adult dragonflies the basis of his Ph.D. degree, and has also studied Odonata in the field in Gambia.

These three authors, each being responsible for different sections of the book, have succeeded in welding their contributions into a homogeneous and very readable whole, without suppressing too much of their individual styles and personalities. Much of the information in the chapters on life-history and behaviour is based on the authors' personal studies, and the occasional use of the first person singular gives life to their accounts and prevents them from appearing too formal to the general reader. The inclusion (as an appendix) of Mr. A. E. Gardner's keys to the larvæ of British dragonflies, with his own illustrations, is a valuable addition to the book. These keys originally appeared in an entomological journal, and their reprinting here will introduce them to a wider public.

The production is entirely up to the standard of the previous volumes, and the work is fully illustrated with plates in both colour and in monochrome and with some line drawings. The line drawings in the chapter on behaviour are an excellent example of how to use bold, simple drawings. There are many colour plates, most of them reproduced from very fine transparencies specially taken by Mr. S. Beaufoy. These were mostly taken under controlled artificial light conditions and are in a sense studio portraits of the living insects. By this means a more uniform colour balance has been obtained, and the background can be chosen to suit the subject. All these colour plates are reproduced at natural size, and while this is an advantage for comparison, it does mean that the smaller specimens lose a certain amount of detail in reproduction. This is particularly noticeable where, as in one or two illustrations in the review copy, one of the colour impressions is slightly out of register. One realizes that to have reproduced the smaller species on a larger scale would have entailed more colour plates and an increase in cost.

As a whole, this is a most interesting book and one which should prove extremely useful not only to students of dragonflies but also to field naturalists and to students, as it not only gives a recent picture of the state of our knowledge of the British Odonata but also shows in what directions further research is needed. D. E. KIMMINS

GROWTH AND FORM IN AN INSECT

The Control of Growth and Form

A Study of the Epidermal Cell in an Insect. By Prof. V. B. Wigglesworth. Pp. vi+140. (Ithaca, New York: Cornell University Press; London: Oxford University Press, 1959.) 21*s*. net.

THIS well-illustrated small book, based on six Messenger Lectures which Prof. V. B. Wigglesworth delivered to a general audience at Cornell University in 1958, displays the epidermal cell of an insect as a medium convenient for the study of the principles of the control of growth and form. The author points out that this limitation of the field of study has both advantages and disadvantages, but the fact that the insect selected is *Rhodnius prolixus*, of which Prof. Wigglesworth has such deep and extensive knowledge, does much to outweigh the disadvantages.

Taking the view that there is much to be said for starting with specialized parts of a complex animal, rather than with a "simple" animal, Prof. Wigglesworth gives a brief description of the complex activities of the epidermal cells in producing the cuticle and later hardening it. He goes on to consider the special cells which become differentiated from the epidermis in the larva of *Rhodnius* and give rise either to dermal glands or sensilla, and puts forward the attractive hypothesis that the fate of the special cells is determined by the concentration of some essential chemical constituent in the epidermis. An epidermal cell which receives an appropriate amount of the essential factor develops into a sensillum, and one receiving a smaller amount into a dermal gland. The active cell first acquiring an effective concentration of the essential factor becomes dominant and by withdrawing the essential factor from its neighbourhood inhibits the development of other sensilla around it. Dermal glands may appear, however, suggesting that they need a lower concentration of the essential factor for their development, a view supported by their closer spacing.

Emphasizing that it is the capacity of the epidermal cells to produce cuticles of different types at different stages of the life-cycle which forms the basis of metamorphosis, Prof. Wigglesworth then discusses the hormones which initiate cuticle development and control its form. The epidermal cell possesses dual potentialities, and produces larval or adult cuticle according to its hormonal environment. It is stimulated to produce cuticle by the growth hormone, which is envisaged as controlling the synthesizing power of the cell by regulating permeability or transport. The juvenile hormone inhibits differentiation towards the adult by accelerating the production of the cuticle, and, since growth ceases when cuticle secretion begins, so limiting the period during which the epidermis can grow and produce a changed body form. Only in the absence of the juvenile hormone can the epidermal cell realize its latent potentiality of laying down cuticle of adult form. Metamorphosis and polymorphism are then discussed in terms of hormonal balance.

The final chapter deals with the integration of growth. The idea that tissue and body fluids convey chemical information on the activity of cells and tissues, so that the activity of one cell is reflected in an environmental change which regulates the activity of another cell, leads to the suggestion that the means of integration are present in generalized form in the epidermal cell and are not restricted to the specialized tissues involved in nervous conduction and hormone secretion.

The labours of many authors over the past twenty years and more have given us much information on the cuticle of insects, and caused us to have, like Prof. Wigglesworth, a profound respect for the epidermal cell which produces such a complex structure. It is refreshing now to have the cell itself considered against the wider background of the control of growth and form. Not only insect physiologists but also biologists generally will be grateful to Prof. Wigglesworth for this book. R. DENNELL

INTERNATIONAL CYTOLOGY

International Review of Cytology

Vol. 8. Edited by G. H. Bourne and J. F. Danielli. Pp. x+541. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 13 dollars.

THIS volume contains the useful address given to a plenary session of the International Congress for Cell Biology in September, 1957, by the veteran French cytologist, Charles Oberling, who has recently died. Besides Oberling on the structure of the cytoplasm, there are fourteen other contributors. Teachers of general zoology will be interested in the papers by Milton Fingerman (physiology of chromatophores) and C. F. Ehret and E. L. Powers (cell surface of *Paramecium*). Cell physiologists will note the work of D. B. Roodyn (metabolic studies on isolated nuclei), D. A. T. Dick (osmotic properties of living cells), H. Holter (pinocytosis) and I. M. Glynn (sodium and potassium movements in nerve muscle and red cells). Histologists will be helped by reading the papers by Leah Lowenstein (mammalian reticulocyte), David Hall (fibrous components of connective tissue, with special reference to elastic fibre), J. B. Bridges (experimental heterotopic ossification) and E. de Robertis (submicroscopic morphology of the synapse). In addition R. D. Preston has considered the wall organization in plant cells, and Bert Vallee and Frederic Hoch have a paper on trace elements in cellular function. The various authors come from France, the United States, Denmark, Argentina, Great Britain and Ireland. It is, of course, an honour to have a paper accepted for this splendid series, and the present contributions are correspondingly valuable.

Some of the papers, such as those of Roodyn, Dick and Glynn, are very complicated and hard going. Where possible the authors have discussed the electron microscopy of their field. The work of Ehret and Powers, which recalls that of Sedar, Porter, Manton and Roth, reminds us that morphological protistology is being re-written by electron microscopists. In his essay, Oberling touched on the past and looked to the future. He mentioned the dismissal in past times as artefacts of all granular, reticular and spongy structures in the cytoplasm, which had led to so much controversy. He wrote: "My generation has lived through this period, and those who in spite of their disappointments have remained morphologists, suffered a good deal". He attributes the past confusion to the physicochemists. This is only partly true. Up to very recent times the cytologists themselves provided most of the ground for controversy. In 1927–28 Covell and Scott stated that the Golgi apparatus of neurones was formed of neutral red-staining droplets, a view supported by E. V. Cowdry in his widely used "Text Book of Histology" (1938); and in 1949, Palade and Claude considered that the Golgi apparatus was formed of myelin droplets, which were supposed to be something different from the germ cell dictyosome (Golgi body). These papers emanated from the Rockefeller Laboratory, and the basic views they advocated were unsound. It is scarcely necessary in Britain to recall the confusion of views at the Royal Microscopical Society's symposium on the Golgi apparatus in 1955.

The position to-day is that, leaving aside ergastoplasm (and plastids), there are three recognized and separate 'large' extra-nuclear cell inclusions—Golgi apparatus, mitochondria and centriole. The latter is a short tube with nine spaced fibrils embedded in its wall. The mitochondria consist of a matrix surrounded by a double membrane, the inner infolded at intervals. The reasons for, and function of, these two membranes are unknown. The mitochondria can divide by binary or multiple fission (*en rosace*). The Golgi apparatus, which also can divide and grow, consists of a dictyosome or aggregated group of dictyosomes formed of layers of oval or rectangular collapsed saccules or membranes, piled up usually closely to form a polarized lozenge-shaped body, in the hollowed base of which a secretion globule may appear. Watery vacuoles, either peripheral or basal or both, almost always become associated with the membranes, and chains of such covered vacuoles constitute the canals of Cajal of neurones. So universal is the dictyosome in its similarity that only a specialist could express an opinion as to whether a given electron micrograph of a Golgi body belonged to *Nemobius*, *Homo*, *Chromulina* or *Elodea*. Here is a universal cell device (or apparatus), vaguely considered as a filter or secretory body, the manner of functioning of which also is unknown. The understanding of this universally similar morphology of the Golgi apparatus is one of the two great basic discoveries due to electron microscopy. The other basic discovery is the understanding of the universality of the 9 + 1 fibrils in cilia and flagella, a truly astonishing thing.

As to the future, Charles Oberling wrote: "Each degree of magnification needs its mode of preservation (of the cells), and I am afraid that it is this prerequisite and not the magnifying power of electron or proton microscopy which will prevent us for the time being, from filling the gap between morphology and chemistry. But let us enjoy the tremendous opportunities within our reach of rich harvests and exciting discoveries for generations of workers".

J. BRONTË GATENBY

MEDICINE AS A SOCIAL SCIENCE

Mirage of Health

Utopias, Progress and Biological Change. By Dr. René Dubos. (World Perspectives, Vol. 18.) Pp. 231. (London: George Allen and Unwin, Ltd., 1960.) 21*s.* net.

THE increasing use of insecticides with their striking and sometimes frightening effects, our recent experience of myxomatosis as well as other odd changes in some bird and animal populations, have made most of us aware of the importance of 'animal' ecology. However, the notion of a 'human' ecology —a study of the balance between environment and human populations—is much less widespread. But the subject is certainly no less complex, and it may be a good deal more exciting if only because the so-called natural balance of things has for ages been knocked about by the whims and fancies of man. His growing ability to control his own destiny and the implications of this control are the broad subject of this book.

One of the whims and fancies which man has cherished down the ages in all societies is that perfect health and happiness are just around the corner. But a life free from pathogens, like the two-car Utopia for which we strive, has its snags, and is probably undesirable as well as impractical. It seems scarcely necessary to say that we know very little about even our major diseases. For example, all infections do not mean clinical illness; some of us with severely damaged arteries do not die of coronary occlusion, and disorganized and cancerous cells have an inexplicable way of disappearing from some patients. Illustrations such as these merely serve to underline the complexity of the interrelated causes of disease—the ecological system in which we live. They provide additional reasons, if any were needed, for throwing overboard the cosy doctrine of specific ætiology and prompt us yet again to reflect upon the wider repercussions of our attack upon disease.

That we live within these finely balanced systems has been recognized for many years and by many writers—its importance for cognitive psychology was emphasized by the *Gestalt* theorists of the 'thirties and for social medicine by Ryle and others in the late 'forties. René Dubos in 1960 has brought together a mass of historical, sociological and biological facts which constitute a fascinating and popular account of this human ecology, an account which is both exciting and provocative.

The World Perspective Series seeks "to reveal basic new trends in modern civilization, . . . and to point to the new consciousness which can contribute to a deeper understanding of the interrelation of man and the universe, the individual and society, and of the values shared by all people". These are high hopes and must be difficult of attainment. Dr. Dubos does not attempt anything so spectacular, but in a quiet way he reaches at least one of these ill-phrased objectives. He traces first the notions of an earthly paradise—of health and happiness—through historical times to the present day and shows how we have developed a touching and altogether unwarranted faith in laboratory science alone. That man can become completely healthy by the simple process of spending money on research is believed by most Americans and many Europeans. 'Health is purchasable' say the doctors, and the National Institutes of Health are embarrassed by the amount of research money which they control. Dr. Dubos emphasizes the contrast between these simple half-truths and the reluctance of Western people to alter ways of life along the lines advocated by the very research workers whose studies they have sponsored. As a result, the patterns change and there is less typhoid and cholera, but at the same time mental disease and heart disease, to say nothing of motor-vehicle accidents, are already taking their places as the epidemics of the future.

After describing biological and social adaptation in various species and communities, the author is in a position to guess at some of the 'risks' which might attend perfect health. Among these risks he sees a decline in our ability to resist biological stress. In short, he feels that were man ever to achieve 'healthiness', he might well be like so many laboratory animals, in danger of the etiolation which comes from an unchallenged existence.

The three related themes of danger—from the decline in the importance of biological selection, from the rising power of man to control his own destiny, and from the changing patterns of disease—thread fascinatingly through the rest of the book. The Plague, Darwin, Pasteur, Dr. Snow and cholera, the Irish famine, the concentration camps in Germany and the contributions of Greek medicine, are all used to build a picture of man's health in relation to his changing social and biological environment. Dr. Dubos ends with a summary word of caution: the creation of a self-chosen pattern of life remains a gamble; Nature will strike back. "It is," as he says, "always risky to tamper with the natural balance of forces in nature."

One might reply: "Of course it is, but that is how we learn". But Dr. Dubos' book is much more than a plea for caution in our dangerously slap-dash thinking about health. It is a learned, well-written and delightful introduction to medicine as a social science. It must be read particularly by the new generation of doctors, the human biologists as yet unencumbered by the pile of facts and loose thinking that is curative medicine to-day.

E. MAURICE BACKETT

SOME ASPECTS OF ATHEROSCLEROSIS

Hormones and Atherosclerosis

Proceedings of the Conference held in Brighton, Utah, March 11–14, 1958. Edited by Gregory Pincus. Pp. xvi+484. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 13.50 dollars.

Connective Tissue, Thrombosis, and Atherosclerosis

Proceedings of a Conference held at Princeton, N.J., May 12–14, 1958. Edited by Irvine H. Page. Pp. x+316. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 9.50 dollars.

THE proceedings of these Conferences are complementary to one another and contain a very worthwhile cross-section of much experimental work in the field of atherosclerosis.

"Hormones and Atherosclerosis" has a collection of 32 papers devoted to various endocrine influences in cholesterol metabolism in experimental animals and in humans. The book opens with short but excellent articles on the biosynthesis of cholesterol by Bloch and Popjak and these are followed by an authoritative account of cholesterol degradation to bile acids by Bergström. The subsequent essays are mainly devoted to the influences of various hormones on lipid metabolism in different species. In the early part of the book the emphasis is on the effects of the thyroid hormones on cholesterol biosynthesis, turnover and concentration in different tissues, by Gould, Milch, Boyd, Pick and others. A considerable part of the monograph is devoted to further experiments on the well-known effects of œstrogens on lipid metabolism, including a discussion on the prediction of œstrogenic side-effects of steroids in man by Drill and co-workers, and a series of essays on the possible usefulness of œstrogens as cholesterol depressants in man by Oliver, Katz, Robinson and Marmorston. The influences of the adrenal cortex and stress are dealt with by Friedman, Seifter, Rosenman, Adlersberg and Furman.

"Connective Tissue, Thrombosis, and Atherosclerosis" contains 16 articles covering a fairly wide spectrum of the field. Duguid presents a clear account of his concepts of atherogenesis and the role of connective tissues in arterial disease, while the chemistry of connective tissue receives a brief but stimulating treatment by Jackson.

The role of elastic tissue in atherosclerosis is briefly dealt with by Lansing, while an outline of the chemistry of the ground substance is treated by Meyer and his colleagues. Some of the metabolic activities of fibroblasts as studied by the implanted sponge method are reviewed by Noble and her associates.

Blood coagulation, fibrinolysis and the countless ramifications of this complex field are treated by Ratnoff, Astrup, Sherry, von Kaulla and their associates. The symposium also contains valuable contributions on the macromolecular basis of collagen structure by Schmidt and Glimcher.

Taken collectively these two books provide a very useful addition to the modern literature on atherosclerosis. On one hand the former emphasizes the many factors which influence lipid metabolism and will be welcomed by all who work on the metabolic aspects of atherosclerosis. The latter review, with its emphasis on the thrombotic facet of atherosclerosis, will tend to restore the balance which is all too frequently absent in many monographs or colloquia on atherosclerosis.

The books are well written, clearly illustrated and very readable, and will prove useful to all interested in the general aspects of atherosclerosis.

G. S. BOYD

A PHILOSOPHY OF COSMOLOGY

Towards a Unified Cosmology

By Prof. Reginald O. Kapp. Pp. 303. (London: Hutchinson and Co. (Publishers), Ltd., 1960.) 35s. net.

COSMOLOGY is a difficult subject, not only because of the nature of its subject-matter but also because the methods of approach are of a kind with which we are quite unfamiliar in other branches of science, but even among works on cosmology the present book is a difficult one to review.

The main difficulty is the author's insistence on the "Principle of Minimum Assumption". His hypothesis, which is really a hypothesis in the philosophy of science but which he considers to be also a truly scientific hypothesis because he can confirm it in a number of cases, is that in physics the minimum assumption always constitutes the true generalization. As an example, by the minimum assumption for the number of planets in the solar system is meant the unspecific assumption that any number of planets can occur. Now, it is quite possible to call this the minimum assumption if the author so wishes, but this procedure of making the minimum assumption is diametrically opposed to the method actually employed in science, and to the method which many philosophers of science think should be employed, for the minimum assumption is the very hardest one to refute. But many of us believe that the best assumption is the one which lays itself open most readily to possible refutation. However, by means of this hypothesis of the minimum assumption, the author was led to the conclusion that a satisfactory cosmological theory requires a continual creation and annihilation of matter, and he was led to this before the Cambridge cosmologists postulated the continual creation which leads to the steady-state theory. It is puzzling that his assumption should lead to a conclusion which is not so very different from the one to which the Cambridge cosmologists were led by exactly the opposite view, that is, by looking for the most refutable assumption.

The author does not deal very fully with the difficulty that annihilation of matter may well lead to experimental effects which have not been observed; for example, to the half-life of the proton which one would expect to be able to measure. But I do not wish to be altogether critical of the book. There are many interesting flashes of insight scattered about it, notably a discussion about gravitation. The author lists a set of problems about gravitation; for example, Why should there exist a field which tends to increase its sources, unlike every other field, which tends to decrease them (because like masses attract)? Why, indeed, do like masses attract, and why have we only ever found positive gravitational masses? Why does the inertial mass always occur in association with an active gravitational mass (if, as I would accept, the general theory of relativity merely incorporates the equivalence of inertial and passive gravitational masses)? Why is there only a limited number of constant ratios between unit charge and the inertial mass of the elementary particles? Can one reconcile what is known about gravitation with action at a distance? All these seem to me questions which are worth asking at this particular time.

C. W. Kilmister

ESSAYS IN COMPARATIVE EDUCATION

The Child, the Parent and the State

By James Bryant Conant. Pp. vi+211. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1959.) 28s. net.

SPUTNIK I had a traumatic effect on public opinion in the United States. A scapegoat seemed necessary, and the public education system was selected. Education and educationists—already under fire from several quarters—were increasingly blamed for the apparent failure of the United States to meet the Soviet challenge. Some of the criticism has been virulent, polemical and not infrequently uninformed. Fortunately Dr. James Bryant Conant, the very distinguished scientist, educational administrator, statesman and diplomat, has entered the fray.

Conant's tremendous contribution to the debate in the collection of essays under review is that his criticism of American education is, as befits a scientist, cautious, balanced and thoroughly informed. He chides its more violent critics, but nevertheless examines the problems of American education within the framework of the Soviet challenge to his country. He is not inclined to see it solely, or even principally, in terms of scientific and technological man-power although this aspect cannot be denied. Rather does he accept Comte's view that the great task of education is to rear "a generation of citizens who will be able to rise to the moral and intellectual challenge of these fateful times". In these terms, Conant appreciates that too few American educators have recognized the international post-war role of their country and that too many still continue to believe that "they can live and prosper in an isolated, insulated United States". He sees the larger problems as those of preparing "men and women who can exercise wise leadership" and of developing "intelligent discrimination in future voters". These are formidable tasks indeed, but tasks which Conant admits have been conscious objectives in American education for a long time.

In the face of these problems the process of policy formulation in the United States is one of great complexity. Fundamentally, as the author's title suggests, there is conflict between the interests and demands of children and parents and those of the State. Hence much of Conant's analysis deals comparatively with the mechanics of policy-making in the United States and in Europe. The crucial issue concerns the part the State should play in the maintenance of academic standards, the organization of the curriculum, the training and qualification of teachers, and the finance of schools. Some of Conant's suggestions sound somewhat platitudinous, but one at least is bold. If taken seriously his plea for Federal aid on a large scale for education is bound to provoke controversy. His own proposals regarding the consolidation of 'high schools', the teaching of foreign languages and the place of mathematics and science in the curriculum are moderate and likely to appeal to the practical educator. His support of vocational schools and for some kind of day continuation system is more novel. Many serious educators, however, will think of his proposals as little more than temporary expedients.

Unlike many critics Conant is aware of the difficulties of reforming education. He recognizes, for example, that some policy decisions are not reversible and makes clear that changing conditions in the United States had more to do with the changes in the educational system than irresponsible theorists. In the face of several possible policies from which to choose Conant consistently applies the pragmatic test of asking what consequences—social, political, economic and educational—are likely to flow from the adoption of any one of them. Indeed, one might hazard the guess that he regards the task of prediction as central to the serious study of education. Certainly only through improvements in this field can the study of education grow into a science.

Conant's own method of inquiry—stated by him to be empirical—seems basically pragmatic. His insights are revealing, his analysis of problems acute, and some of his solutions bold. Yet some doubts might be raised about the effectiveness of his comparative approach. The text and very full notes contain much information about the schools of Europe. The appendixes provide a valuable digest of Mr. Khrushchev's memorandum on Soviet education of September 21, 1958, and an extract from the December, 1958, "Law of the Supreme Soviet on School Reorganization". Parenthetically, both documents reveal how universal are some of the problems of education in this technological age. But his analysis of policy formulation in mid-nineteenth century England, present-day Western Germany and the Soviet Union seems dangerously to over-simplify very complex and subtle processes. There are, in brief, rather more sophisticated models on which to base comparative education studies.

Finally, in distrusting discussions about the meaning—and presumably the aims—of education and in eschewing theory in favour of an empirical approach, Conant seems to have failed to distinguish between normative theories and predictive theories. Students of education, in fact, are in real need of the latter and it might be that comparative studies, more than any other type, might make a significant contribution to this task.

Brian Holmes

The Making of the Broads

A Reconstruction of their Origin in the Light of New Evidence. By Dr. J. M. Lambert, J. N. Jennings, C. T. Smith, Charles Green and J. N. Hutchinson. (R.G.S. Research Series, No. 3.) Pp. vii+153+7 plates. (London: Royal Geographical Society, and John Murray (Publishers), Ltd., 1960.) 25s.

THOUSANDS of people know the "Broads". What pleasant memories they evoke—lovely country, interesting bird life, good sailing, joyous parties aboard a motor launch! But how many holiday makers have ever asked themselves how these large lakes were formed? Clearly they are different from any other sheets of water in Britain; How did they come into being? Much research has been devoted to this problem of recent years, and it has been attacked from various points of view—geological, historical, philological, botanical, etc. As the outcome of these investigations it would seem that everything now points to the conclusion that the broads resulted from peat diggings during the Middle Ages. Somewhere about the fourteenth century slight land sinkage, perhaps combined with a tidal break-through such as occurred a few years ago, flooded the peat workings, and this flood water could not drain away owing to the new lower level of the land relative to the sea. The broads, then, were turbaries. It can be shown that, as should be the case, they have vertical peat sides, nowadays somewhat masked by subsequent slight infilling of silt and mud, and we can sometimes also notice transverse baulks of undug peat forming ridges, to-day only just covered by the water; there are also islands of peat similarly only just below water-level. Historical records show that vast peat workings did exist in this area in the early Middle Ages, and the method of working can be determined. Fairly suddenly these methods changed, and much of the peat exploitation ceased. This would seem to correspond with the flooding of the workings.

It must be remembered that transport in the eleventh, twelfth and thirteenth centuries was difficult, and little suitable fuel other than peat existed in East Anglia, which nevertheless was a well-populated part of the country. That peat digging should have existed on a large scale is not surprising. The fact of land sinkage perhaps coupled with tidal break-throughs altered the whole picture and resulted in the broads we know to-day. So whether the holiday maker is sailing over aristocratic Ranworth or stately Barton or proletarian Wroxham, let him spare a moment to remember the old peat workers, his forerunners, to whose labours his present enjoyment is due.

MILES BURKITT

Premier Colloque International de Photographie Corpusculaire, Strasbourg, 1er au 6 Juillet, 1957

(Colloques Internationaux du Centre National de la Recherche Scientifique, No. 79.) Pp. 451. (Paris: Centre National de la Recherche Scientifique, 1958.) 5,300 francs.

THE introduction of the photographic emulsion as a detector of charged particles has had an impact on physics which will be familiar to students of evolutionary biology. We can recognize a long and rather obscure development period, a sudden emergence as a practical device, and then an explosive deployment into many fields and applications as its very adaptable features were recognized. In about a decade a vast literature has grown around the subject of nuclear track plates which must bewilder those about to use them for the first time. Nor are there any signs that track plates have reached the final stage of the evolutionary process, namely, the slow decline and ultimate extinction in the face of the competition from newer types of charged particle detectors. This is evident from the subjects covered in this book, which is a record of the First International Conference on Particle Track Photography held at Strasbourg in 1957. The main aims of this conference were to examine the present state of our knowledge concerning the photographic action of charged particles, to survey the results obtained in recent years, and to seek ways of improving the emulsions to meet the changing requirements of physics and the widening fields of application. There are about fifty contributions by delegates from fourteen countries on the theory of latent image formation, the preparation, properties, processing and application of nuclear emulsions. The book is well illustrated by diagrams and photographs and provides a valuable account of the latest techniques written by experts, many of whom were pioneers in the development of track-plate photography.

D. L. ALLAN

The Transits of Venus

A Study of Eighteenth-Century Science. By Prof. Harry Woolf. Pp. xiii+258+11 plates. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1959.) 48s. net.

IF one says of this book that it is a careful and scholarly work describing the aims and adventures of those who, in the eighteenth century, tried to determine the distance of the Earth from the Sun by observations of Venus on the rare occasions when the planet was seen projected on the solar disk, one has said almost everything possible by way of general appreciation.

As a contribution to the history of astronomy this is an important work which will be useful primarily as a complete record of the hopes and fears, successes and failures, hair-breadth escapes and solid achievement of the many scientists and travellers who took part in the observational schemes. One can, however, see more in the volume than a catalogue of historical sources. The tale, considered as a whole, shows how essentially modern the eighteenth century was, and how particularly France, Britain and Sweden could even at that time plan great scientific projects in a manner which would not be out of place to-day. The science of the seventeenth century still had recognizable roots in medievalism: that of the eighteenth looked forward with a philosophy still unchanged in our own time. It is even conceivable that we could draw a modern lesson from this record, and by the use of multiple photography of Mercury or Venus when projected on the solar disk overcome the uncertainties introduced by the indefiniteness of the solar limb in any one exposure, and reintroduce the transit method as a modern means for the determination of the solar parallax.

DAVID S. EVANS

Évacuation et Récupération de la Chaleur des Réacteurs Nucléaires

Par Richard Alami et Paul Ageron. (Introduction au Génie Nucléaire, Tome 3.) Pp. ix+246. (Paris: Dunod, 1958.) 2,900 francs.

THIS, the third volume of an introduction to nuclear energy, is devoted to the removal and utilization of heat from nuclear reactors. The work is directed towards engineering students and those already engaged in the nuclear field who are not specializing in heat transfer.

The first of the four chapters commences with a discussion of the way in which heat is produced in a nuclear reactor. The fundamental laws of heat transfer are next reviewed, and then, after defining the required characteristics of a nuclear coolant, separate sections are given to aqueous, gaseous, liquid-metal and organic coolants. The chapter concludes with a section on aqueous and liquid-metal fuels.

The second chapter deals with the conversion of heat to mechanical energy and includes separate sections on steam and gas turbine cycles. The third covers application of theory to practical reactor systems, some thirteen projects being described according to their coolant classification. The final chapter details methods of determining thermal stresses in simple geometries.

The presentation is attractive, and the text is supported by adequate diagrams and worked examples. Comprehensive tables of physical properties are arranged conveniently within the text. Each chapter includes a reasonable bibliography of supporting references.

The work affords a useful introduction to the subject, but, without implying any criticism of it, it would seem that English readers are already adequately catered for by a number of existing British and American books. R. J. Symes

Nigeria's Feeding-Stuffs

Their Composition and Nutritive Value. By V. A. Oyenuga. Second edition. Pp. 65. (Ibadan, Nigeria: University Press, 1959.) 8*s.* 6*d.*

AGRICULTURAL progress in all under-developed countries has been delayed because of a lack of knowledge, particularly of the basic facts about the soil and the crops of these regions. Overworked staff in Government research stations have usually been overwhelmed by the need to give all their attention to problems of immediate practical importance. Many of us hoped that the new university colleges would do something to encourage fundamental research, particularly in the sciences relating to agriculture. This book shows one instance of this hope being fulfilled. It is particularly encouraging to find that Nigerian members of staff, like Dr. Oyenuga, are making such a useful contribution to the development of scientific agriculture in their own country.

This book, which is a revision and expansion of the first edition published in 1955, lists the majority of the important foods, both of man and his livestock, which grow in Nigeria. It gives analyses of their composition, including such data as their protein and starch equivalent, and their nutritive value. Useful notes on the cultivation and use of each crop are included. Readers who do not know Nigeria may sometimes be surprised, for example, by such statements as that the water melon has the highest calorific value (658 calories per 100 gm.) of any that has been determined; the mystery is cleared up by the explanation that in Nigeria water melons are grown for their seeds and not for their watery flesh. All who work on problems of nutrition on man or animals in tropical countries, and particularly in West Africa, will find Dr. Oyenuga's book a very useful tool. Kenneth Mellanby

Australian Native Plants for Home Gardens

By A. E. Brooks. Pp. xvi+149+40 plates. (Melbourne and Sydney: Lothian Publishing Company, Pty., Ltd., 1959.) 45*s.*

THE Australian bush is particularly rich in beautiful floriferous plants fit to grace any garden. Many have already been brought into cultivation, and the aim of this book is to make known to the increasing number of native plant enthusiasts which species are obtainable from nurserymen in Australia and the treatment they require in the garden. The information is presented in dictionary form with brief descriptive and cultural notes arranged alphabetically under the botanical names. Popular names are given also, and an index is provided for them. Articles on such topics as propagation, manuring and transplanting are interspersed, and, together with lists of species flowering at different seasons, or suited to particular conditions, add much to the usefulness of the book. Very few of the plants mentioned can be cultivated out of doors in the British Isles. For the London area they would include one *Grevillea* and one or two ti-trees (*Leptospermum* spp.) among the shrubs, and the golden everlasting (*Helichrysum bracteatum*) and Swan River daisy (*Brachycome iberidifolia*) among the herbs. The paucity of hardy species combined with the inadequacy of the descriptive matter for identification and absence of keys limits the sphere of usefulness of the book to Australia. These deficiencies are to some extent ameliorated by the inclusion of seventy photographs of a high standard by which the majority of the genera are illustrated. R. Melville

Antibiotic Therapy and Staphylococcal Diseases

Edited by Dr. Henry Welch and Prof. Maxwell Finland. (Antibiotics Monographs, No. 12.) Pp. xii+208. (New York: Medical Encyclopedia, Inc.; London: Interscience Publishers, Ltd., 1959.) 4.50 dollars.

THIS volume is No. 12 in the series of "Antibiotics Monographs" and covers the important subject of antibiotics effective against staphylococcal infections.

After a foreword in characteristic style by Marti-Ibanez, the first chapter by Welch deals with the staphylococcal problem and the effects of early antibiotics, penicillin, chloramphenicol, the tetracyclines and bacitracin. The next six chapters deal with erythromycin, oleandomycin, novobiocin, vancomycin, ristocetin, and kanamycin. Each is written by a well-known authority in the use of these antibiotics. The last chapter consists of recapitulation and discussion by Finland.

The book is excellently produced. It gives much useful information about each of the antibiotics considered, full references to their use in clinical practice, an assessment of their effectiveness and discussion of the ease with which drug-resistant organisms arise.

It ends with the conclusion that antibiotics against staphylococci should be used sensibly and only for clear indications, that they should never be used for prophylaxis on a wide scale in hospitals or in closed communities particularly for long periods, that the antibiotics most suitable for each case should be selected and changes made after adequate trial has shown them to be ineffective or inadequate, or when other infections are demonstrated or evidence of toxicity precludes their further use. R. Knox

ARE THE LAWS OF NATURE SYMMETRICAL?

By PROF. O. R. FRISCH, O.B.E., F.R.S.*

BY symmetry I shall mean mirror symmetry, exhibited by such flat figures as a heart or a fleur-de-lis or the letter A. There are two tests for symmetry. One is to see if a plane can be found—the plane of symmetry—which bisects the figure so that, of the two halves, one is the mirror image of the other. Hence, any figure together with its mirror image in an arbitrary plane constitutes a symmetrical figure. The other test is to form the mirror image of the given figure and see if the two look alike. Children might find it difficult to perform that test since they notoriously confuse *d* and *b*, or *p* and *q* (but would they call them alike if they saw them side by side ?). But apart from that the two tests are equivalent, for flat figures; though not for spatial shapes, as we shall see.

Considered as a shape in space, any flat figure is symmetrical, its own plane being the plane of symmetry. The flat shape of a glove is symmetrical, but not the glove itself, the two sides of which are different. Many crystals are symmetrical, but some are not. Many of them will pass the first test—of having a plane of symmetry—and it is easy to prove that they then also pass the second test, of being 'congruent' with their mirror image. But the converse is not true: there are shapes that are congruent with their mirror images but that have no plane of symmetry. This is, of course, well known to crystallographers, but seems surprising when first encountered. Actually we know much more complex forms of symmetry, with several planes of symmetry; but here I am concerned only with the basic difference between symmetrical and asymmetrical shapes.

The important point is that the internal measurements of any shape are not changed when it is mirrored. Hence, for any asymmetrical shape there exist two forms, say, a right-handed and a left-handed one, and the internal measurements are the same for the two. For example, two helices may be drawn on cylinders of the same size, and at the same pitch, and yet be quite different. One is related to our right hand as the other is to our left hand, and so a convention for naming them has come about; but this can be used only by beings who know what we mean by right and left.

So geometry gives no preference to any shape over its mirror image. Does physics ? To put it more precisely: any set of geometrical measurements, carried out on a given shape, will give the same results if carried out on its image. Is the same still true if we extend it from geometrical measurements—of lengths and angles—to physical measurements, say, of speeds or forces or temperatures ? Would any experimental arrangement give the same result as its mirror image ?

The fundamental laws of Newton on which mechanics is based certainly make no distinction between right and left. A weight hung on a string can be made to swing in a circle, and the time for a turn is the same whether it swings clockwise or anti-clockwise. Actually, there is a slight difference because the Earth is turning; this can be eliminated by doing the experiment on the equator, or by just correcting for it. Even then there may be a difference because the string is twisted; so we should strictly use two weights hung by strings which are twisted the opposite way! Anyhow, if all such trivial errors are avoided, the direction of swing makes no difference.

The passage of polarized light through a sugar solution seems to be different. In the absence of the solution, minimum light is obtained with the two Nicol prisms crossed; but with the solution in the light-path, the second prism must be turned to the left to restore darkness. Here we seem to have an asymmetric phenomenon: with the mirror image of this arrangement, that is, with the prism turned to the right, we get brighter light rather than darkness. But the sugar molecules are the cause of that asymmetry; they are twisted, and if we replace them by others which are their mirror image and then turn the prism to the right, we shall once again get darkness, and symmetry is restored.

In the same way we can explain the apparent asymmetry of Oersted's famous experiment, which greatly worried him and his contemporaries. A compass needle above a horizontal wire and parallel to it is deflected when we pass a current through the wire. As before, an apparently symmetrical arrangement gives an unsymmetrical result. But the arrangement is not really symmetrical. The magnetism of the compass needle should be attributed, according to Ampère, to electric currents that go around it. Hence the arrangement is no longer symmetrical; in order to convert it to its mirror image the needle must be turned round, and then the current, of course, deflects it in the opposite sense, as demanded by symmetry.

I hope these examples will make it plausible that the laws of classical physics are indeed symmetrical. Here I mean by classical those phenomena where macroscopic bodies are concerned, made from very large numbers of atoms. But in this century we have learned to observe single atoms, and here a new difficulty appears. An atom passing through a layer

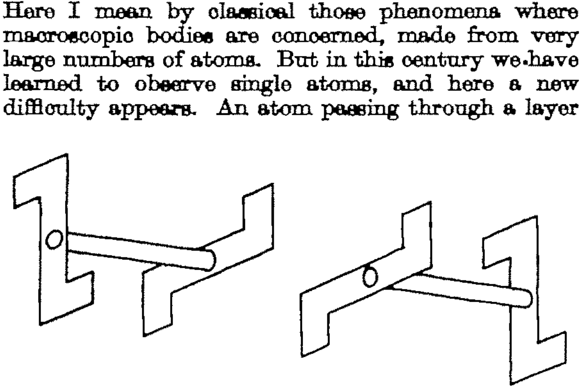


Fig. 1. These two shapes are identical (congruent), as can be seen by turning one by 90° about its rod, and are also mirror images of each other; yet each has no mirror plane

---

* Substance of an Evening Discourse at the Royal Institution, delivered on May 11.

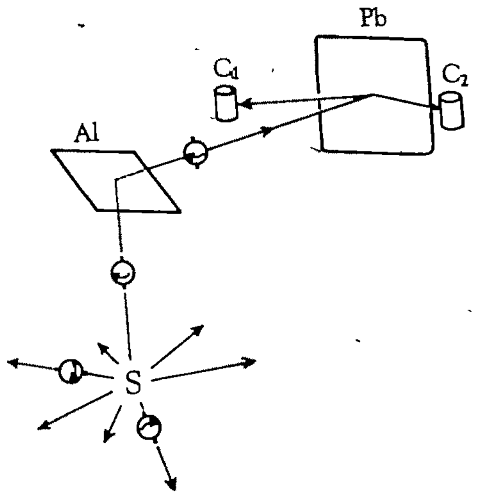


Fig. 2. Electrons from a beta-active source S tend to spin to the left about their direction of flight; that can be shown by scattering them twice, first from an aluminium foil Al and then from a lead foil Pb. The two symmetrically placed counters, C_1 and C_2, then count at slightly different rates

of gas or an electron passing through a metal foil will suffer a random deflexion, either to the right or to the left. Whichever it does, it behaves unsymmetrically in a symmetrical situation. But what else can it do? Its only alternative would be to remain undeflected, like Buridan's ass, which starved between two equal bundles of hay, obedient to the principle of symmetry. A real ass would eat one of the hay bundles at random, and nobody nowadays would worry about its unsymmetrical action. If out of 10,000 asses in that situation 6,000 turned to the right and only 4,000 to the left, then we might deduce that asses behave unsymmetrically; from the action of one ass nothing follows.

So in studying single atoms we must study them many times, or many of them, and analyse the results statistically. Until 1957 (with one single exception) no atomic process had been found to behave unsymmetrically, when averaged over many repetitions. But in 1956 reasons were given to suspect the radioactive beta-decay of unsymmetrical features, and early in 1957 a number of experiments were performed that confirmed this suspicion.

Radioactive phosphorus emits electrons in all directions. If a stream of those electrons that travel vertically upward is made to strike a sheet of aluminium, and those that are thereby deflected by 90° are then made to strike a sheet of lead plate, we should expect that of the electrons that are deflected by the lead plate, equal numbers should go to the right and to the left. But experiment shows that this is not so: about 10 per cent more electrons are recorded on the right than on the left.

Since the arrangement is quite symmetrical, the two positions of the counter represent two experimental arrangements, one the mirror image of the other; yet they give different counting rates. But before I discuss the wider implications of this, I want to describe the mechanism that accounts for this result. It is easy to verify that the electrons reach the lead plate as a symmetrical stream; Why, then, are more of them deflected to the right than to the left? Reversing the lead plate makes no difference, so it must be some property of the electrons. Now, a similar behaviour is seen with a tennis ball that has been given a spin about an axis across its direction of flight: striking a surface normally, it yet tends to go off sideways. The electrons do not, of course, bound back from the lead plate like balls from the floor, but rather like balls from an irregular array of nail heads which represent the atomic nuclei in the lead plate. Even so, the spin does cause an asymmetry in the deflexion pattern, and that asymmetry was indeed calculated by Mott as early as 1929, as soon as Dirac had formulated his mathematical theory of the electron spin.

So the asymmetry we observe indicates that the electrons strike the lead plate with a tendency to spin to the right rather than to the left, like couples performing a Vienna valse. Of course, they were originally travelling upward from the radioactive source before they were deflected by the aluminium sheet. Such a deflexion has little effect on the spin; so we finally conclude that the asymmetry comes from the fact that the radioactive nucleus tends to give each electron a spin to the left on sending it off.

That conclusion could have been reached in 1930: for in that year C. T. Chase found the same asymmetry (see *Phys. Rev.*, 36, 1060; 1930). But the time was not ripe; the effect was small and seemed inexplicable; nobody took notice, and the experiment was soon forgotten. Of course, electrons always spin, but usually in a random manner; and, indeed, when Chase's experiment was repeated with electrons from a hot wire, the asymmetry disappeared (which was erroneously taken to mean that his original experiment had been in error). How then does the nucleus cause the emitted electron to fly off with a definite sense of spin?

To that kind of question physics has no answer, no more than to the question: How does a positive charge attract a negative one? The attraction between opposite charges and many other more complicated electric and magnetic phenomena are fully described by Maxwell's equations; but not 'explained', since that would require their reduction to something more fundamental, and no such reduction has yet been achieved (although Einstein and others have tried). In the same way, the emission of electrons from radioactive nuclei is described in every detail, including the direction of spin, by a theory of which the foundations were laid by Fermi, more than twenty-five years ago.

In its original form, Fermi's theory did not predict any preferential direction of the electron spins; in those days, all physicists believed firmly in the symmetry of the laws of Nature. But it was soon clear that the emission of electrons—or beta-rays, as they were called—from nuclei was in a class apart from other atomic or nuclear phenomena. In quantum theory we compute the probability of transition between an initial state and a final state by assuming a certain interaction between the two states; for those beta-transitions, that interaction turned out to be weaker by a factor of many millions than in other phenomena.

In the past decade or so, several other processes which go by weak interactions have been discovered: the spontaneous transformation of a pion (pi-meson) into a muon (mu-meson), or a neutral lambda-hyperon into a pion and a proton. All those transformations happen within less than a millionth of a second, but that is a long time on a nuclear scale, and the interaction between the initial and the final state is found to be in all these cases just as weak as in beta-transformations.

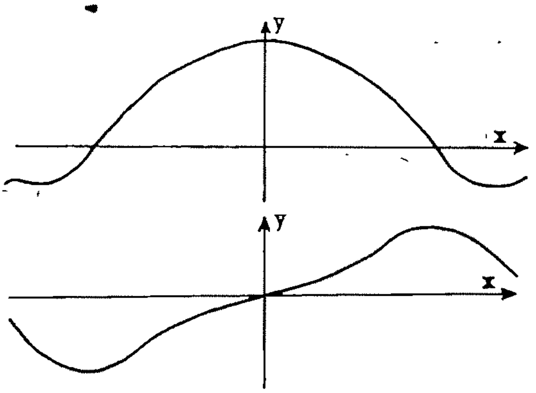


Fig. 3. Graphs representing functions of even parity (above) and odd parity (below)

Of particular interest here were the K-mesons, particles about half as heavy as protons, which were found to break up sometimes into two pions, sometimes into three. This behaviour was in conflict with a well-established rule of quantum mechanics: the rule of 'conservation of parity'. Originally, the parity of a number meant its property of being either odd or even. Later, that concept was extended to apply, not just to numbers, but to mathematical functions. When a quantity y varies in dependence on a quantity x, we call y a function of x, and we can represent a function by a graph. Now if a change in the *sign* of x has no effect on y, we say the function has even parity (or briefly, is even); when it causes y to change sign as well, we say the function has odd parity. The concept is easily extended to the case when f depends on several quantities, say, x, y and z, which may represent co-ordinates in space.

Such functions of space are very important in quantum theory, where they are usually called wave functions, because they resemble waves in special cases. A wave function may have odd or even parity, and it is an important fact that the parity remains unchanged even if the system to which the wave function belongs breaks up (as long as it is not disturbed from outside). This 'conservation of parity' will hold as long as the laws which govern the system are symmetrical, that is, make no difference between right and left, and this was never doubted until about 1956. About that time it became clear that the K-mesons presented a puzzle; it was shown that the system of three pions into which a K-meson can blow up has a wave function with the opposite parity from that of two pions which can also result from the break-up of a K-meson. For a time it was thought that perhaps there were two different kinds of K-meson, having opposite parity; but as the measurements became more accurate and still no other difference between the supposed two kinds could be detected, that idea became unpopular.

In October 1956, T. D. Lee and C. N. Yang, two young, Chinese-born theoreticians working in the United States, published a paper which made history and for which, two years later, they received the Nobel Prize. They looked at the evidence for parity conservation in a variety of processes and found that there was no such evidence for those processes which depended on weak interactions. They proposed some tests, and within a few months they were performed, with positive results. The first tests were quite complex and needed resources found only in a few laboratories; but soon much simpler experiments were devised which proved the simple rule that whenever a particle that has spin is sent out as a result of weak interaction, it tends to spin in a left-handed way about its direction of flight. The particle may be visualized as being like a little left-handed propeller, or that it is fired from a barrel with left-handed rifling, but of course those are just pictures.

Does all this mean that, in her weak interactions, Nature is left-handed, and that her laws are not symmetrical? In a certain sense, yes. But we may widen the concept of symmetry. It has long been known that there is a measure of symmetry between electric charges and the opposite kind. We call them positive and negative, but those are purely conventional labels (and rather unfortunately chosen, since usually it is the 'negative' electrons the movement of which constitutes an electric current). For a time it looked as if the positive charge was definitely associated with the heavy part of matter, the atomic nuclei, and more precisely with the protons which form part of atomic nuclei, and the negative charge with the much lighter electrons. But in 1932 positrons were discovered, which are the positive counterparts of the electrons, and negative protons were first made and observed in 1954. Ever since then, it has been possible to imagine a magic mirror—let us call it a charge mirror—which would leave the shape of an object unchanged but turn all its positive charges into negative ones and *vice versa*. It would even affect some neutral particles: the neutron, which we can image as a small spinning magnet, would be changed into an 'anti-neutron' still spinning in the same direction, but its magnetic poles reversed. In brief, our magic mirror would turn every particle into its anti-particle; but the forces between them would not be changed thereby and the entire system would behave just as before.

But again—just as with a real mirror—this is true only as long as we exclude weak interactions. I said before that any particle emitted as a result of a weak interaction tended to spin to the left about its direction of flight. But if it is an anti-particle that is emitted, then it will tend to spin to the right. That can be verified experimentally: there are radioactive substances that emit positrons rather than electrons, and those positrons are indeed found to spin in the opposite direction.

So the outcome of a weak-interaction experiment is different, according as we change it to its mirror image in an ordinary mirror—which changes right to left—or in our fictitious charge mirror which changes plus to minus. But if we use both mirrors at once then the outcome remains unchanged. To put it in a jocular way: if a physicist had stepped through the looking glass, like Alice, he would be able to tell by measuring the spin direction of electrons emitted in beta-decay, following Lee and Yang; but if at the same time he had stepped into an 'anti-world' where all the particles—including those of his own body—had been transformed into anti-particles, then he could never tell the difference, even with Drs. Anti-Lee and Anti-Yang to help him.

Does such an anti-world actually exist? We do not know yet. When a particle and its anti-particle meet, they annihilate each other and their energy is converted into penetrating radiation. Such radiation is very easily detected, and very little is present on the Earth; hence anti-particles must be rare, not only on the Earth, but all through our galaxy. But we cannot exclude that other galaxies may be made from anti-matter. Our hope of finding out is based on a careful study of those cases where two galaxies collide (a slow process of interpenetration which may last a million years). If one of them were made from matter and the other from anti-matter, an enormous intensity of gamma-radiation would result which we might observe, directly or indirectly; but so far there has been no conclusive evidence for such radiation. So we do not know yet whether Nature as a whole is charge-symmetrical, with equal numbers of galaxies and anti-galaxies, or whether anti-particles are merely fleeting visitors to our world, created by the clash of high-energy particles and annihilated again almost at once.

To sum up: before 1957 the laws of Nature were symmetrical in two separate ways which we may call space symmetry and charge symmetry. Since 1957 each of these symmetries by itself has ceased to be accurate; but they have become wedded into a vaster, more majestic, symmetry, a truly royal wedding the sight of which delights the philosophical mind.

BLUE HAZES IN THE ATMOSPHERE

By Dr. F. W. WENT

Director, Missouri Botanical Garden, St. Louis, 10

THERE are dozens of everyday experiences which can be cited to substantiate the reality and ubiquity of the blue heat or summer haze, which covers, particularly in summer on sunny and windless days, the whole countryside. We must exclude from this enumeration the haze which is produced in cities by 'smog' (partial oxidation products of petrol vapours) or by smoke from fires or industrial activities. But when we are in the countryside far away from cities, a blue haze is still present, usually much bluer than industrial smokes and hazes. Distant mountains are often blue, and may occasionally become almost invisible in a light blue haze. This is perhaps best illustrated with a description of the Tuscan countryside of the sixteenth century, as given by Leonardo da Vinci in his notebooks.

When reading this, one becomes aware of the number of 'Blue Mountains' (for example, in Australia, where blue hazes over the eucalypt forests are very common) and 'Blue Ridges' (in Tennessee, near the 'Smoky Mountains'), all named after one of the most typical aspects of these mountains: that they are usually enveloped in a blue haze or smoke. This haze occurs more commonly in summer, in areas only little populated, at times when no fires occur.

On warm summer afternoons, the Sun's rays breaking between the clouds can be seen as shafts of light against the dark undersides of these clouds. These rays become visible only because they pass through the even mass of haze. When the blue rays have been filtered out of the sunlight, this light becomes more yellowish (in the tropics the Sun is sometimes called the 'copper cad'), or even red (at sunset). These residual red rays produce the *Alpenglühen*, and the deficiency of blue light at sunset makes all our colour pictures taken at that time too yellow.

There is no better way to observe the blue haze than by flying over the countryside. When flying at a few thousand feet altitude, the fields and forests become indistinct near the horizon. The horizon becomes suddenly clear and sharp when the aeroplane rises above the temperature-inversion layer which, during summer, usually lies at 10,000 ft. The horizon is then formed by the clouds which float in this inversion layer with all haze contained underneath, and depending on the density of the haze, the ground surface is remarkably indistinct. Photographs taken from the aeroplane on days with dense haze are lacking in contrast, whereas on hazeless days, similar pictures are brilliant.

There have been a number of suggestions as to the nature of the haze: (1) smoke; (2) dust; (3) water vapour; (4) fog. Even a summary consideration will show that it can be none of these four possibilities. Concerning (1), these hazes are prevalent over moist tropical uninhabited jungles, over cultivated fields in summer, and in general over places without fires. Besides, the smoke plumes of fires or factories can be followed for dozens of miles downwind where they have not merged completely with the surrounding air. Therefore, the even blue haze cannot have its source in fires. Besides, most smoke is yellow or brown, whereas the common summer haze is blue or grey.

Point (2) can also be dismissed easily. The most pronounced haze occurs on quiet days with very low wind velocities, whereas on windy days hazes are less common. Besides, hazes occur already one day after a good rain, and their prevalence over forests and fields speaks equally against dust. Finally, again the blue colour makes dust an impossibility; dust always has the colour of the soil from which it rises.

The possibility that the haze is either (3) water vapour, or (4) fog, can also be ruled out. In the first place, the haze is most pronounced on warm sunny summer days. It never merges gradually into clouds; these remain always distinct. Water does not have any trace of light absorption in the visible part of the spectrum; water vapour as such can therefore never be visible. It can be observed only after it has condensed into droplets, as fog or clouds. But these droplets are at least 5 mμ in diameter and therefore diffract and reflect all colours equally, making them pure white in sunlight. Smaller water droplets, for example, of 1 mμ diameter, are stable only in strongly over-saturated air, and then they would immediately grow to greater size. Only particles or droplets smaller than the wave-length of light will reflect predominantly the blue rays, and such 0·1 mμ or smaller particles give rise to a blue haze.

We come therefore to the conclusion that blue hazes must consist of very minute, submicroscopic particles. This size precludes their formation by fragmentation of larger particles; breaking any matter up into sub-microscopic particles requires enormous forces and fantastic amounts of energy, which are nowhere in evidence on the quiet summer haze days.

The only remaining possibility is that these hazes are formed by agglomeration or condensation of molecules already present in the air. This is only possible, in that size-range, by chemical forces, because the kinetic energy of gas molecules at ordinary air temperatures precludes their condensation.

Fortunately several cases are known in which application of light or chemical energy leads to the condensation of gas molecules to blue hazes. The first of these cases was described almost a hundred years ago by Prof. John Tyndall, of Dublin.

He showed that when a beam of intense light was passed through a tube filled with air containing organic vapours a delicate blue light was emitted by that part of the air through which the light had passed. The lower the concentration of the organic vapours, the more slowly the so-called blue cloud formed, and the deeper the blue colour. On continued irradiation the colour of the blue cloud became lighter until it was whitish. Tyndall also found that the air remained optically empty, and that the blue light emitted by the cloud was polarized, indicating that it was reflected by submicroscopic particles, which obviously grew rapidly until they reflected all wave-lengths, and thus produced a whitish light.

Another case of experimental blue haze formation has been described and demonstrated by Dr. Arie Haagen-Smit, of the California Institute of Technology. When he mixed dilute petrol or olefine vapours with a low concentration of ozone, a blue cloud (with 'smog' smell) formed. This model experiment indicates what is happening in the atmosphere of a city, where considerable amounts of petrol vapours are emitted into the air, and where the energy of sunlight, catalysed by nitrogen oxides, oxidizes the olefines present.

An experiment, similar to that of Haagen-Smit with olefines, shows that volatile organic substances produced by plants behave in the same way as petrol vapours and ozone. When low concentrations of terpenes are injected into an ozone-bearing atmosphere, a blue haze develops. This is clearly shown in the case of dropping a handful of crushed pine needles, or any other aromatic plant material, into a container with ozone. The crushed leaves soon become enveloped in a slight blue haze, which becomes gradually whiter. This behaviour is exactly like that of organic vapours in the strong light of Tyndall's experiment.

Now it can be shown that considerable amounts of volatile organic substances are emitted into the air in sunlight. A pine forest produces quantities of volatile terpenes, such as pinene, which give the forest its piny smell. The fragrance of meadows is also due to volatile organic substances, and so is the aromatic smell of sagebrush and other types of vegetation of dunes and semi-arid regions. The sweet odour of the forest floor covered with autumn leaves is caused by terpenoid compounds, probably derived from decomposing carotenoids.

The amount of these volatile organic compounds produced yearly by all land-plants and their decomposition products is of the order of 10^8 tons. All this disappears again from the air since only a short distance from forest, meadow, or sage, the aromatic odours are no longer noticeable, at least during day. At night, whiffs of strong aromas may drift for much greater distances, but during the day a mechanism exists which removes the odours. This cannot be a simple oxidation to carbon dioxide and water. Even in the plant no enzymes exist which can decompose terpenes after they have been formed.

But through the experiments of Tyndall with light, and those with ozone, we know that partial oxidation can result in condensation of terpenes to macromolecules which refract the blue light. This is the major—and only demonstrable—mechanism by which the molecularly dispersed (and therefore smellable) aromatic compounds in the air can be deodorified. Therefore the same mechanism explains the removal of terpenes from the air, and the formation of a blue haze.

What happens to the particles which cause the blue haze? We can imagine two mechanisms. One is their oxidation to carbon dioxide and water. But in the first instance, they were formed because oxidation did not result in complete oxidation; and the addition products of the ozonides and peroxides produced by light-oxidation of terpenes are scarcely likely to be more oxidizable than the lower-molecular parent substance.

Therefore, the second possible mechanism is that they continue to grow in size and agglomerate into particles which become large enough so that they can be precipitated with rain or snow. They may then change colour from blue to white, grey, brown, or black. Judging by observable phenomena, the last-named seems to be the actual case. Commonly in the afternoon one finds the upper layer of the blue haze layer to be denser and of a grey or black colour. This is only visible when viewing this layer tangentially, that is to say, from an aeroplane flying in the inversion layer. In addition to this one major thin layer of dark colour, there often are several others at about 1,000-ft. intervals; usually there are one to three, but occasionally as many as seven can be counted. The grey, brown or black colour of these layers indicates that the haze particle size is well above 0·5 mμ, very much above that of the blue hazes under the inversion layer. These denser and darker layers of particles must have originated either in the stratosphere, where we do not have sufficient source materials, or in the haze layers below. This means that the sub-microscopic blue haze particles must grow into 1 mμ size particles in the inversion layer, in a relatively short time-period, measured in hours or days. This presents theoretical difficulties, but the facts seem to be clear-cut. There is some direct evidence indicating the transformation of the blue haze into larger particles.

Whenever a layer of convection clouds (strato- or alto-cumulus) accumulates above a blue haze-saturated air layer, certain phenomena can be observed. There is usually a zone of very active cloud appearance and disappearance in the lower end of the inversion layer; and it is exactly in that zone that very thin, dark grey or black wisps of cloud are seen. I call them 'veil clouds' for apparent lack of a specific name. They are clearly defined along the edges of disappearing strato-cumulus cloudlets. Their dark colour is definitely not due to shadows, for they surround a perfectly white cumulus on all sides. Veil clouds are also visible, not associated with any white clouds, but are always very thin, dark in colour, and occur only in the primary and secondary inversion layers. Frequently the lower surface of strato-cumulus consists mainly or partly of veil clouds. Wherever they extend between the strato-cumulus they remain dark in colour, and therefore I believe that a considerable part of the darkness of the lower side of strato-cumulus clouds consists of veil clouds, and that their dark colour indicates that their chemical composition differs very much from water. I suggest that veil clouds associated with alto- and strato-cumulus clouds are accumulations and condensations of the blue haze and therefore that they consist of particles of bituminous or asphaltic materials.

At the size the particles reach in veil clouds they may be effective condensation nuclei, and thus may play a part in cloud formation and even in rain production. They might thus partially replace sodium chloride particles as cloud- and rain-forming nuclei.

Only over vegetated areas are blue hazes and veil clouds observed. Over oceans one can see dilute white hazes, apparently consisting of sodium chloride particles, produced by evaporation of droplets of sea water, splattered by rain or splashing droplets into the air. Over absolute deserts no blue hazes occur (usually only yellow dust layers occur there); but over the creosote-covered California semi-deserts, and over the aromatic Australian interior, blue hazes, of perhaps lower concentration than the hazes hanging over Europe or the Mid-West of the United States, are typical. Blue hazes are typical of all tropical vegetated areas, pine forests, and forests in general.

About the fate of the bituminous and asphaltic particles in the veil clouds and grey or black inversion layers, little can be said. It is almost certain that they return to the Earth's surface with rain and snow, become attached to clay and other soil particles, and thus are either washed down with rivers into delta areas, where they might be the source materials for petroleum deposits, or they become incorporated in humus and peat, and provide the basis for much of the heat content of bituminous coals.

I suggest that the blue hazes and veil clouds play a very important part in the heat balance of the Earth and specifically of the atmosphere. They probably absorb about 20 per cent of all the Sun's radiation reaching the Earth. Therefore they should be considered when calculating the heat conversions near the Earth's surface.

There is another interesting aspect of the veil clouds. They must have a considerable potential heat content. Perhaps they provide not only part of the ions needed to build up the enormous potential differences required for lightning, but they might also provide part of the energy for maintaining the multi-mile long lightning shafts. One of the reasons for suggesting this is that the denser the vegetation and the more terpenes volatilize (due to high temperatures), the more intense the thunderstorms are. Over oceans, over deserts, and over the Arctic, they are absent.

Thus it was suggested that volatilization of terpenes and other plant products results in the production of, first, blue haze, then veil clouds, and finally, bituminous materials which, when returned to the Earth by rain and snow, produce the source materials for petroleum formation. The quantities produced are of the right order of magnitude, and all facts seem to fit into a consistent picture, giving a balanced point of view of many, until recently, unrelated facts.

We need proof of many of the statements and suggestions made here before they can be accepted as any more than a hypothesis. But the hypothesis may serve as a basis for further observations on the hitherto neglected blue hazes and veil clouds.

CYTOPLASMIC PARTICLES AND THEIR ROLE IN PROTEIN SYNTHESIS

THE Colloid and Biophysics Committee of the Faraday Society sponsored an informal discussion on this subject which took place under the chairmanship of Prof. J. A. V. Butler, at the University of Reading during March 28–29. The meeting was attended by approximately 150 people. Twenty-three communications were presented; a considerable number of participants contributed in an informal manner to a stimulating and fruitful discussion.

Studies in the field of protein synthesis, which are designed to elucidate some part of the mechanism by which amino-acids are linked to form peptide chains, have become numerous in the past five years. During this period research in this field reached the stage at which a concern with the development of sufficiently simple biochemical systems suitable for examination *in vitro* superseded the employment of whole organisms for investigations on the incorporation of amino-acids into tissue proteins. A similar trend has also occurred in the field of studies on micro-organisms, the cell components of which can also be fractionated and their metabolic behaviour afterwards examined. In view of the large extent to which amino-acids are incorporated into the proteins of the microsomes they are considered to be an important site of protein synthesis in the cell. In micro-organisms the cell membrane and particles inside it are assumed to be functionally analogous to the microsomal structures found in cells of large organisms. Concurrently with the attention given to the problem of protein synthesis in and by microsomes some research workers have been able to make use of other cytoplasmic components, the mitochondria, to demonstrate that isolated mitochondria are capable of forming their own proteins.

The success of metabolic studies on preparations of cell particles and a correct interpretation of such results often depends on some knowledge of the structure of the cell components. Their examination by physico-chemical and microscopic techniques has yielded useful evidence on their structure as well as on the effect on it of different procedures applied for their isolation. It may here be said that one of the purposes of holding this informal discussion at this time was to provide an opportunity for investigators of the dynamic as well as the structural and morphological aspects of protein synthesis to meet and exchange views.

The opening speaker (C. de Duve, Louvain) rightly dwelt at some length on the limits of resolving power of techniques of cell fractionation. This problem is of particular importance in the examination of the localization of single enzymes, or of enzyme systems. Prof. de Duve discussed the results achieved by his group in applying the technique of centrifugation in a density gradient to the localization of enzymes in tissues. He also reported on another approach, density equilibration in a gradient. This technique makes use of differences in density of particles to separate them in a suitable medium.

Electron microscopy has been of much help in formulating hypotheses which would try to explain some aspects of protein synthesis. It was pointed out by M. S. C. Birbeck and E. H. Mercer (London) that whereas cells such as hepatic cells which synthesize and secrete protein possess an endoplasmic reticulum, that is to say, membranes covered with particles, cells which retain the synthesized protein appear to contain free particles only. Efforts to correlate the site of synthesis with the location of particles or of the endoplasmic reticulum are made difficult by the existence of cell types in which these two points have been observed to be in different parts of the cell.

Many investigators have accepted the particles having a diameter of 15 mμ seen by electron microscopy in the cytoplasm of cells fixed with osmium tetroxide as the structural basis of microsomal nucleo-protein. V. Hanzon (Uppsala) has obtained evidence that these particles may not exist in the living cell since they cannot be detected in pancreatic cells fixed by freeze-drying and subjected to the vapour of osmium tetroxide. These particles seemed to be formed rapidly by a change in the internal milieu of the cell as it is affected by, for example, homogenization or fixation with osmium tetroxide in aqueous medium. Should this observation be confirmed by examination of other cell types it would link up with the results of other investigations which have given evidence that there is no direct relation between the number of visible granules and the content of ribonucleic acid of the microsomes. These ribonucleoprotein particles, now generally referred to as ribosomes, can be examined in the ultracentrifuge as H. E. Huxley and G. Zubay (London) have shown in their studies using *E. coli*. Ribosomes from this organism were found to be able to exist in a number of different stable forms. They could be interconverted by changes in the composition of the medium, particularly in the concentration of free magnesium ions. In addition these workers were able to examine the effect of such changes under the electron microscope. Thus, particles of size 50 *S* have an 'active face' which becomes opposed to another 50 *S* or 30 *S* particle. Examination of 70 *S* particles showed them to be made of two sub-units which resemble 50 *S* and 30 *S* particles, respectively. The pattern shown by ribosomal ribonucleic acid in X-ray diffraction photographs was compared by A. Klug, J. T. Finch and K. C. Holmes (London) to that given by extracted ribonucleic acid. It was considered likely that ribonucleic acid from various ribosomes had its own characteristic configuration; in contrast, the configuration of spherical viruses was probably determined by that of the protein framework.

One effect of chloramphenicol on micro-organisms is to inhibit protein synthesis. S. Dagley and J. Sykes (Leeds) were able to show that in *E. coli* exposure of the cells to chloramphenicol resulted in an accumulation of abnormal species of ribosomes which are apparently useless for protein synthesis. If the antibiotic was displaced from such preparations by magnesium ions, normal ribosomes of size 29 *S* were formed again. The results of an investigation of physical properties of ribosomes from the Jensen sarcoma were reported by M. L. Petermann (New York). The capacity of these ribonucleoprotein preparations to bind protein was found to depend on *p*H or the concentration of magnesium ions, and was observed to be sensitive to changes in ionic strength.

K. McQuillen (Cambridge) was able to report results of an extensive investigation which he and co-workers at the Carnegie Institution of Washington made on time relationships during protein synthesis in *E. coli*. Kinetic studies showed that the smaller ribosomes probably were precursors to the larger. During cell growth the ribonucleic acid and the structural protein of the ribosomes were found to be conserved. Regeneration of ribosomes occurred at an exponential rate in depleted cells; protein, however, was synthesized at a rate proportional to the ribosome content at any time. Evidence was given that radioactivity from amino-acids passed through the ribosomes where it had a transient existence as a protein before it appeared as a soluble protein. The use of ribosomes to study the mechanism of incorporation of amino-acids into proteins has been extended by A. Korner (Cambridge) to preparations obtained from rat liver. These ribosomes prepared by treatment of microsomes with deoxycholate were found capable of incorporating amino-acids on incubation in the presence of adenosine triphosphate and magnesium ions for more than 2 hr.

Most current theories on the mechanism of protein synthesis require the presence of ribonucleic acid from two cytological sources: from the microsomes and from the cell sap (*S*-ribonucleic acid). L. Bosch (Amsterdam) examined the metabolic behaviour of fractions obtained by passing ribonucleic acid through a column of 'Ecteola' resin. Only one of the four fractions obtained by stepwise elution of *S*-ribonucleic acid seemed to be involved in the transfer of amino-acids to microsomes and of radioactivity from phosphorus-32-labelled *S*-ribonucleic acid to microsomal ribonucleic acid. Conversely, only one of three fractions of microsomal ribonucleic acid was found to be capable of accepting radioactivity from phosphorus-32-labelled *S*-ribonucleic acid. The part which *S*-ribonucleic acid might play in protein synthesis was also discussed by V. V. Koningsberger (Utrecht), who reported on the existence in baker's yeast of small, carboxyl-activated peptides originating from activated amino-acids.

F. Gros (Paris) gave an account of experiments in which an alteration in the composition of ribonucleic acid led to modifications in the biosynthesis of proteins. When the uracil analogue 5-fluorouracil was added to growing cultures of *E. coli* some proteins produced were found to have an altered amino-acid composition. The synthesis of new specific protein could also be detected which differed markedly both in biological and physical properties from that produced under normal conditions. These effects appeared to be due to the changes in the ribonucleic acid alone because they also occurred in the presence of thymidine which would make unlikely the incorporation in place of thymine of 5-fluorouracil or its analogues. Another most promising development in the quest to shed light on the role of ribonucleic acid in protein synthesis was discussed by E. M. Martin (London). The use of encephalomyocarditis virus, a small ribonucleic acid virus, which can be propagated *in vitro* within Krebs II mouse ascites cells, may make it possible to demonstrate net synthesis of protein. Viral protein can easily be purified and is then available for further chemical study. This system may also allow the study of the effect of previously modified viral ribonucleic acid on protein synthesis. Preliminary experiments designed to examine the time course of events after infection of the host cell indicated that a marked inhibition of the turnover of ribonucleic acid, as measured by incorporation of 6-carbon-14 orotic acid, was followed by the appearance of most of the virus in the mitochondrial fraction.

The incorporation of amino-acids in the protein of whole microsomes requires the presence of the so-called *S*-ribonucleic acid and of certain enzymes from the cell sap. However, evidence has been produced to show that in some microsomal preparations the addition of these factors may be omitted whereas in others different enzymic extracts can replace these '*p*H-5 enzymes' from the cell sap. M. Beljanski (Paris) showed that a soluble enzyme preparation purified from *Alcaligenes faecalis* stimulated the incorporation of amino-acids into the protein of a particulate fraction from the same micro-organism. The same enzyme preparation was capable of replacing *S*-ribonucleic acid and '*p*H-5 enzymes' in a system suitable for the incorporation of amino-acids into microsomal protein from rat liver. This soluble enzyme preparation did not contain those activating enzymes which catalysed the exchange of adenosine triphosphate with pyrophosphate. However, a transfer in the presence of this enzyme preparation of orthophosphate from nucleoside triphosphate to the homologous diphosphate could be observed for the nucleotides of adenine, guanine, cytosine and uracil. If amino-acids were added to this system the formation of peptides was detected. Although the link is not clear between the presence of enzymes which bring about the above-mentioned transfer of orthophosphate to nucleoside diphosphates, and the ability of this enzyme preparation to stimulate the incorporation of amino-acids into proteins, it was of interest to have a report from J.-P. Zalta (Paris) that he could detect this transfer in certain microsomal fractions from rat liver. They were obtained by the action on whole microsomes of detergents of the polyoxyethylene and arylalkylsulphonate type. These fractions were observed to be capable of incorporating amino-acids into their protein without addition of any enzymic system from the cell sap.

The composition of ribonucleoprotein fractions from the microsomes of rat liver has been investigated by P. Cohn and J. A. V. Butler (London). Extraction with acid of these ribonucleoprotein preparations revealed the presence of basic proteins which, like histones, contained about 25 per cent of basic amino-acid residues but possessed a higher content of acidic residues than histones. Some observations on the process of incorporation of amino-acids into various protein fractions of microsomes indicated that, in contrast to results obtained on the living animal, incorporation under conditions *in vitro* apparently occurred to only a small extent in protein fractions which were not associated with ribonucleic acid in the endoplasmic reticulum. Such a connexion between extent and pattern of incorporation into microsomal fractions and the structural integrity of the membranes of the reticulum, and the possible enzymic inhibition resulting from damage to their lipoproteins were suggested by the experiments of A. von der Decken and T. Hultin (Stockholm). The mushroom poison phalloidin was observed to inhibit, under certain conditions, the incorporation into whole microsomes, but not into a ribonucleoprotein preparation which was derived from microsomes by removal of much lipoprotein material with the aid of a detergent. P. Emmelot and E. L. Bennedetti (Amsterdam) were also able to report an inhibition of the ability of whole microsomes to incorporate amino-acids if the rats had previously been injected with dimethylnitrosamine.

Differences in the requirements for the incorporation of amino-acids into proteins of mitochondria and of microsomes were indicated by the paper of D. B. Roodyn (London). The addition of cell sap or of '*p*H-5 enzymes' was found not to be essential, nor was the process of incorporation sensitive to ribonuclease. The distribution of radioactivity in the protein of various fractions obtained by differential centrifugation of mitochondria disrupted by treatment with a non-ionic detergent was reported. M. V. Simpson (New Haven) has employed mitochondria of both rat liver and calf heart to study the incorporation of amino-acids into cytochrome *c*. Mitochondria from calf heart which maintained their ability to incorporate for periods up to 12 hr. permitted the demonstration of a net increase in cytochrome *c* of about 20 per cent during this time. This synthesis required the supply of energy and the presence of amino-acids. It was also observed that amino-acids were incorporated into total protein of a supernatant fluid obtained from mitochondria subjected to ultrasonic treatment.

Much of the available evidence shows that ribonucleic acid is in some manner concerned with protein synthesis. R. W. Hendler (Bethesda) discussed the possibility that complexes between amino-acids and lipids might be involved in the transport of amino-acids and in protein synthesis. Extraction with organic solvents of the oviducts of laying hens, or of the cell wall and ribosomes of *E. coli*, revealed the presence of amino-acids which were bound to lipids in some way. A possible connexion between protein synthesis and the occurrence of amino-acid-lipid complexes was suggested by the pattern of their chromatographic distribution which was altered by processes which inhibit protein synthesis. The existence of such complexes in *Bacillus megaterium* was reported by G. D. Hunter (London), who suggested that their properties would be consistent with those of a precursor of labelled protein. Other studies gave evidence that the primary site of protein synthesis was present in material which sedimented at comparatively low speeds with the cell membrane, after osmotic lysis of protoplasts. A different approach to the problem of the mechanism of protein synthesis in micro-organisms was reported by B. Nisman and H. Fukuhara (Garches, France), who examined the ability of cell fractions of *E. coli* to incorporate amino-acids. Protoplasts were lysed by treatment with digitonin and then subjected to differential centrifugation. Of the two particulate fractions produced, one contained little and the other no enzymes which catalysed the exchange between adenosine triphosphate and pyrophosphate. Both fractions, however, were capable of readily incorporating amino-acids into protein.

P. COHN

NEWS and VIEWS

British Association for the Advancement of Science

THE July issue of *Advancement of Science* is noteworthy for a number of reasons. Besides articles on a variety of widely differing subjects by leading authorities, it provides enough information about the forthcoming Cardiff meeting of the Association (August 31–September 7) to whet the appetites of those who will be attending. There is to be a whole-day meeting freed from sectional activities when all members will be able to consider the bewildering world food-population problem. Speakers will include Dr. H. C. Wright, Prof. D. V. Glass, Principal W. A. Lewis, Prof. Dudley Stamp, Sir Alexander Fleck, Prof. H. D. Kay and Prof. P. M. S. Blackett. The needs of young people are to be provided for at Cardiff along similar lines to the admirable junior British Association meetings which have been held during 1960 in Birmingham, Belfast and Sheffield. Besides illustrated lectures and a 'brains trust' there is to be a display of work being done in science classes in many Welsh schools.

Ministry of Aviation : Mr. F. S. Barton

MR. F. S. BARTON retired on August 31, thus terminating some forty years in the public service, almost the whole of it in the radio field. He is the eldest son of the late Prof. E. H. Barton, of University College, Nottingham, who was the only Englishman to work with Hertz in Bonn during 1893, work for which he obtained his doctorate of the University of London. F. S. Barton was educated at Nottingham High School and was a foundation scholar of St. John's College, Cambridge. His Cambridge career was interrupted during the First World War by service with the Royal Naval Air Service Radio Experimental Unit at Cranwell. Returning to Cambridge in 1918, he obtained a first class in the Natural Sciences Tripos and rejoined as a scientific officer the Instrument Design Establishment at Biggin Hill, transferring to the Royal Aircraft Establishment, Farnborough, in 1922. Mr. Barton continued to serve there, his chief interest being in radio control of pilotless aircraft and radio research work, rising to be deputy head of the Department, until he left in 1941 to assume the appointment of director of radio engineering to the British Air Commission in Washington. While there, he served on numerous joint British–American committees and was the vice-president during 1943 of the Institute of Radio Engineers. Mr. Barton returned to Britain at the end of 1946 as director of communications development, becoming afterwards director general of electronics research and development at the time of the integration of the Air and Army sides of electronics research and development in the Ministry of Supply. In the autumn of 1955 he was posted to the U.K. High Commission in Ottawa to inaugurate on a more formal basis the interchange of research and development and production information between Canada and the United Kingdom in the defence field. While in Canada he was during 1954–56 the Council representative for the Institution of Electrical Engineers in the province of Ontario.

Mr. C. J. Francis

MR. C. J. FRANCIS has been promoted to deputy chief scientific officer in the Ministry of Aviation and appointed to the post of counsellor (Defence Research and Supply) to the United Kingdom High Commission, Canada, in succession to Mr. F. S. Barton. He joined the Civil Service in 1939, and spent the War years in the Directorate of Communications Development, where he had responsibilities for the ground radar chain, radar navigational aids, and blind-bombing aids. During 1945–54 he was at the Telecommunications Research Establishment (now Royal Radar Establishment), and was divisional leader in charge of development of ground search radars for both military and civil applications. In 1947 he became superintendent in the Airborne Radar Department, and was responsible for research and development of blind-bombing systems, Doppler navigational aids, radar reconnaissance systems, and airborne collision warning; for part of the time he was, in addition, head of the Blind Landing Experimental Unit at Martlesham. In 1954 he was appointed to the British Joint Services Mission in Washington, covering the research and development programmes undertaken by the United States Services in the field of electronics. In 1957 he returned to the United Kingdom as assistant director of electronics research and development (air), which post he will relinquish on taking up the appointment in Ottawa.

Mr. M. B. Morgan, C.B.

MR. MORIEN BEDFORD MORGAN has been appointed deputy controller of aircraft (research and development) in the Ministry of Aviation. In this appointment—which takes effect in September—he will succeed Dr. W. Cawood, whose appointment as chief scientist to the War Office was announced in July. Mr. Morgan, who has been scientific adviser to the Air Ministry since July 1, 1959, was born in 1912 and educated at Rutlish, Merton, and at St. Catharine's College, Cambridge. At Cambridge he obtained first-class honours in the Mechanical Science Tripos and won the Seely Prize in aeronautics in 1934. After an apprenticeship with Mather and Platt, Ltd., he joined the Royal Aircraft Establishment, Farnborough, in 1935, where as a member of the Aerodynamics Department he was engaged on general flight research and development, specializing on problems of stability and control. He was appointed head of the Aerodynamics Flight Section at Farnborough in 1946, and in 1948 was made head of the newly formed Guided Weapons Department. He held this post until January 1954, when he took over as deputy director (air), Royal Aircraft Establishment, a post he held until 1959. In 1957 he was awarded the Silver Medal of the Royal Aeronautical Society for his contributions in the execution and direction of aeronautical research and development. He has maintained a keen interest in flying—he obtained his pilot's '*A*' licence in 1944.

Animal Husbandry at Bristol : Prof. T. K. Ewer

Prof. Tom Keightley Ewer, at present professor of animal husbandry in the University of Queensland, has been appointed to the newly established chair of animal husbandry in the Veterinary School of the University of Bristol. Prof. Ewer, who will take up his appointment early in 1961, was born and educated in England and emigrated to Australia. He graduated in the Veterinary School of the University of Sydney in 1937, having previously obtained the H.D.A. with honours at the Hawkesbury Agricultural College. During the war years Prof. Ewer held appointments with the New Zealand Department of Agriculture and at the Canterbury Agricultural College, and was engaged on work on nutritional and parasitological problems of sheep. In 1947 he was awarded a Wellcome research fellowship by the Animal Health Trust which enabled him to conduct work on ovine rickets in the Institute of Animal Pathology at Cambridge, where he was awarded the degree of Ph.D. Prof. Ewer accepted the appointment he now holds in 1950 and was Dean of the Faculty of Veterinary Science in the University of Queensland for five years. In recent years he has carried out two assignments with the Animal Production Branch of the Food and Agriculture Organization—one in Venezuela, the other in Burma. Prof. Ewer's list of publications is in the field of nutrition in the sheep, his current interest being in the use of sorghum silage and various protein and non-protein nitrogen supplements.

National Academy of Sciences–National Research Council : Appointments

The following appointments as chairmen of divisions of the U.S. National Academy of Sciences–National Research Council have been announced: Prof. Robert C. Elderfield, professor of chemistry in the University of Michigan, as chairman of the Division of Chemistry and Chemical Technology; Dr. Edward P. Espenshade, jun., chairman of the Department of Geography at Northwestern University, as chairman of the Division of Earth Sciences; Dr. Emil W. Haury, professor and head of the Department of Anthropology at the University of Arizona, as chairman of the Division of Anthropology and Psychology; Prof. J. Barkley Rosser, professor of mathematics at Cornell University, as chairman of the Mathematics Division.

The Henry Bryant Bigelow Medal

The first Henry Bryant Bigelow Medal for oceanography has been awarded to the man it honours. Dr. Bigelow, one of America's foremost marine scientists, was among the founders of the Woods Hole Oceanographic Institution. He was its first director, served later as president of the Corporation and is now chairman of the Board of Trustees. He is also professor emeritus of zoology at Harvard University, having taught there for nearly half a century, and is a research oceanographer and former curator of the Museum of Comparative Zoology at Harvard. The Bigelow Medal was established earlier this year by the Trustees of the Oceanographic Institution without the knowledge of their chairman. It is designed with a likeness of Dr. Bigelow on the face and the Institution's first and most famous research vessel, *Atlantis*, on the back. With it go a citation and a cash prize of 2,500 dollars. It is to be awarded from time to time to those "who make significant inquiries into the phenomena of the sea".

Cloud Pictures from Satellite *Tiros* I

The March issue of the *Monthly Weather Review*, published by the U.S. Weather Bureau (on June 15), contains a number of fascinating photographs of cloud systems taken from the satellite *Tiros* during April 1960. The height of the satellite varied between 436 and 460 miles. The photographs are of the cloud systems of temperate-zone depressions over the Atlantic, Pacific and Mediterranean and a tropical cyclone north of New Zealand. The synoptic charts are printed alongside, and the correspondence between the cloud belts and the familiar curved fronts of the weather maps is most striking. The photographs show three major systems, the cloud belts within the systems, and cloud areas within the belts. Both single photographs and mosaics covering large areas are reproduced. There can be no doubt that cloud photographs transmitted from artificial Earth satellites will be a major tool of the weather forecaster of the future.

Intergovernmental Conference on Oceanographic Research

Scientists and government officials from thirty-four countries meeting in Copenhagen during July 11–16 at the invitation of Unesco have agreed to place the whole subject of oceanography on an international footing. Recognizing the importance of oceanographic research for the world as a whole, they recommended that Unesco set up a permanent intergovernment oceanographic commission to organize concerted action by States and by international bodies. Hitherto, the main obstacle to the development of oceanographic research has been the lack of qualified oceanographers. Oceanography has been somewhat of a poor relation among the various branches of science and the number of laboratories and university courses devoted to it is relatively very small. Oceanography now requires large-scale international co-operation. The Conference therefore recommended a number of measures, the chief of which is that an intergovernment oceanographic commission be set up and work with a special Office of Oceanography within the Department of Natural Sciences of Unesco to co-ordinate research on a permanent basis, the Commission meeting, in principle, once a year. This is subject to approval by the 82-nation General Conference of Unesco which meets in Paris next November.

The shortage of oceanographers, considered as one of the main obstacles to oceanographic research, led to the recommendation that the number of fellowships financed by Unesco be appreciably increased so as to offer greater training facilities for such specialists, particularly for those countries in which oceanography is little developed and which wish to participate in oceanic research. Such training should include participation in expeditions organized by the various countries or by Unesco and in short lecture courses or training courses in research institutes and institutions of higher education. Unesco is also asked to organize a conference to discuss the means of developing teaching in the marine sciences in universities. Because the training of oceanographers is so urgent, the Conference recommended that the money proposed in Unesco's budget for 1961–62 for the operation of an international oceanographic vessel be used for other training activities. Other steps towards international co-operation recommended by the Conference in a series of resolutions are the standardization and intercalibration of methods and equipment—such as the sizes and types of nets and the techniques used in the collection of plankton; the collection and exchange of oceanographical data; and the organization of joint research programmes in specified regions by groups of countries, such as that planned for the Indian Ocean. The Conference also asked Governments and international organizations to take immediate steps to prevent pollution by radioactive material and to intensify their research programmes in this field.

Cosmic Radiation Studies in South America

THE Latin American Council of Cosmic Radiation, with members from Argentina, Bolivia, Brazil, Chile, Mexico, Peru, Puerto Rico and Venezuela, met during August 1–3 at the Centro Brasileiro de Pesquisas Físicas in Rio de Janeiro. Observers representing the International Union of Pure and Applied Physics and Unesco were also present. The meeting was called and organized by Unesco's Centre of Scientific Co-operation for Latin America, Montevideo. The Council decided to organize a brief course of three weeks duration and seminars to be held in Mexico beginning late in June 1961. The latter will cover the following topics: composition of primary cosmic radiation, physics of interplanetary plasma, solar physics, time variations, extensive air showers and theory of geomagnetic effects. An effort will be made to secure the participation of physicists from other than Latin American countries in these seminars. The Council hopes to send through proper channels suggestions for experiments which can be made aboard space vehicles and artificial satellites. Members of the Council attending the Rio meeting were Prof. José Manzano (Argentina), Dr. Narayan Nerurkar (Bolivia), Prof. Georges Schwachheim (Brazil), Prof. Gabriel Alvial (Chile), Prof. Manuel S. Vallarta (Mexico) and Prof. Manuel Bemporad (Venezuela). Observers present were Prof. Gabriel Fialho (International Union of Pure and Applied Physics), Dr. Angel Establier (Unesco), Prof. Gleb Wataghin (University of Turin) and Prof. Gianpietro Puppi (University of Bologna). Prof. Vallarta acted as chairman.

Fossil Meteorites

ADDITIONAL information is provided by B. I. Vronsky (*Priroda*, 9, 116; 1959) on the probable 'fossil meteorite' (*Nature*, 184, 1026; 1959). This meteorite was discovered in November 1957 in the valley of a small river, Zarya, a tributary of the Susuman River, itself a tributary, Berelekh, Magadan district of Siberia. This meteorite, which received the name 'Susuman' and which weighed about 19 kgm., was discovered at the base of an alluvial deposit consisting of gravels and mud. Thus, in age it is assumed to be Post-Glacial and about 15–20 thousand years old. It is only now that it has been made known that in this region, a few years previously, two similar meteorites have been discovered in similar situations. Thus, the iron meteorite, 'Mal'dyak', was discovered at a depth of 4·6 m. in gravels of the River Mal'dyak situated 28 km. to the south of Susuman. In 1941 the iron meteorite 'Burgavli', weighing 24·9 kgm., was found in the gravels of the River Adachi, a right tributary of Yana River. These three meteorites are now being studied in detail.

Industrial Health in Britain

MR. R. CARR asked in the House of Commons for a statement about the development of industrial health services in Britain. The Minister of Labour, Mr. E. Heath, said in reply on July 25 that the development of such services is under consideration by the Industrial Health Advisory Committee. Legal requirements safeguarding the health of industrial workers are contained in the Factories Acts and Regulations, which are constantly being revised and extended. In addition, many firms voluntarily provide medical and nursing services, and to encourage more employers to do so, a booklet is to be published later this year giving details of the cost of some of these services, together with the views of management and work-people about them. Group schemes have also operated successfully in a few places with special circumstances, such as Slough and Harlow, and we now need to explore the possibilities of establishing group schemes in areas of a different kind. Another need is the further use and development of industrial hygienic services to carry out chemical, physical and biological tests where special hazards exist or are suspected. The Minister said that arrangements are being made to set up an organization to collect information about existing facilities regularly and to make it available to employers. He had discussed further action with the Nuffield Foundation, which has had considerable experience in promoting industrial health schemes, and the Trustees of the Foundation are allocating £250,000 for the further development of group industrial health schemes and industrial hygienic schemes. The money will be used to assist practical schemes which promise to become self-supporting, and in selecting such schemes the Foundation would work in the closest co-operation with the Ministry of Health.

Preparing Teachers for Health Education

HEALTH education is not always recognized as a discipline of its own and given its appropriate place in the training of teachers. A report of a joint World Health Organization/Unesco Expert Committee (World Health Organization: Technical Report Series. No. 193. 1960. 1*s*. 9*d*.) provides a flexible framework of guiding principles for such training, which should take place not only through courses of instruction but also through the teacher's actual mode of life in his training institution, his contact with student health services, and his experiences when practising teaching. Health education in schools should be based on the health needs and interests of the children, the teacher having opportunities for imparting it, both directly and by the part he can play in the school health services and in planning a healthy school. To enable him to make the most of his opportunities he must have some knowledge of growth and development, personal and community health, health practice in schools, and methods of health education. The report discusses these subjects, the future teacher's life as a student in relation to his opportunities for health work and to health services for students, practice teaching and the education he acquires as a fully-fledged teacher. Other sections deal with planning of training for teachers in health education, the desirability of one person in each training institution being responsible for co-ordination of courses and activities in health education, and possible future national and international developments, studies and research in the subject.

The Research Defence Society

The Research Defence Society policy of presenting factual information in readily assimilable forms on 'explosive' topics like immunization, vaccination and animal experiments continues with an excellent pamphlet on vaccination against whooping cough, diphtheria and tetanus (*Conquest* Pamphlet No. 11. Research Defence Society, 11 Chandos Street, Cavendish Square, London, W.1. 6*d*.). The methods of immunization against these three conditions and the problems arising in connexion with the procedure are considered together for two reasons : the first is that protective injections against these diseases are now usually given earlier in life than are most others ; and the second that these substances are often given all together as a mixture, thus minimizing the number of injections required. The value of the pamphlet is that in no cases are dangers minimized or awkward questions evaded. These are put simply, answered objectively, and include information which indicates where preventive medicine may not always have been effective. The pamphlet should be widely distributed in maternity and child welfare clinics.

Genetic Recombination in *Salmonella typhimurium* occurring during Transmission of Colicinogeny

An interesting item in the annual report of the Lister Institute for 1960 is an investigation by Drs. Ozeki and Howarth into the recombination of chromosomal genes in systems in which colicinogeny is being transmitted. Their results indicate that, in about one pairing in a million, genes believed to be located in the bacterial chromosome (for example, genes regulating various biosynthetic steps and a gene for resistance to streptomycin) undergo recombination. Recombinants can be detected in small numbers whenever colicinogeny-I is being transmitted at high frequency, and in larger numbers when colicinogeny-*E*1 is also being transmitted. Many pairs of genes cannot be simultaneously transduced by a single phage particle, probably because they are not close together in the bacterial chromosome, only a very small fraction of which can be enclosed within a single phage particle. A number of crosses involving such pairs of apparently unlinked genes were made by the newly discovered method of hybridization, and in every instance a fraction of the recombinants was found to have received both pairs of genes concerned from the strain which was transmitting colicinogeny. This suggests that, in this new kind of hybridization, either the whole or at least a large fraction of the chromosomes of the transmitting strain is enabled to recombine with the chromosome of the acceptor strain, in contrast to the situation in phage-mediated transduction. It seems likely that the new method of hybridization may prove of great value in determining the arrangement of the genes along the whole length of the *Salmonella* chromosome, a problem which could not be investigated with the previously available method of hybridization by phage-mediated transduction.

Nature Conservation in East Anglia

A booklet, "Nature and Conservation in East Anglia", produced on the occasion of the Duke of Edinburgh's visit on July 8, 1960, describes briefly the work of the Conservation Corps of the Council for Nature in clearing scrub for the National Trust at Wicken Fen, the Nature Reserve at Havergate Island and Orfordness, and the work of the Field Studies Council at Flatford Mill (pp. 16. London: The Council for Nature, 1960). This attractive booklet also gives brief accounts of the work of the Council for Nature and the Royal Society for the Protection of Birds as well as of the Nature Conservancy, and is well designed to promote public awareness of our heritage of wild life and the need to conserve it more effectively.

Darwin's Notebooks

In Part 3 of "Darwin's Notebooks on Transmutation of Species", Sir Gavin de Beer shows that the contents of the "Third Notebook" owe nothing to Malthus's work (*Bull. Brit. Mus.* (*Nat. Hist.*), Historical 2, No. 4. London, 1960). "It is therefore of great importance to note that Darwin hit on the principle of natural selection independently. After a consideration of changes resulting in the formation of new species, he wrote : 'All this agrees well with my view of those forms slightly favoured getting the upper hand and forming species'. " Darwin himself realized the historical importance of these lines, because at a later date when he looked through his "Notebook", he wrote at the head of it : "Towards close I first thought of selection owing to struggle". How the stimulus of Malthus's book put Darwin on the scent of natural selection is well brought out in this edited version of his "Third Notebook".

Lancaster Royal Grammar School Natural History Society

The extra-mural duties involved in running a society in a grammar school is an arduous task for the masters and boys concerned. Lancaster Royal Grammar School may be rightly proud of its Natural History Society, which has recently celebrated its twenty-first anniversary. The society periodically publishes a magazine, and, in the ninth issue of *The New Biologian*, the contributions include articles by the masters and boys, records of the Society's activities, etc. The articles include descriptions of biological stations and field study centres and show the value of these in awakening genuine interests among the participating students. One clear difference emerges from the journal and those of natural history societies established in boarding schools: almost invariably in the latter their journals contain some record of original work by boys. Biology masters in grammar schools would do well to examine them.

The Korsakov Journal of Neuropathology and Psychiatry

Arrangements have been completed for the quarterly publication of an English translation of selected papers from the well-known Soviet periodical, *The Korsakov Journal of Neuropathology and Psychiatry*. The English edition will begin with the first issue of 1960, and will contain English abstracts of all articles not translated. The translated journal will be published by Pergamon Press, and Dr. W. Ritchie Russell (Oxford) will act as English editor.

American Society for Cell Biology

A group of cell biologists met in New York on January 9 and again on May 28 of this year, and organized a new society, the purpose of which is to further the development of cell biology and to improve communication among scientists representing diverse disciplines. Membership is expected to include biochemists, biophysicists, cytologists, histologists, microbiologists, physiologists and others having in common an interest in the cell. The organization has been named the American Society for Cell Biology. Applications to join the Society should be sent to Dr. Montrose J. Moses, Box 2982, Duke University School of Medicine, Durham, N.C. Membership is not restricted to residents of the United States.

Maccabæan Prize and Medal

THROUGH the generosity of the Maccabæans, the Faculty of the History of Medicine and Pharmacy of the Worshipful Society of Apothecaries is able to offer an annual prize of not less than 25 guineas, with a bronze medal, for the best original essay on a subject connected with the history of medicine or pharmacy written by an undergraduate or graduate less than thirty years of age. Further information can be obtained from Dr. F. N. L. Poynter, The Wellcome Historical Medical Library, 183 Euston Road, London, N.W.1.

Research in Biochemistry and Allied Sciences

A COLLOQUIUM on the Organization and Financing of Research in Biochemistry and Allied Sciences is to be held under the joint auspices of the Biochemical Society and the British Association, in the Physiology Institute, Newport Road, Cardiff, on September 7 (the last day of the British Association meeting) at 2 p.m. It is expected that the following speakers will take part: Prof. John Pryde (chairman), Prof. A. Haddow (British Empire Cancer Campaign), Dr. F. J. C. Herrald (Medical Research Council), Sir William Slater (Agricultural Research Council), Mr. C. Jollife (Department of Scientific and Industrial Research), Dr. G. F. Marrian (Imperial Cancer Research Fund), Prof. F. C. Happold (University of Leeds), Dr. F. A. Robinson (on behalf of industry), Dr. J. B. Bateman (U.S. Embassy, London), Prof. A. Neuberger (St. Mary's Hospital Medical School). The Colloquium is being organized jointly by Dr. K. S. Dodgson, Physiology Institute, University College, Newport Road, Cardiff, and Dr. W. J. Whelan (meeting secretary of the Biochemical Society), from whom particulars can be obtained.

The Night Sky in September

FULL moon occurs on Sept. 5d. 11h. 19m. U.T., and new moon on Sept. 20d. 23h. 13m. The following conjunctions with the Moon take place: Sept. 1d. 08h., Saturn 4° S.; Sept. 12d. 01h., Aldebaran 0·2° S.; Sept. 13d. 10h., Mars 5° N.; Sept 23d. 22h., Venus 3° S.; Sept. 27d. 10h., Jupiter 5° S.; Sept. 28d. 14h., Saturn 4° S. In addition to these conjunctions with the Moon, Venus is in conjunction with Spica on Sept. 20d. 22h., Venus being 3° N.; and Mercury with Spica on Sept. 26d. 16h., Mercury being 1° N. There will be a total eclipse of the Moon on September 5 and a partial eclipse of the Sun on September 20–21; both eclipses will be invisible at Greenwich. There were two eclipses in March of this year, making in all four in 1960. As is usually the case when four eclipses occur in a year, they take place in pairs about six months apart. Mercury and Venus are too close to the Sun for observation. Mars rises at 22h. 15m., 21h. 50m. and 21h. 20m. at the beginning, middle and end of the month, respectively. It is in Taurus at the beginning of September and moves into Gemini on Sept. 20. Mars is rapidly becoming brighter, its stellar magnitude being +0·5 and its distance from the Earth 106 million miles in the middle of the month. Jupiter sets at 22h. 40m., 21h. 50m. and 20h. 55m. on September 1, 15 and 30, respectively; it is in Ophiuchus, but conditions are not very favourable for observation. Its stellar magnitude is −1·8 and its distance from the Earth on September 15 is 470 million miles. Saturn is in Sagittarius, east of Jupiter, and sets at 0h. 00m., 23h. 05m. and 22h. 05m. at the beginning, middle and end of the month, respectively. It is stationary on September 15 and afterwards resumes eastward motion among the stars. Its stellar magnitude is +0·6 and its distance from the Earth in the middle of the month is 890 million miles. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Sept. 9d. 4h. 45·1m., ξ^1 Cet. (*D*); Sept. 12d. 1h. 14·3m., 89 Tau. (*R*); Sept. 12d. 1h. 21·3m., σ^2 Tau. (*R*); Sept. 13d. 1h. 05·0m., 117 Tau. (*R*). *D* and *R* refer to disappearance and reappearance, respectively. The autumnal equinox occurs on Sept. 23d. 01h.

Announcements

MR. M. D. TAYLOR, of the Department of Chemical Engineering, King's College, University of Durham, has been awarded a CJB Scholarship, of the value of £450 per annum, for two years in the first instance. This scholarship scheme, administered jointly by Constructors John Brown, Ltd., and the Institution of Chemical Engineers, is to encourage research in chemical engineering and, in particular, in chemical plant design.

AN International Symposium on Photoelasticity will be held during October 29–31, 1961, at the Illinois Institute of Technology, Chicago, Illinois. Further information can be obtained from Dr. Paul D. Flynn, Illinois Institute of Technology, Chicago 16, Illinois.

A SYMPOSIUM on Redox Processes will be held at the Chemical Laboratories, University of Allahabad, under the auspices of the Chemical Research Committee, Council of Scientific and Industrial Research, India, during January 1961. Further information can be obtained from Dr. Satya Prakash, Department of Chemistry, University of Allahabad.

A CONFERENCE on Diffraction will be held during November 9–11 at the Mellon Institute, Pittsburgh, Pennsylvania. Sessions will be devoted to metals and alloys, instrumentation, structures, polymers and fibres, refractories, electron probes and electron diffraction. Further information can be obtained from L. F. Vassamillet, Mellon Institute, 4400 Fifth Avenue, Pittsburgh 13, Pennsylvania.

THE Institution of Electronics, with the co-operation of the Hull Electronic Engineering Society, is to hold an Electronics and Instruments Exhibition and Convention at the Farmery Hall, George St., Hull, during the period September 28–30. Admission will be free of charge and by tickets obtainable from exhibitors, or from W. Birtwistle, General Secretary, Institution of Electronics, 78 Shaw Road, Rochdale, Lancs., or from C. W. Wyan, Honorary Secretary, Hull Electronic Engineering Society, 2 Lockton Grove, Calvert Road, Hull, Yorks.

ERRATUM. In the communication entitled "Structure of β-Acylacrylic Acids", by Prof. Nils Hellstrom, in *Nature* of July 9, p. 146, the description of the ordinate of Fig. 1 is incorrect; for "Acid/sodium hydroxide" read "Sodium hydroxide/acid".

THE FOURTH INTERNATIONAL GOITRE CONFERENCE

THERE is a growing body of opinion in favour of replacing the large international conferences, attended by three or four thousand people, by smaller gatherings of an international character, and devoted to more specialized topics. At such meetings there should be better opportunity for expert discussion of communications, less overlapping of programmes and, above all, a chance of seeking out and talking with specific participants. Confirmation of the correctness of such expectations was afforded by the very successful meeting of the Fourth International Goitre Conference held in London during July 4–8. In all, about 600 endocrinologists, clinicians and biochemists, drawn from more than forty countries, took part. More than a hundred papers were delivered, and a book of abstracts of about 500 words each, in four languages, was provided at the time of registration.

A very large part of the subject-matter reported at the Conference was devoted to endemic goitre, and papers were read which surveyed its incidence in various parts of the world, the genetic aspects of the subject, and the part which goitrogens and other factors might play in its etiology. That iodine deficiency, in the opinion of Perinetti *et al.* and Kicic *et al.*, is the most important cause of endemic goitre was shown by the reliable effects which iodized salt had brought about in the disappearance of the condition in such different areas as Mendoza in Argentina and Gornja Josanica in Yugoslavia. On the other hand, Kilpatrick *et al.* suggested that iodine deficiency probably plays only a part in the development of goitre in an area to the west side of Sheffield, which was compared with a coastal district near Edinburgh. Although the iodine content in the water supply in the two districts is not dissimilar, there was a higher incidence of goitres in Sheffield. More fish was consumed in Scotland. It was further noticed that there was a definite familial linkage in the disease. An examination of the iodine content of goitrous thyroids did not reveal consistently low values as compared with normal thyroids. Observations of the seasonal incidence of goitre in sheep and cattle and the similar seasonal variation in anti-thyroid activity of milk (even in dried milk) suggests that though iodine may play a part in the incidence of goitre in the Sheffield area, goitrogens may also be a contributory factor.

Similar views were put forward by Costa *et al.*, who conclude that endemic goitre is a process which goes beyond mere alteration in thyroid function and that it is not a simple adaptation by the gland to iodine shortage. In a very careful examination by Koenig in Switzerland of nineteen endemic cretins, ranging in ages between 46 and 93 years, a number of interesting facts arose. It is difficult to find cretins born in Switzerland after 1910, which is at least ten years prior to the inception of iodine prophylaxis. Results of determinations of protein-bound iodine and the uptake of thyroidal iodine-131 show wide individual variation. In most cases these values were low, but in some they were normal and in others high. Some cretins responded well to exogenous thyroid-stimulating hormones, while others did not. The basic metabolic rate was a most unreliable indication of the state of affairs.

Cassano *et al.* believe that iodine deficiency may arise from excessive renal loss. They found that a high rate of excretion of iodine normally occurs in puberty and pregnancy and, significantly, in Cushing's disease and acromegaly, suggesting a hormonal basis for the increased renal excretion. The hormone most active on renal clearance of iodine is aldosterone. In any areas where iodine deficiency is likely, increased renal clearance of iodine, as in pregnancy and puberty, might favour the development of goitre.

A number of *Brassicae* are goitrogenic when fed to animals. Astwood *et al.*[1] isolated L-5-vinyl-2-thio-oxazolidone (goitrin) from yellow turnips, but this cyclized derivative of an *iso*thiocyanate does not exist as such in the plant but is formed enzymically from progoitrin, identified by Greer as a mustard oil glycoside. It is now reported (Greer *et al.*) that the conversion to goitrin can be accomplished by micro-organisms in the animal gastrointestinal tract. Both cooked and raw brassicaceous vegetables are therefore potentially goitrogenic, the effect being an iodine-blocking one.

Endemic goitre is not always associated with a deficiency of iodine in the soil and a relation to pasture has been suspected. Thus, in Tasmania endemic goitre occurs and it has been shown that cows fed on the brassica 'chou-moellier' secrete an active goitrogen in their milk which is consumed in quantity by school children. Peltola reports a somewhat similar situation from Finland, where endemic goitre areas exist. Recently published researches of Bachelard and Trikojus[2] go far to elucidate this problem. They find the turnip weed *Rapistrum rugosum*, which grows abundantly in certain areas of Australia, to contain a glycoside of cheiroline (γ-methylsulphonylpropyl-*iso*thiocyanate). Cheiroline had a variable goitrogenic effect when administered to rats, suggesting its possible transformation into an effective goitrogen in the animal body. Incubation of cheiroline with cows' ruminal contents afforded *sym*-di-cheiroline thiourea $(CH_3SO_2[CH_2]_3NH)_2C=S$. This interesting transformation may occur more generally with *iso*thiocyanates and be of importance in bringing about endemic goitre.

Dimitriadou *et al.* believe that there may be a defective synthesis and storage of fully iodinated hormones in some cases of non-toxic goitre and that this might be due to a defective iodinating mechanism. By means of their 'supplemented iodine-131 test' it was possible to calculate the amount of iodine-127 available to the thyroid, the rate at which iodine-131 became fixed organically into the various iodinated amino-acids in the gland, and also to estimate the size of the thyroid iodine stores. Results indicated little difference in urinary iodine excretion between patients with thyrotoxicosis, those with non-toxic goitre (with or without avid uptake of iodine) and euthyroid individuals. Stores of iodine compounds in the thyroid were diminished in cases of non-toxic goitre and the rate of transfer of iodine-131 into heavily iodinated compounds, that is to say, diiodotyrosine and the iodinated thyronines, was slower in such persons. This defective or slowed iodinating mechanism can be compensated for, however, by iodine supplements even though, by normal standards, these persons were not deficient of iodine in the diet.

A number of authors reported studies in which family pedigrees were examined to discover the incidence of abnormal thyroid behaviour. Fraser *et al.* and Thould and Scowen reported on the condition known as Pendred's syndrome, the main features of which are bilateral deafness, observed early in life, and goitre developing from about eight years onwards. The defect, which is probably congenital lack of a peroxidase enzyme system in the thyroid, results in inadequate organic binding of iodine. The condition is rare, and genetic data suggest that the syndrome is inherited in a recessive manner.

Other genetic studies were reported on simple goitre. One pedigree of 250 individuals was studied (Van Wyk *et al.*) which suggested that the occurrence of goitre in this family was a simple dominant trait which is more commonly overt in the female. Serologically there was a characteristic abnormality which consisted of a protein-bound iodinated constituent migrating electrophoretically with the albumin fraction. Other studies in a different family provided evidence of defective peripheral dehalogenation of iodotyrosines.

Elucidation of the process of biosynthesis of its hormone by the thyroid gland has proved to be a peculiarly baffling problem. The process may be divided into the three stages of concentration of iodide from the blood (the 'trapping' mechanism), iodination of thyroglobulin and release of thyroxine or triiodothyronine from the gland. Such a subdivision, although convenient, is somewhat arbitrary since it becomes increasingly clear that the metabolism of iodine must be considered within the thyroid gland as a whole.

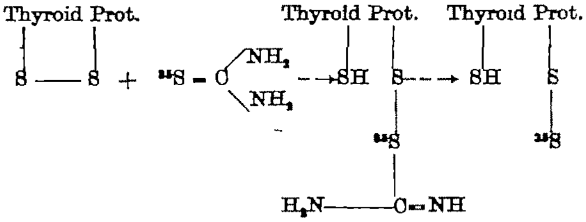
Thiocyanate and perchlorate are both known to prevent the accumulation of radioiodine by the thyroid. Wollman and Reed reported experiments designed to ascertain whether thiocyanate can, in addition, affect the iodination process and involving measurements of the binding-rate and thyroid/serum ratio (T/S) of injected radioiodide computed for different levels of serum thiocyanate. If two thyroidal compartments, an iodinating and a non-iodinating, respectively, were envisaged and the concentration of radioiodide in the latter was assumed to parallel that of serum, binding-rate constants became independent of serum thiocyanate-levels, consistent with the hypothesis that thiocyanate acts solely by decreasing the concentration of radioiodide at the binding site.

Perchlorate is excreted virtually unchanged (Lewitus *et al.*). Administration of $K^{42}Cl^{36}O_4$ showed that it is distributed in the body as is the iodine ion, being similarly concentrated in the thyroid gland. The supposed antagonism between perchlorate and iodide is of a competitive nature. These two ions have nearly the same ionic volume. Monofluorosulphonate, difluorophosphate and fluoroborate also have approximately the same ionic volume and are isoelectronic with perchlorate, and trial shows that they also inhibit the uptake of iodine by the thyroid. These studies lead to the conclusion that the 'trapping mechanism' may be merely a specifically adapted protein with a spatial arrangement that will chelate those ions which will fit into its spatial structure.

The synthesis of thyroglobulin in the mouse has been followed autoradiographically after injection of labelled leucine (Nadler *et al.*). Maximum activity was seen in the epithelium within 0·5 hr., followed by a decline as activity rose in the colloid (maximum in 35 hr.). These results are interpreted as indicating synthesis of a pre-thyroglobulin in the epithelium followed by secretion as thyroglobulin into the colloid, where it is iodinated prior to breakdown and release of thyroxine and amino-acids. The number of cells in the epithelium controls the rates of these processes. De Groot reported upon the early stages of *in vitro* hormonogenesis in sheep thyroid slices and in living rats. A homogenate of the thyroid tissue was separated into mitochondrial, microsomal and soluble fractions which were then analysed. Soluble fraction protein-bound iodine-131 as per cent of total protein-bound iodine-131 increased rapidly, then plateaued and was apparently all thyroglobulin. No thyroxine was identified in slice homogenates. It seems that in the iodination of thyroglobulin, iodine-131 may be transferred from a particulate fraction.

There is still much discussion concerning the possible role of a thyroid peroxidase in oxidizing iodide to iodine available for iodination. This chemical reaction can occur *in vitro* and therefore seems attractive, but it will be recalled that, among others, Glock[4] has severely criticized the evidence purporting to show the presence of a true peroxidase in the thyroid gland. Alexander reports that thyroid and salivary gland homogenates oxidize iodide in the presence of hydrogen peroxide added as such or generated by auto-oxidation of flavin. Catalase or anaerobiosis prevents flavin activation. The iodine formed by oxidation will iodinate tyrosine and to a lesser extent histidine, but the presumed natural acceptors, thyronine and di- and tri-iodothyronine, are *not* iodinated by this system.

That biological iodination may, in fact, be brought about by a different mechanism is suggested by a most interesting communication from Maloof and Soodak. These authors had previously demonstrated the desulphuration of sulphur-35-labelled thiourea by a cytoplasmic particulate system of thyroid. Thiouracil and thioacetamide are similarly desulphurated, the products being about 50 per cent protein-bound sulphur-35, 27 per cent thiosulphate, 10 per cent sulphate and 10 per cent an unknown compound. The protein-bound sulphur-35 is non-dialysable and stable to acid, but 80 per cent of it is displaced by such alkaline reagents as cyanide, sulphite, sodium hydroxide or by thiols such as cysteine, reduced glutathione and diethyldithiocarbamate. The desulphuration of thiourea is strongly inhibited by sulphite and cyanide, nucleophilic anions which are known to split disulphide bonds forming a thiol and an S-alkyl thiosulphate or alkyl thiocyanate, respectively. Using $Na_2{}^{35}SO_3$, it is found that it also forms protein-bound sulphur-35, which is quantitatively and qualitatively similar to that arising from labelled thiourea. The results suggest that both react with thyroid protein disulphide bonds forming a new mixed disulphide linkage as follows :



Free sulphydryl groups do not play a part in the desulphuration of thiourea since pre-incubation with SH reagents is not inhibitory. Parallel observations on the iodination reaction in this *in vitro* system suggest that a disulphide bond may be involved in the formation of an active iodinating intermediate. Hence, cleavage of an S—S bond in thyroid tissue by thiourea may be a factor in the inhibitory action of this compound. The desulphurating effect appears to be specific since it did not occur with liver tissue preparations.

Anti-thyroid drugs are not only of great therapeutic value, but also the study of their action continues to throw light upon the mechanism of biosynthesis of thyroxine, as the last-mentioned contribution clearly shows. For the medical treatment of thyrotoxicosis in the United States, according to McClintock and Gassner, propylthiouracil, 1-methyl-2-mercaptoimidazole and 5-iodo-2-thiouracil are most commonly used, while the British 'Carbimazole' has only been introduced there during the past year. The trend is to use these drugs for pre-operative preparation although their use as the sole method of curative therapy still has adherents. The first three have been compared for involutional activity. 5-Iodo-2-thiouracil appeared superior and gave less trouble during subsequent surgery. All the compounds are, however, associated with toxic reactions (4–8 per cent). It may be mentioned in this connexion that one of the advantages of 'Carbimazole' is its comparatively low toxicity.

The mode of action of anti-thyroid drugs has been investigated by Rimington. Recent work shows that where thiol ⇌ thione tautomerism is possible, involving carbon and nitrogen, compounds exist mainly in the thione form (hydrogen on nitrogen not on sulphur); configuration may be 'fixed', however, by alkylation. Using 'Neo-mercazole' ('Carbimazole': 1-methyl-3-carbethoxy-2-thioglyoxalone) for standard reference, a series of compounds were compared including derivatives of 3-mercapto-1,2,4-triazole and the alkyl-fixed thiol and thione form corresponding to 'Neo-mercazole' itself, namely, 1-methyl-3-ethylglyoxaline-2-thione and 2-ethylmercapto-1-methylglyoxoline. None was as potent an anti-thyroid in rats as 'Neo-mercazole' and the thione configuration appeared to be that responsible for anti-thyroid action. Measurement of the inhibitory effect of these drugs upon a horseradish peroxidase system *in vitro* showed no correlation with anti-thyroid activity.

Mayberry and Astwood have used propylthiouracil to study the intrathyroidal metabolism of iodine in rats. The distribution of iodine-131 in controls 24 hr. after dosing was triiodothyronine 2·6 per cent, thyroxine 21·2 per cent, iodide 2·7 per cent, monoiodotyrosine 25·2 per cent, and diiodotyrosine 42·4 per cent, and these proportions varied little during six days while 53 per cent of the iodine-131 left the gland. In the propylthiouracil-treated group, 92 per cent of activity left the gland in the same time, while the proportion of thyroxine steadily diminished. If recycling of iodine-131 was prevented by a large dose of iodide following the isotope, rate of loss of iodine-131 was only slightly greater than in the controls and the distribution was similar except for a slow drop in monoiodotyrosine. These results suggest that propylthiouracil not only blocks iodination but may also inhibit coupling of iodotyrosines.

The lipid metabolism of the thyroid has been investigated using phosphorus-32. Experiments on rats of depletion of sialic acid, iodine-131 and iodine-127 from the gland indicate that the concentration of the former affords a measure of the thyroglobulin content. Histochemical methods have been used in investigations of prolonged dietary iodine deficiency and of normal and pathological glands. Lindsay and Jenks studied a number of dehydrogenases, diphosphopyridine nucleotide and triphosphopyridine nucleotide diaphorases, monoamine and cytochrome oxidases and found most of these enzymes increased in animals treated with propylthiouracil, but greatly decreased after hypophysectomy or thyroid feeding. Tricarboxylic acid cycle enzymes are present in thyroid glands, but in lower concentrations than in sheep liver (Dumont). They are not inhibited by anti-thyroid drugs and are raised in glands from treated thyrotoxicosis patients. Blood pyruvic acid is high in toxic goitre but normal in non-toxic goitre (Gasiorowski). It remained high after attainment of the euthyroid state.

The firmness of binding of thyroxine in sera has been measured by determining the proportion held back on a suitable resin; enhanced binding is found in myxœdema, after propylthiouracil and in pregnancy but weak binding in hyperthyroidism (Mitchell *et al.*). Attention was, however, directed by Hamolsky *et al.* to the effects of factors such as carbon dioxide tension, buffers and *p*H on thyroxine binding in sera. At *p*H 8·6 an irreversible increase in binding occurs. The pattern of thyroxine binding in normal and pathological conditions has been the subject of several investigations. The pre-albumin shows a greater elective affinity for triiodothyronine than for thyroxine (Andreoli *et al.*).

The discovery of triiodothyronine has turned attention to the deiodinating enzymes and the metabolism of the thyroid hormones. Thus, Lissitzky *et al.* reported that thyroxine bound to specific binding protein is protected from deiodination and that in cells there is competition for thyroxine between deiodinase and thyroxine bound protein.

The tadpole has long been used for the study of thyroxine. With its development into a frog, concomitant alterations occur in responsiveness to thyroid hormone and the manner or rate at which it is metabolized (Galton and Ingbar). The results presented are consistent with, but do not prove, the hypothesis that hormonal response is linked to hormonal degradation. The fate of the doubly labelled sulphuric ester of triiodothyronine in the rat is rapid hydrolysis followed by deiodination. It appears to be either a storage or transport form of the hormone (Roche *et al.*). Radioactive 'Triac' and 'Tetrac', the acetic acid analogues of triiodothyronine and thyroxine, respectively, are found by Green and Ingbar to be metabolized differently in man.

Peripheral biochemical anomalies as well as thyroidal disturbances are thought to be present in sporadic cretinism from studies by Klein of the half-value times of thyroxine metabolism.

The relationship of pituitary to thyroid function has been studied by Becker *et al.* Patients with active or inactive Graves's disease did not show an immediate decrease of thyroid function following total hypophysectomy.

One of the most difficult conditions commonly associated with thyrotoxicosis to understand, and also one of the most unpredictable in its course, is exophthalmos. A number of interesting papers were read on the subject. Bartels and Irie showed, by studying patients suffering from severe progressive exophthalmos, that there was no close relationship between the development of the condition and the functional state of the thyroid or the type of treatment given for hyperthyroidism. Hitherto the course, degree and severity of exophthalmos have often been regarded as being influenced by the type and extent of the treatment offered for thyrotoxicity. A significant minority of patients developed exophthalmos before hyperthyroidism, and in five cases of severe exophthalmos no hyperthyroidism was noted at any time.

Dobyns described the use of fish (*Fundulus heteroclitus*), for the measurement of the level of an exophthalmos-producing substance in serum. Only in patients with active, progressive exophthalmos was exophthalmos-producing substance clearly demonstrable. Condliffe *et al.* provided evidence, from work with ion-exchange chromatography, that thyroid-stimulating hormone and an exophthalmos-producing substance are separate entities.

Contributions to our knowledge of the relationship between pituitary and thyroid activity, as well as a further understanding of those substances circulating in the blood stream which affect the activity of the thyroid gland, both in health and disease, were made by a number of authors. Two important papers (Purves and Adams, and J. M. McKenzie) described an abnormal thyroid-stimulating agent present in the blood of hyperthyroid persons. It appears not to be present in normal persons; the substance differs from normal thyrotrophin, for example, in the duration of its effect on the thyroid of guinea pigs and mice. It is active far longer than thyroid-stimulating hormone. The substance is active in hypophysectomized animals, thus demonstrating that it acts directly on the thyroid. The amount in serum appears to be correlated more closely with the degree of exophthalmos present than the severity of hyperthyroidism. Halmi *et al.* showed that thyroid-stimulating hormone stimulates rapidly the output of iodide from the thyroid, but the uptake of iodide more slowly.

El Kabir reports a reliable assay method for thyroid-stimulating hormone based on release of iodine-131 in incubated guinea pig thyroid slices. Generally speaking, thyroid-stimulating hormone values were high in patients with thyrotoxicosis and untreated primary myxœdema, whereas in exophthalmic ophthalmoplegia the values did not differ appreciably from normal.

Hellman *et al.* pointed out that apart from the differences in thyroxine-levels to be found in myxœdema and hyperthyroidism, there were also profound differences in the metabolism of androgens. If the thyroid dysfunction is corrected, disturbances in the androgens return to normal. Androsterone, of which low levels are found in hypothyroidism and high levels in hyperthyroidism, can be shown to produce to some extent the actions of thyroxine itself (thyromimetic effect).

No significant thyroxine formation was found by Taurog *et al.* in thyroidectomized rats. On the other hand, large daily injections of iodide had a stimulatory effect on growth. Since no thyroxine can be detected in the plasma, the possibility must be considered that iodide itself may have a thyroxine-like effect on tissues when given in high concentrations.

The connexion between serum cholesterol-levels, hyperthyroidism, hypothyroidism and the incidence of myocardial infarction has fascinated many, and a number of papers were devoted to these subjects.

One of the most interesting concepts which has arisen in recent years in connexion with the etiology of disease is that of auto-immunization, namely, the production by the body of antibodies against one of its own tissue components. That this could be a mechanism has often been suspected, but not clearly demonstrated, until Doniach and Roitt's work on Hashimoto's thyroiditis. Positive serological reactions can be obtained with the serum of such patients. Trotter and Belyavin observed complement fixation reactions between thyroid extracts and sera from patients of nearly all cases of Hashimoto's thyroiditis. The antigen is probably derived from the thyroid cells and appears to reside in the microsome fraction. Most cases of spontaneous myxœdema and about one-third of patients with thyrotoxicosis afford serum with a relatively low titre, as do occasional cases with non-toxic goitre, thyroid carcinoma or normal subjects. This cellular antigen can be detected in extracts of all types of thyroid, but is most abundant in thyrotoxic glands. Fixation of complement by the antigen and its corresponding antibody may be prevented by an inhibitory factor. The serum from patients with Hashimoto's disease commonly contains antibodies also against thyroglobulin. These are demonstrable by precipitation reactions and are distinct from those to the 'cellular antigen'.

A striking objective demonstration of the cytotoxicity of Hashimoto's sera was presented in a film by Pulvertaft *et al.* Primary cultures of human thyroid cells put up in fresh Hashimoto's serum showed few, if any, surviving cells at 18 hr. Substitution of Hashimoto's serum for normal serum in an 18-hr. old culture was followed by immediate darkening of the filamentous mitochondria and their gradual dissolution followed by rapid death of the cell. On the other hand, cultures grown for 36 hr. appeared to remain unaffected. The factor in Hashimoto's serum is thermolabile and specific; it does not kill all cells in a dense culture. Somewhat conflicting evidence was presented by Irvine, who argues that Hashimoto humoral antibodies are of secondary etiological importance. He considers that the basic pathology of Hashimoto's disease may be damage to the basement membrane, possibly due to cell-bound antibodies. Humoral antibodies, secondary to the escape of colloid, would then be an effect, rather than a cause, of the disease. However, since serological reactions are frequently demonstrable in thyroid disease, even in a small percentage of cases of unequivocal thyrotoxicosis according to Alexander *et al.*, and since some patients without Hashimoto's disease have a few clinical features of thyroid over-activity, screening tests for Hashimoto's thyroiditis should always be undertaken.

Two papers were presented in which the incidence of cancer was related to the use of radioactivity therapeutically. Winship and Rosvoll discussed an attempt which had been made over twelve years to examine the past history of children who, prior to the age of fifteen years, developed cancer of the thyroid. Where it has been possible to interrogate the parents of the children very fully, in 81 per cent of the cases there was a history of irradiation having been given therapeutically for a variety of reasons. Commonly, X-ray therapy had been given to try to treat an enlarged thymus. Sometimes similar treatment had been given for enlarged tonsils and adenoids; in others, for hæmangiomata and nævi. The latent period for the development of malignancy appears to be 7–12 years, and in most cases 400–700 r. had been given. The most common type of carcinoma encountered was the papillary type. Another investigation of a not dissimilar character was reported by Pochin. Careful analysis of the actual incidence of leukæmia in patients treated with radioactive iodine for cancer of the thyroid, when compared with the incidence of the disease in the healthy population at large, suggests that leukæmia may have to be regarded as a calculated risk (even if only a small one) when this treatment is used for thyroid cancer. Pochin, however, suggested that when smaller dosages are given for the treatment of thyrotoxicosis, the present known incidence of leukæmia does not appear to be greater than that which could have been said to have arisen by chance. Nevertheless, it is clearly desirable to watch this situation carefully and to extend observation over a longer period.

Ackerman *et al.* reported a simple and accurate test for the diagnosis of thyroid cancer. This consists of giving orally 500 mc. of phosphorus-32. Twenty-four hours later, multiple counts are taken of the radioactivity from suspicious nodules. In six cases uptake of phosphorus-32 was increased markedly. These were afterwards shown to be malignant tumours. It was very interesting to find that one case of Hashimoto's disease also suggested malignancy by this test. Thirty-four negative tests were produced and in all those operated upon (22), except one, benign tumours were diagnosed.

It is twenty-two years since the last International Goitre Conference, and although striking advances in both knowledge and technique have occurred during this time, it will be apparent that many fundamental problems still remain unresolved.

The late Edwin Ramsdell had prepared an address which was read at the opening of the conference. In it he reminded the members that at the third conference there had been no mention even of anti-thyroid drugs, let alone of radioactive isotopes. How completely the position has changed will be evident from the wide compass of topics dealt with in 1960.

C. Rimington
R. A. Milhy

---

[1] Astwood, E. B., *et al.*, *J. Biol. Chem.*, 181, 121 (1949).

[2] Bachelard, H. S., and Trikojus, V. M., *Nature*, 185, 80 (1960).

[3] Glock, G. E., *Nature*, 154, 460 (1944).

THE BRITISH COMPUTER SOCIETY

HARROGATE MEETING

SOME 400 delegates attended the second annual conference of the British Computer Society, held at Harrogate during July 4–7. The president, Dr. M. V. Wilkes, noted with satisfaction that the Society, with one annual meeting behind it, was indeed flourishing.

In his opening address, Dr. Wilkes announced the formation of an International Federation of Information Processing Societies, in which the British Computer Society would represent the United Kingdom. The Federation has elected its secretary-treasurer (A. Speiser, Switzerland), president (I. Auerbach, United States) and vice-president (A. Walther, Germany), and has announced that its next conference will be in Munich in September 1962.

Dr. Wilkes referred to the activities of the publication committees of the British Computer Society, and especially to the technical committees on automatic programming. He thought that scientific auto-coding was now generally accepted, but that the break-through in auto-code language for commercial applications, the results of which could be devastating, was still to come. One of the most important current problems was that of data-transmission, and he compared the rather slow teleprinter circuit, with difficult checking facilities, with the telephone circuit with forward error-detecting codes and automatic repeat when necessary. An interesting point was that 100 per cent accuracy is not essential, the aim being to make the transmission of information as accurate as any further processing thereof. He envisaged the less-pecunious universities ringing round to their more fortunate brethren, sending their problems by telephone to the fastest and cheapest service. Again, however, he warned that the solution of the problem, though imminent, was not yet effected.

The second session discussed a common computer language. C. Strachey (formerly of the National Research Development Corporation) outlined the problems arising in the construction of such language and its advantages to programmers, and mentioned important advances made by the United States in the technique of 'list-processing'. He made a plea for humans to regard their time as valuable, and to refrain from relapsing into slavery to the machine. R. Brooker (University of Manchester) spoke in technical terms of some recent work in constructing translating routines, carried out at Manchester, for any 'computer-oriented' language, and reported success with regard to the autocodes of *Pegasus* and *Mercury*. These methods apparently need a machine with a fairly large store, though K. Tocher (United Steel) reported success in devising restricted autocodes for smaller machines.

Business applications also have their auto language, and R. Paine (I.C.T.) outlined the desirable features of such a language and some attempts made to meet them. He warned that management cannot yet dispense with its programming staff, that the language of the accountant is not yet that of the computing machine, and envisaged the evolution of long-hand and short-hand versions of the language. This contribution included the comments that a computer conference might be described as a "meeting of contiguous word-noises", and that machine manufacturers' advertisements of business computer autocodes rarely err on the side of modesty.

At about this stage one notes with sorrow the transformation of certain features of the English language, and too often its mutilation which, in these vulgar times, seems to accompany the development of any new scientific field, and in which computer terminology is second to none. One finally applauded the question, "What exactly, please, is a programmer ?", and listened with regretful admiration to the chairman's "Since it is now time for coffee, I shall have to treat that question as rhetorical !"

The next session was also concerned with language and general-purpose programmes, this time for market research (A. Douglas, University of Leeds, and R. Cook, Elliott Bros.), which provided facilities for receiving and verifying data, forming frequency tables, and printing results in any desired format, and in general statistical survey work (F. Yates, Rothamsted), and success was reported with several of the smaller machines.

Small computers were also featured in a symposium on their use in a variety of problems covering clerical processes, production-control in a medium-sized factory, an analysis of a reasonably complicated hydro-electric system, and stock control in a shoe factory. This sequence of thoughtful, well-presented papers seemed to leave the audience rather bemused. Did they, one wonders, ponder on the remarkable advances in the past decade when machines like the Stantec *Zebra*, ICT 1201, Elliott 402 and 802 and Ramac 305 can now properly be described as small, or were they shattered with the perfect simplicity of a data-transmission system in which a gamekeeper reads water-levels once a week, cycles ten miles, and sends off postcards ?

S. Clarke (Elliott Bros.) and S. Gill (Ferranti) gave accounts of recent respective visits to the U.S.S.R. and the United States. Clarke reported great Russian interest in British computing equipment and their own assessment of a four years lag behind the West. He described some Russian machines, none of which has a rapid access store of more than about 2,000 words, and noted that their present main interests were in automation and language translation. He found little effort in general data-processing and commercial applications other than in pay-roll work. The Chinese have apparently made a perfect copy of one of the largest Russian machines in one year, indicating perhaps the shape of things to come.

Gill found advances in the United States rather disappointing in actual machines, and thought that new British projects such as the *Atlas* have no clear trans-Atlantic superior. In programming techniques parallel operation and time-sharing are all the rage, but enthusiasm for international machine languages like *Algol* (scientific) and *Cobol* (commercial) are somewhat on the wane. For example, no *Algol* compiler is yet working efficiently for any machine in the United States, and university research is concentrated on more general studies in the theory of computer programming. He commented on the work of Hao Wang, an Oxford mathematical logician at present in America, who on an International Business Machines computer proved 350 significant theorems in "Principia Mathematica" in 8½ min., exclusive of printing time. Wang has remarked on the great significance for mathematics of the cross-fertilization of 'inferential calculus' and computing machines. Here is certainly a fascinating field of research, needing for its success mathematicians of the highest competence and machines of a size greater than any at present installed in a British university.

Attention was directed in one of the sessions to the organization of computing centres in universities (R. Buckingham, University of London) and industrial establishments (A. Bagshaw, Ferranti). University work covers a very broad field, mainly scientific, with consequent advantages for the 'open shop' method of working, in which most users write, test, and perhaps run their own problems. This, of course, is not always possible; the 'unflappability' of the Chancellor of the University of Oxford would, one imagines, be tested severely, and unfairly, by his first few attempts at programme checking. Commercial centres have similar problems except that scientific work is beginning to be swamped by general data-processing calculations, with consequent greater economy in more operator-controlled machine running. This tendency will intensify when 'time-sharing' machines come into general use. A. Beaven (National Computer Research) had a different problem of organization, involved in the training of operators and the writing of programmes to check and correct data, derived from automatic paper-tape punches attached to accounting machines, for input to a computer, such data amounting to nearly three-quarters of a million paper-tape characters a month.

Time-sharing was put into practice when the numerical analysts, in surprisingly large numbers, discussed some new techniques for applying predictor-corrector formulæ in initial-value problems and for the iterative solution of non-linear boundary-value problems in ordinary differential equations, the determination of latent roots of matrixes when the parameter appears in non-linear form, and the behaviour of the remainder term and other aspects of Gauss-type quadrature formulæ. These papers comprised a small but fairly representative sample of current research in 'computer-oriented' numerical analysis. At the same time, the larger group studied problems of simulation in chemical plants, power stations and other works, the computer being used to make adjustments to the detailed process, using a 'mathematical model' and a statement of objectives, in order to increase efficiency and output.

On the last morning, D. Polley (Ministry of Pensions and National Insurance) and Col. L. Slater (Royal Army Pay Corps) gave accounts of respective progress in the installation of data-processing schemes for insurance records and for the payment of the military. In both cases the machinery required seemed to be substantial, with reels of magnetic tape and a 'Xeronic' printer on one hand, to cope with the processing, in a six-monthly period of each year, of thirty million tax-reduction cards, and on the other an International Business Machine 705 computer, 1,401 tabulation system and a staff of 100. Soldiers must have their pay, and one sympathizes with the problem of maintaining continuity in reimbursement and record in the process of changing from manual to automatic operation.

Finally, a small symposium (which might well have shared time with numerical analysis so that all, including myself, could have heard about simulation) discussed techniques of accounting, in wholesale and retail branch control, in 'invoicing' in general, in the paper industry in particular, and in banking. Here, it seems, the problems of programming are trivial compared with those of deciding the factors which should be taken into account (as, for example, the loss of weight in stored cheese), and of collecting all the parts into a coherent logical entity.

The organization of the meeting was good and its after-effects promising, since those who could not attend will apparently have a chance to study at more leisure at least some of the main contributions, which will be published in the *Computer Journal*. We lacked only sunshine (perhaps mercifully in the Harrogate Sun Pavilion) and, as usual, time for adequate discussion. The Pavilion was just large enough to accommodate the full audience and reception and entertainment, provided by the Mayor, and a small exhibition of computing mechanisms, models and plans, provided by the leading British manufacturers, in an atmosphere at once both sufficiently formal and intimate.

L. FOX

THE MUSEUMS ASSOCIATION

THE sixty-sixth annual conference of the Museums Association was held in the city of Stoke-on-Trent during July 4–8, by kind invitation of the Corporation and University College of North Staffordshire. Dr. W. E. Swinton, of the British Museum (Natural History), presided over some 330 delegates.

The conference was warmly welcomed at this its first visit to Stoke by the Lord Mayor, and in his presidential address Dr. Swinton dwelt on the present plight and difficulties of the museum movement. He welcomed increased grants made by the Treasury to the national museums, and the provincial museums through the scheme administered by the Victoria and Albert Museum. He also looked forward to the founding of further regional councils based on the existing prototype in the south-west of England. Dr. Swinton deplored the absence of travelling museums in rural districts, for they had been so eminently successful in the United States, and he felt convinced that they would supply a real need in Britain. Dr. Swinton, taking his text from the underground geology in the area, then discussed the injection of art and science into industry and the way in which literature and the arts had influenced the industrial life of the city.

The presidential address thus paved the way for the main discussion of the conference, which concerned itself with the relations of museums and industry, introduced by Sir Colin Anderson, Mr. Ian Cox, Mr. John Moores and Sir John Wedgwood. All speakers agreed that with the competition of television and shop displays the standard of exhibition in museums should be high and modern in outlook. It was also felt that the displays should be stimulating and give pleasure as well as instruction. Curators should study the methods of salesmanship. In the same way that no shop would freeze its windows, museums must be prepared to change their displays as often as possible. Museums, on their part, can do much to stimulate new designs and help to maintain high standards of craftsmanship.

Another important discussion concerned the purchase of art objects for museums. The speakers included Sir Anthony Blunt, Dr. Trenchard Cox, and Messrs. G. L. Conran, Terence Mullaly and Hugh Scrutton. It was generally agreed that directors should make more frequent contact with the London market, although even then purchases were to a great extent a matter of chance with either local or national opportunities. It was also stressed that rare and expensive objects should not be the desiderata of museums but they should endeavour to create an individual character.

At the annual general meeting it was decided to increase institutional members on the Council from three to six and to request nominations for these from regional organizations.

Dr. D. B. Harden (London Museum) was elected president and Mr. Phillip James was confirmed in his office as secretary. It was decided to hold the next conference at Plymouth during June 19–24, 1961.

Social functions included an informal reception at Keele Park by invitation of the University College, a reception and dance by invitation of the Lord Mayor and tours of the Arnold Bennett country, the Potteries, Kedleston and Dovedale. Official visits were also made to the local museums.

THE BRITISH STEEL CASTINGS RESEARCH ASSOCIATION

THE progressive growth of one of the youngest research associations was marked recently by the open days held during June 28–30 by the British Steel Castings Research Association at its Research Station in Sheffield. The open days were attended by 546 representatives, principally from member companies and from users of steel castings.

The opening of the Association's Research Station was noted in these columns (*Nature*, 180, 221; 1957). Within three years the Association has found it necessary to add a further 10,000 sq. ft. to its accommodation, while its staff has increased in this period from forty-nine to seventy-six. The increased accommodation has provided substantially more space in laboratories devoted to chemical analysis, metallurgy, sand testing and mechanical testing. The machine shop has been correspondingly enlarged, and new laboratories have been provided for radiography and the handling of isotopes used in investigations employing radioactive tracers and for the analysis of gases in steel. The experimental foundry has also been enlarged to the extent of 50 per cent in floor area, providing floor space for the installation of a 56-lb. vacuum melting furnace, for pilot plant studies of dust and fume collection equipment and for the study of foundry plant and equipment on a scale approximating to that of installations in production foundries. The total cost of the extensions together with the equipment installed therein has been £60,000, bringing the total cost of the Research Station to £165,000 within a period of four years. The present income of the Association is a little more than £100,000 per annum. The number of steel foundries in Great Britain is not large, and the present subscription income represents an average subscription of £1,000 a member. That the Association can maintain such a high level of subscription and has, in fact, recently increased the subscription rate by nearly 10 per cent is indicative of the importance that the industry attaches to its co-operative research.

The demonstrations of the Association's work, which were on show at the open days, illustrated very well the point that many of the problems associated with the production of steel castings are non-metallurgical in character. A large proportion of the research effort is concerned with moulding materials and with the interactions that occur at high temperatures between molten steel and the sands and other refractories from which moulds are made. One of the Association's major problems has been to evolve quantitative techniques for the measurement of such phenomena as the friability of moulding sands on drying, the erosion of moulds that occurs when molten steel flows over the surface, the penetration of molten steel into the interstices between sand grains and the 'flowability' of moulding sands, that is, the ease or difficulty with which they may be compacted in narrow pockets, etc. Techniques have been evolved for these and similar measurements; for example, it has been possible, by using a test casting in which a controlled air pressure is applied to the liquid steel, to synthesize in a casting only 15 in. high the ferrostatic head experienced at the bottom of a casting 20 ft. in height. This technique has greatly facilitated the study of the penetration of liquid steel into moulding materials.

Much attention has been given to the development of mould paints and washes, and new formulations based on the dispersion of refractory particles in alginate suspensions have been developed which produce paint films that do not crack on drying or when molten steel is poured into the mould. These are a considerable advance on commercially available washes and are being applied on an increasing scale in the foundries of the Association's members.

The engineering section of the Association devotes considerable effort to studies of plant and equipment used in foundries and is actively engaged on investigations of factors affecting the performance of moulding machines and shot-blasting equipment. Studies are also being made of both wet and dry methods for the reclamation of used foundry sand. Here the problem is to remove from sand grains the layer of dead bonding clay to enable the sand to be re-bonded for cores and moulds.

From its inception the Association has always maintained a lively interest in problems relating to industrial health in foundries. Its recent activities have included the development of an exhausted fettling bench which combines control of fine dust with a substantial reduction in noise pressure-level when castings are cleaned with pneumatic chipping hammers. These benches are now being made by two manufacturers.

Studies are also being made of atmospheric pollution from foundry steel-making furnaces, and a survey has recently been completed of the fume emission of arc furnaces varying from 30 cwt. to 80 tons capacity and from side blown ('Tropenas') converters.

The Association attaches considerable importance to liaison with its member companies, and they are regularly visited by senior members of the staff to discuss aspects of the Association's work ripe for development and also to advise on technical problems arising in production. Conferences and discussion groups are also organized both on a national and a regional basis, and during the past year an average of eight representatives per member company participated in these meetings. The Association also organizes short training courses for representatives of members on subjects such as moulding sand control, steelmaking techniques, etc. During 1961 a training course is to be organized on work simplification in foundries.

The seventh annual report of the Association has recently been published, and in presenting this to the annual general meeting on June 28, Dr. R. Hunter (Clyde Alloy Steel Co., Ltd.), the chairman of the Association's Council, invited members' attention to notable features of the report. He directed special attention to the expanded programme of liaison with industry referred to above and also to the establishment of a joint committee, the Steel Castings Development Committee, between the Research Association and the trade association, the British Steel Founders' Association. The function of this Committee is to disseminate data designed to promote the greater use of steel castings, and the Research Association has in hand a substantial programme of work for this Committee to determine properties of steel castings on which data are now lacking. A useful start has also been made in the provision of lectures and lecture material for presentation to engineering societies and engineering departments of technical colleges.

A. H. SULLY

CULTURE, SOCIETY AND HEALTH

DURING June 1–3, 1960, the Division of Anthropology of the New York Academy of Sciences and the Research Institute for the Study of Man jointly arranged a conference on culture, society and health. Among the many interesting papers was one dealing with cancer frequency and socio-cultural factors and another which examined the frequency of coronary artery disease in population groups. The study of socio-cultural factors in cancer was carried out by Walter B. Quisenberry, Division of Preventative Medicine, State Department of Health, Honolulu.

The population of Hawaii is made up of approximately 35 per cent Japanese, 23 per cent Caucasians, 18 per cent Hawaiians and part-Hawaiians, 12 per cent Filipinos, 6 per cent Chinese and 6 per cent others such as Koreans, Samoans, and Puerto Ricans.

Quisenberry's investigations showed that the incidence of stomach cancer is highest in Japanese men. There are probably many socio-cultural factors such as dietary habits which play a part in causing this. Primary cancer of the liver, however, is most frequent in Filipino men. Filipino men probably eat foods which are higher in carbohydrates and lower in protein and vitamin B_1 than those of other ethnic groups.

Filipino and Japanese men have the lowest incidence of lung cancer in Hawaii; Japanese men and Filipino men have probably smoked fewer cigarettes over the years than Caucasian men. The Caucasian breast cancer rate is five times the Japanese rate; Japanese women have been slower in giving up the nursing of children than have the Caucasians. Cancer of the large intestine is more frequent in Caucasian women than in any other ethnic groups; the diet habits and, perhaps, the bowel habits of Caucasian and Japanese women are different.

Cancer of the prostate gland is about nine times more frequent in Caucasian men than in Japanese men; the socio-cultural factors which may be responsible for this great variance in incidence of prostatic cancer may be related to differences in love-making and mating habits of the two ethnic groups. Cancer of the nasopharynx is most frequent in Chinese; it is possible that there is irritation of the nasopharynx in Chinese from hot liquids such as tea.

Cancer of the uterine cervix is most frequent among Hawaiian and part-Hawaiian women; because Hawaiians are by nature phlegmatic, the women probably do not receive as good care following pregnancies as do women of other ethnic groups. Skin cancer is most frequent among Caucasians; this is due probably more to differences in skin pigmentation than to socio-cultural factors.

Quisenberry suggests that some of the ethnic differences in the frequency of cancer may disappear with the integration of different racial groups in Hawaii. The changes may bring about either lower or higher incidences of cancer. For example, cancer of the breast seems to be increasing in Japanese women due to the stopping of nursing of children.

The study of coronary artery disease was carried out by David M. Spain of Beth El Hospital, New York, and indicates that there has been a significant increase in the incidence of coronary atherosclerotic heart disease over the past twenty-five years in the United States. The possible environmental factors associated with this increase have been evaluated in relation to the possible common denominators in the environment believed to be associated with the reported low incidence of coronary artery disease in the South African Bantu, the Eskimo and the Chinese.

The preliminary findings of factors thought to be associated with coronary atherosclerotic heart disease in a study on several thousand males of the same ethnic origins from the New York metropolitan area were presented to illustrate the complex problems involved in the validation of the significance of such data. Such questions as standards of measurement, criteria for diagnosis, body build, occupational physical activity, obesity, hypertension, serum lipids, urinary oestrogens, diet and smoking habits were analysed while the limitations of studying coronary artery disease in living population groups, as well as the fallacy of generalizing from the findings in autopsy populations, were clearly shown.

THE STRENGTH OF SOLIDS

PROF. A. H. COTTRELL in his discourse to the Royal Institution on June 15, entitled "The Strength of Solids", emphasized the importance of this subject in engineering, and also in the functioning of the bones and muscles of the human machine he distinguished between two kinds of strength—that limited by plastic yielding and that limited by fracture. The manner in which a material fails depends on the relative values of strength against such ductile or brittle failure.

Those brittle materials which have very high inter-atomic forces and which should therefore have very high strengths are nevertheless weak due to the presence of small cracks or notches which act as stress concentrations. When a relatively flawless specimen of such a material can be prepared, it is found to have a strength that approaches the theoretical value. It is not, however, practicable to make such specimens in large enough size or sufficient quantity to be of use for structural components in engineering.

The ultimate strength of a ductile material depends on the stress at which a neck begins to form in a tensile test, that is to say, on its plastic behaviour, which involves the yield stress and work-hardening characteristics. An over-hardened material will not be ductile. The plastic deformation of crystalline solids is due to the sliding of crystal layers over one another. Slip over any layer is not simultaneous, but is due to the movement of a dislocation line which separates the slipped from the unslipped portion. Ordinary solids in engineering contain many sources of dislocations so that they are intrinsically soft and ductile. The vast amount of plastic deformation permissible enables a ductile material to absorb the energy of shock loading and is a protection against fracture. Strengthening is achieved by placing obstacles in the paths of the dislocations—by alloying, heat treatment, neutron bombardment, etc. If, however, too much strengthening is given the plastic yielding strength may exceed the fracture strength and the material would become brittle.

Steel, though normally ductile, is a borderline case, low-temperatures or impact loading or a combination of these factors can cause brittle failure—a phenomenon which has led to many engineering failures.

Prof. Cottrell concluded with some remarks on fatigue failure, which is not yet fully understood. It is observed that in fatigue, plastic deformation becomes concentrated on a few slip planes, so that slip bands develop and then initiate cracks. It would appear that this is a process of local work softening.

K. J. Pascoe

RESEARCH IN CASE STUDIES

THE use of case studies in management training is well acknowledged as an important method of linking practical problems with management theory. However, as a training technique it is still unfamiliar to many people; and many who have heard about it have had no experience of it. Such was the basis and cause of a proposal by the South London Committee during the 1959–60 session to explore the methods of using case studies. This promised to bring significant benefits to members of the British Institute of Management in the South London area.

The effective use of a case-study discussion demands considerable skill on the part of the chairman if it is to have a real impact on every member of a case-study discussion group, from the vociferous to the reticent, and worth-while contributions from all are to be obtained. On account of this, the Committee felt that it should obtain guidance and training from an authoritative source. Co-operation was therefore established with Miss Avice V. Turnbull, research officer on case studies, Royal Institute of Public Administration, and special lecturer in management studies, Northampton College of Advanced Technology, London, and Mr. Z. M. T. Tarkowski, adviser on training, and special lecturer in management studies, Northampton College of Advanced Technology, London, who have done a considerable amount of work in this field.

The South London Committee convened a Case Study Group, at the meetings of which, at monthly intervals, various case studies were considered. The bulk of those so far discussed were from a series produced by Mr. Tarkowski, which give a representative sample of management situations, each in a typical British context. The way discussion went was analysed afterwards, under the leadership of Miss Turnbull.

The wisdom of selecting this approach became apparent early on in the series of meetings of the Group. Postmortems brought out the many interrelated points which have to be recognized and brought to bear on each other by the chairman. The effect of the size of the group, of a time limit, of the extent of the previous experience of the use of case studies, the attitudes of members, the need for the leader to draw members into the discussion and to encourage cross-fertilization of ideas without imposing on the group, are some of the many points which were discussed and which call for skilful leadership.

The reaction of the group depended upon the nature of the case study. If, at first sight, a specific management problem was apparent, or if the case study described a dramatic situation, such as a conflict of actual decisions taken, there was a tendency to examine the obvious problem and to suggest a satisfactory line of action which could be the next step to be taken in the situation. Where the management problems were more intangible and demanded a deeper analysis of individual characters, and of the situation, the more limited approach was replaced by a broader consideration of the personalities and the influences of the background in the work situation which caused a strained atmosphere. In fact, more than one problem can be isolated in these case studies, depending on the perception of individual members of a group. Practice in this type of analysis gave more satisfaction to the members of the Group. At the last meeting held, a case study already previously discussed was re-examined, and comparisons were made with the first discussion. These brought out the wide range of issues which can be illustrated by a single case study, and how diverse two discussions of the same case study can be.

Co-operating with Mr. Tarkowski and Miss Turnbull, several members of the Group have appeared as 'characters' in case study exercises held as part of a course at the Northampton College of Advanced Technology. The object of these exercises is to make the case studies more vivid and realistic, to bring out subtle issues of verbal communication and to give members of the group practice and experience in day-to-day interviews and conversations, which form a large proportion of a manager's work. So far as is known, no course on quite similar lines has been developed elsewhere.

The South London Committee has now arranged a week-end conference on "Research Necessary for the Preparation and Use of Case Studies : Some Recent Work and Prospects for Further Developments in Great Britain", to be held during October 7–9 at the British European Airways Staff College, East Burnham, Slough, Bucks. Further information can be obtained from A. E. Hoult, South London Branch, British Institute of Management, c/o Management House, Fetter Lane, London, E.C.2.

THE RESEARCH COUNCIL OF ALBERTA

THE fortieth annual report of the Research Council of Alberta, covering the year 1959, contains lists of advisory committees and their membership and of the staff of the Research Council besides a list of publications for the period 1955–59 (pp. v+54. Report No. 79. Edmonton: Research Council of Alberta, 1960). During the year, programmes on geology, ground-water and soils were brought together in an "Earth Sciences Branch", and work on coal, petroleum, natural gas and gasoline and oil testing in a "Fuels Branch". The ground-water studies are providing basic information on the ground-water resources of Alberta, and have offered substantial annual savings of water costs, for example, from the research on charging of water from Driedmeat Lake into a nearby gravel terrace. In surface geological mapping in the Taber area a buried Indian camp site was uncovered in the valley walls of the Oldman River, and along with Indian artefacts the skeleton of a buffalo and a willow branch were found, for which radiocarbon dating gave an age of 11,000 years. The Geological Division has developed a mineral dressing laboratory with the special purpose of investigating the possibility of refining Alberta sands. Studies of Cretaceous stratigraphy have been expanded into a co-ordinated programme, and a sub-surface study of Lower Cretaceous strata of central Alberta is in progress with the purpose of establishing the interrelations of the marine and non-marine zonations. Upper Cretaceous beds in the Peace River region have been zoned micro-faunally, and the southward marine extension of these strata is being examined for micro- and macro-faunal content.

The Coal Division is continuing an investigation of carbonization, which during the year has shown that the carbonization reaction is much faster than was thought, and the overall reaction is only slow because the coal-tar products have difficulty in working their way out of the carbonaceous residue; the overall reaction can be accelerated considerably in presence of nitric oxide. The Natural Gas Section is examining a process for recovering helium from natural gas, and the Petroleum Division discovered that mud from the bottom of a local lake contained completely developed petroleum pigments along with traces of other oil materials. Pilot plant experiments were extended to work on a concentric flow of heavy oil and water mixtures in a 1,000-ft. experimental pipe-line, which showed that injection of about 30 per cent of water gave a pressure drop of up to about 75 per cent. The Industrial Engineering Services Group has made good progress in studies on carburation to permit the satisfactory use of propene and butane as engine fuels. Studies have been commenced on the effects of various solvents on plastic pipes, and a 500-ft. length of buried pipe carrying natural gas is now being observed under actual operating conditions.

Satisfactory progress is also reported in the highway research programme. The co-operative cloud physics and hail research programme is now in its fourth year, and the results should indicate whether Alberta hail is generally similar to that studied in Europe or whether there are significant differences in structure. The special weather-radar continues to give much information on the cloud systems moving through the area, and a meso-network of some thirty microbarographs has now been arranged at intervals of about 10 miles. Preliminary results from the study of nucleation represent a major advance in the basic approach to the hail problem, and following the study of nucleation commenced last year at McGill University, the work was continued during the summer with the project group at Penhold, where a method of determining the amount of 'freezing nuclei' in rain-water, or water obtained from melted hailstones, was applied.

ROTHAMSTED EXPERIMENTAL STATION

F. C. BAWDEN, whose style of writing could profitably be copied by directors of other research institutes, states in his annual report for 1959 of the Rothamsted Experimental Station* that the ultimate aim of agricultural research must be to increase the efficiency of agriculture by lowering unit costs of production and improving the quality of the produce. The very wide range of activities described in this report offers scope for assessing the contribution of Rothamsted towards this goal. Whether this aim will be better served by the empirical approach of much of the work reported, or by the establishment of general principles formulated on research of a more fundamental nature, is obviously a question which must exercise the mind of any good scientific leader. Perhaps the best compromise is to encourage developments along both lines, the correct allocation of resources depending on many factors.

There is no question that the work on the use of fertilizers, irrigation, and the control of weeds, pests and diseases has the immediate practical aim of increasing agricultural efficiency; but there is plenty of evidence throughout this report of more academic inquiries covering such varied matters as the underground activities of organisms as diverse as slugs, earthworms, fungi, nitrogen-fixing bacteria and an eel-worm that transmits a soil-borne virus; the internal structure of viruses and the relative infectivity of intact virus particles and their separated nucleic acids; the activities of enzymes in insects, bacteria and leaves; the biology of weeds and the relation between the potassium supply of soils and the nature of the clay minerals.

In the Chemistry Department, where work on fertilizers has always loomed large and has been responsible in no small measure for the present high efficiency of arable crop production in Great Britain, much basic work is now proceeding on soil organic matter, nitrogen, phosphorus and potassium. It might fairly be said that soil fertility studies at Rothamsted have suffered in the past from the 'NPK' (nitrogen–phosphorus–potassium) complex; but attention is now being directed towards other elements such as magnesium and molybdenum. Judged by the increasing incidence of hypomagnesemia in farm animals, this interest is timely or even late, and if the work on micronutrients merely indicates that deficiencies of such elements are likely to be rare in Britain, it will serve its purpose.

Biochemistry increasingly emerges as the central discipline in agricultural research; and its impact can be seen in many departments ranging through soil chemistry, botany, pathology, insecticides and fungicides. In the Biochemistry Department itself, work is concentrated on plant enzyme systems, but there is some collaborative work with the Nematology Department on eel-worm hatching factors. One wonders whether the work on the extraction of protein from leaves has not now served its valuable purpose and should be handed over for large-scale development to industry and governments in countries where malnutrition is still a serious problem.

Russian claims that inoculation of soil with *Azotobacter* increases crop yields have been treated with scepticism in the Western world. None too soon, these reports are being properly investigated by the Soil Microbiology Department, and under some conditions, at present ill-defined, inoculation has increased yields significantly.

One of the dangers when a research station reaches the size of Rothamsted is that each department may work on isolated problems when more progress is likely to be made, particularly in biological research, by inter-departmental co-operation. There is disappointingly little evidence of this collaboration where it might be most valuable, for example, between the Chemistry Department, Pedology Department and the Soil Survey of England and Wales. That such co-operation is possible and fruitful is evidenced by the work of the Macaulay Institute in Scotland. On the other hand, it is pleasing to see the Botany Department is studying the effect of soil-water deficit on plant growth, clearly complementing the work in soil physics, where the study of agricultural meteorology, which has already had a notable effect on the practice of irrigation, is being extended into the field of micro-meteorology.

There is an encouraging sign of collaboration in the report of the Entomology Department. Changes in soil fauna brought about by long-term bare-fallowing are being studied, and at the same time other departments will study changes in soil organic matter, microflora, physical properties, organisms causing crop diseases, nematode populations, and the survival of weed seeds. Perhaps this will be the forerunner of other co-operative work, and for a start one might suggest similar studies when land is put down to grass. After all, grass is still the most important crop of Britain, and unless the Agricultural Research Council objects to duplication of effort, it would be stimulating to see Rothamsted paying more attention to grassland soils and some of the problems of herbage production.

T. W. WALKER

* Lawes Agricultural Trust. Report of the Rothamsted Experimental Station for 1959. Pp. 288. (Harpenden: Rothamsted Experimental Station, 1960.) 10*s*.

CONVERSION OF CYCLOPENTADIENE INTO NEW BICYCLOPENTYL DERIVATIVES

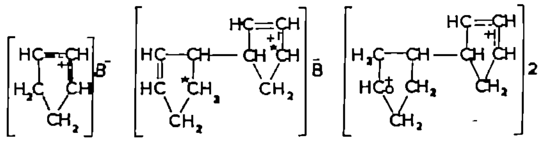
Structure Determination with the Help of Proton Magnetic Resonance Spectroscopy

Diels–Alder diene associations, including the dimerization of cyclopentadiene, are susceptible to trichloroacetic acid catalysis[1], with carbonium ions as intermediates[2]. The catalysed formation of endo-dicyclopentadiene, $C_{10}H_{12}$, was studied at acid concentrations up to 0·16 *M* (25°). It has now been found that at higher acid concentration, for example, 0·5 *M*, cyclopentadiene is almost quantitatively converted into a trichloroacetic acid ester (I). $C_{12}H_{13}O_2Cl_3$, n_D^{25} 1·5085, λ_{max} (ethanol) 242 mμ; ε_{max} 800 l./mol.-cm. This ester polymerizes so quickly on heating that it cannot be distilled, but purification by fractional thawing is possible. Alkaline hydrolysis produces an alcohol (II), $C_{10}H_{14}O$, b.p. 84–86°/0·2 mm., n_D^{25} 1·5105, λ_{max} (ethanol) 243 mμ, ε_{max} 400 l./mol.-cm., 3,5-dinitrobenzoyl ester m.p. 112–113°, phenyl urethane m.p. 64–65°. Bromination and hydrogenation established the presence of two double bonds in ester (I) and alcohol (II); the double bonds must be conjugated because of the specified position of the λ_{max} values.

There is no carbonyl frequency in the infra-red adsorption spectrum of alcohol (II), which excludes the possibility of hydroxyl being attached to unsaturated carbon. Hydrogenation of alcohol (II) produced a saturated alcohol (III), $C_{10}H_{18}O$, b.p. 95°/0·5 mm., n_D^{25} 1·4844, 3,5-dinitrobenzoyl ester m.p. 79–82°, phenyl urethane m.p. 88–92°, acid phthalate m.p. 80–82°, which was dehydrated to hydrocarbons $C_{10}H_{16}$, b.p. 112–115°/100 mm., n_D^{25} 1·4796, the infra-red absorption spectrum of which was very similar to that of a mixture of cyclopentyl–cyclopentenes, prepared according to v. Braun and collaborators[3].

Hydrogenation of both hydrocarbons gave bicyclopentyl $C_{10}H_{18}$, which proves that the alcohols (III) and (II) and ester (I) are bicyclopentyl derivatives. Alcohol (III) was oxidized to a ketone, $C_{10}H_{16}O$, b.p. 74–75°/1·3 mm., n_D^{25} 1·4743, 2,4-dinitrophenylhydrazone m.p. 129–131°, semicarbazone m.p. 197–198°, which was not identical with the well-known 2-cyclopentyl-cyclopentanone. Thus, the hydroxy-group of alcohols (III) or (II) cannot be attached to a carbon atom in juxtaposition to the junction points of the two five-membered rings. The proton magnetic resonance spectrum of pure liquid alcohol (II) is characterized by peaks *A*, *B*, *C* and *D* at − 0·82, − 0·05, 0·18 and 2·72 parts per million (p.p.m.). These chemical shifts (which are defined by the dimensionless number $[H_s - H_r/H_r] \times 10^6$ when H_s and H_r are the resonance fields of sample and reference (water)) are assigned as follows: *A* corresponds to hydrogen on unsaturated carbon, *B* to hydroxyl hydrogen, *C* to hydrogen bound together with hydroxyl to saturated carbon and *D* to the other hydrogens on saturated carbon. The assignment is consistent with the proton magnetic resonance spectra of alcohol (III) and cyclopentanol and with the relative peak positions in the pure liquid state and in carbon tetrachloride solution. Peak area measurements showed that four hydrogens must be attached to unsaturated carbon. An investigation of the proton magnetic resonance spectra of ester (I) and of the trichloroacetic acid esters of alcohol (III), cyclopentanol and ethanol lead to similar conclusions.

All the observations taken together prove that alcohol (II) is 3-(cyclopenta-2′,4′-dienyl)-cyclopentanol.



I I′ I″

The new bicyclopentyl derivatives can be converted thermally and catalytically into polymers of unusual properties, which will be described elsewhere.

C. F. Blakely
R. J. Gillespie
L. Roubinek
A. Wassermann
R. F. M. White

---

[1] Wassermann, *J. Chem. Soc.*, 618 (1942).

[2] Rubin, Steiner and Wassermann, *J. Chem. Soc.*, 3046 (1949).

[3] v. Braun, Kamp and Kopp, *Ber.*, 70, 1756 (1937). Vapour phase chromatography showed that the 'cyclopentyl–cyclopentene' of these authors is a mixture of isomers.

Kinetics and Mechanism

The rate, R_{ester}, of the trichloroacetic-catalysed reaction, 2-cyclopentadiene + trichloroacetic acid → trichloroacetic acid ester of 3-(cyclo-2′,4′-dienyl)-cyclopentanol (see previous communication), (ester (I)), has been measured. The results can be summarized by:

$$R_{ester} = k_{ester}[\text{cyclopentadiene}]\,[\text{trichloroacetic acid}]^2 \qquad (1)$$

where k_{ester} is $10^{4\cdot3}\exp(-9900/RT)(\text{l./mole})^2\ \text{sec.}^{-1}$ in carbon tetrachloride and $10^{4\cdot4}\exp(-9700/RT)$ $(\text{l./mole})^2\ \text{sec.}^{-1}$ in benzene. It has been shown before[1] that the rate, R_{dimer}, of the trichloroacetic acid catalysed dimerization, 2 cyclopentadiene → endo-dicyclopentadiene, is given by:

$$R_{dimer} = k_{dimer}[\text{cyclopentadiene}][\text{trichloroacetic acid}] \qquad (2)$$

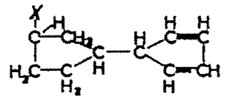
Using k_{ester} and k_{dimer}, relating to 25° and carbon tetrachloride, the ratios R_{dimer}/R_{ester} are 4·4 ± 0·8 and 0 022 ± 0 004 according to whether the trichloroacetic acid concentration is 0·0050 or 1·0 *M*. It is understandable, therefore, why the preparative isolation of ester (I) is only possible if the trichloroacetic acid concentration is sufficiently high (see previous communication).

Rate expression (1), the influence of polar aprotic solvents (nitrobenzene and nitromethane), which increase R_{ester}, and of proton acceptors (water, ethanol, acetone dioxan) which act as retarders, are compatible with a mechanism represented by:

$$M + HB \underset{k'_1}{\overset{k_1}{\rightleftharpoons}} i;\ i + M \underset{k'_2}{\overset{k_2}{\rightleftharpoons}} i';\ i' \underset{k'_3}{\overset{k_3}{\rightleftharpoons}} \text{endo-dicyclopentadiene}$$

$$i' + HB \underset{k'_4}{\overset{k_4}{\rightleftharpoons}} i'';\ i'' \underset{k'_5}{\overset{k_5}{\rightleftharpoons}} \text{ester (I)} + HB$$

In these equations M is cyclopentadiene, HB is trichloroacetic acid, i and i' are singly charged ion pairs $\overset{+}{C}_5H_7 \ldots \bar{B}$ and $\overset{+}{C}_{10}H_{13} \ldots \bar{B}$ and i'' is a doubly charged ion pair $\overset{++}{C}_{10}H_{14} \ldots 2\bar{B}$ (B = trichloroacetate). Application of the stationary state approximation and assuming that $k_1M[HB] \gg k'_1 i'$; $k_2 iM \gg k'_4 i'' + k'_3$ [dimer]; $k_3 \gg k'_2$ or $k_4[HB]$; $k_4 i' \gg k'_5$[ester (I)]; $k_2M \gg k'_1$ leads to (1) with $k_{\text{ester}} = k_1k_4k_5/(k_4' + k_5)k_3$ and to (2) with $k_{\text{dimer}} = k_1$. We suggest the following formulæ for i, i' and i''.



alcohol (II): $X = OH$

ester (I): $X = C_2O_2Cl_3$

Conversion of i' into endo-dicyclopentadiene and of i'' into ester (I) involves removal of one HB; in the former case a C–C bond is formed between the carbon atoms indicated by asterisks, while in the latter case combination of one B^- occurs with the carbon atom indicated by a circle.

It has been shown (unpublished experiments) that the interaction of endo-dicyclopentadiene and trichloroacetic acid leads predominantly to the trichloroacetic acid ester (II′) of exo-hydroxydihydrodicyclopentadiene, rather than to ester (I). Thus the velocity coefficient, k_6, of the reaction endo-dicyclopentadiene + trichloroacetic acid $\xrightarrow{k_6}$ ester (II′) is probably large compared to k'_5.

C. F. BLAKELY
A. WASSERMANN

Department of Chemistry,
University College,
London, W.C.1.

---

[1] Rubin, Steiner and Wassermann, *J. Chem. Soc.*, 3046 (1949).

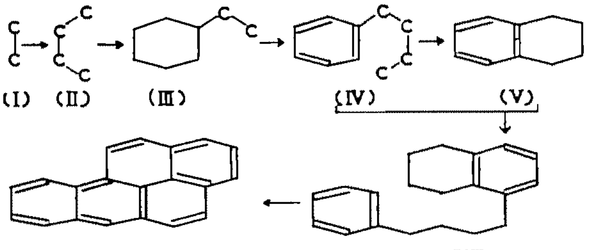
MODE OF FORMATION OF 3,4-BENZOPYRENE IN HUMAN ENVIRONMENT

By PROF. G. M. BADGER, R. W. L. KIMBER and T. M. SPOTSWOOD
University of Adelaide, South Australia

SOOT, coal tar, shale oil and some petroleums have long been recognized as the probable cause of certain 'industrial cancers', particularly cancers of the skin. Yamagiwa and Ichikawa[1] demonstrated experimentally that coal tar has cancer-producing activity in laboratory animals, and a pure carcinogenic hydrocarbon, 3,4-benzopyrene (VII), was isolated from coal-tar pitch in 1933[2]. The same hydrocarbon has since been identified in soot[3] and in shale oil[4]. 3,4-Benzopyrene may be chiefly responsible for the cancers caused by soot, coal tar and shale oil; but other carcinogenic hydrocarbons, notably 3,4 : 8,9-dibenzopyrene, 3,4 : 9,10-dibenzopyrene and 3,4-benzofluoranthene have since been identified in coal tar[5].

In recent years 3,4-benzopyrene and other polycyclic aromatic hydrocarbons have been identified in carbon blacks[6], in processed rubber[7], in atmospheric dust[8], in the exhaust gases of petrol and diesel engines[9], in coal gas[10], in coffee soots[11], in human hair wax[12], in oysters and barnacles taken from polluted water[13], in Icelandic smoked food and in the soot from a smoked sausage factory[14], in snuff[15], in tobacco[16] and in cigarette and tobacco smoke[17]. This widespread occurrence of 3,4-benzopyrene in human environment suggests that this hydrocarbon may be implicated in the causation of some cancers in addition to those of industrial origin. The mode of formation of 3,4-benzopyrene therefore seems to be of importance.

The carcinogenic hydrocarbons which occur in human environment seem to be formed only at high temperatures, that is, by reactions under pyrolytic conditions[18]. Several plausible mechanisms for the formation of 3,4-benzopyrene can be postulated, notably the addition of a two-carbon unit to chrysene or to 1,2-benzanthracene, or of a four-carbon unit to pyrene. As a working hypothesis, however, it was suggested[18] that 3,4-benzopyrene may be formed from simple units by a step-wise synthesis, as in (I) → (VII). Possible intermediate compounds would be ethylene or acetylene (for I), butadiene or vinylacetylene (for II), styrene or ethylbenzene (for III), and phenylbutadiene, *n*-butylbenzene or tetralin (for IV and V).



(I) (II) (III) (IV) (V) (VII) (VI)

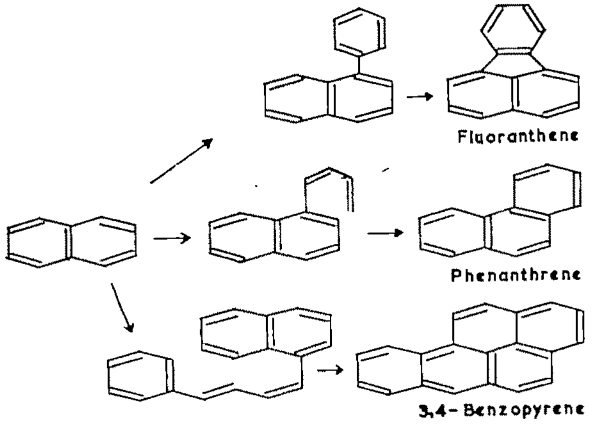
In his classical experiments, Berthelot[19] showed that when acetylene is heated it gives a tar containing benzene and other aromatic hydrocarbons; and Kennaway[20] later showed that tar prepared by passing acetylene and hydrogen through a tube at 700° has powerful cancer-producing properties. It has now been found that tar produced by the pyrolysis of acetylene contains 2 per cent 3,4-benzopyrene[21].

The incomplete combustion of organic compounds often gives some acetylene[22], and acetylene has been detected in tobacco smoke[23]. Nevertheless it seems unnecessary to postulate that the pyrolysis of substances giving benzopyrene invariably proceeds by initial cracking to a two-carbon unit, followed by re-synthesis. Indeed, it seems more reasonable to suppose that the formation of benzopyrene from dicetyl[24] and from aliphatic tobacco hydrocarbons[25], for example, proceeds by initial cracking to a C_{16} unit, which afterwards gives a C_6–C_4 unit (IV, V), and that two such units then give the key intermediate (VI).

The participation of an intermediate such as (VI) in the formation of benzopyrene has some experimental support. When tetralin is treated with aluminium chloride it gives a complex mixture ('Schroeter tar')[26] which becomes carcinogenic on heating[27], and which has now been shown to contain 3,4-benzopyrene[28]. 6-4′-Phenylbutyltetralin is a major constituent of this mixture; some 5-4′-phenylbutyltetralin (VI) would also be expected, and, although none could be isolated[28], its absence may be due to its too ready conversion into the 3,4-benzopyrene actually isolated. Attempts to synthesize 5-4′-phenylbutyltetralin (VI) have so far been unsuccessful; but the related 1-4′-phenylbutylnaphthalene has been shown to give some 3,4-benzopyrene (albeit in small yield) on pyrolysis[29].

In order to test the hypothesis further, several possible intermediate compounds (butadiene[30], styrene[31], ethylbenzene[29], phenylbutadiene[32], *n*-butylbenzene[29] and tetralin[33]), have been pyrolysed at 700° and the resulting tars analysed. 3,4-Benzopyrene has been identified in each case, but the amount formed varied from compound to compound. Moreover, other compounds (toluene[29], *n*-propylbenzene[29] and indene[34]), which are not direct intermediates in the scheme (I) → (VII), were also found to give some benzopyrene on pyrolysis. However, it may be significant that of the simple alkylbenzenes the one having a C_6–C_4 structure (IV), namely, *n*-butylbenzene, gave the greatest quantity of 3,4-benzopyrene[29].

In each case it has been possible to predict which bonds must have the lowest bond dissociation energies, and will therefore be most likely to break (at the high temperature involved) to yield free radicals. The observed products can then be accounted for by secondary reactions involving these initial or primary radicals. In the pyrolysis of phenylbutadiene[32], for example, phenyl-, butadienyl- and phenylbutadienyl-radicals must be important initial radicals; and naphthalene is an important product of this pyrolysis. The presence of fluoranthene, phenanthrene, and of 3,4-benzopyrene in this tar can then be accounted for by attack of the radicals mentioned on naphthalene, followed by cyclodehydrogenation.



In the same way the alkylbenzenes must undergo primary fission to radicals such as $C_6H_5\cdot$, $C_6H_5CH_2\cdot$, $CH_3CH_2\cdot$, etc., and the products can be accounted for by secondary reactions involving these radicals. Chain re-synthesis must proceed to an appreciable extent, for naphthalene is present in all the tars, and this must be formed from a C_6–C_4 unit. The probable mechanism of chain re-synthesis may be illustrated by the following:

$$\begin{aligned} &Ph\cdot + CH_2 = CH_2 && \rightarrow PhCH_2CH_2\cdot \\ &PhCH_2\cdot + CH_2 = CH_2 && \rightarrow PhCH_2CH_2CH_2\cdot \\ &Ph\cdot + CH_2 = CHCH = CH_2 && \rightarrow PhCH_2CH = CHCH_2\cdot \end{aligned}$$

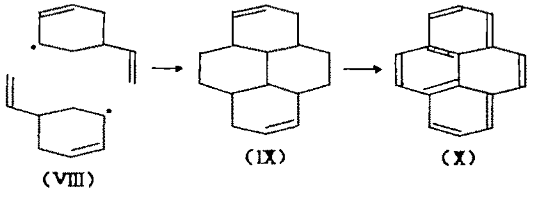
A detailed examination of the results (Table 1) leads to the conclusion that the formation of 3,4-benzopyrene from chrysene or 1,2-benzanthracene by reaction with a C_2 unit can be discounted on the basis of the wide variations in the relative yields of these compounds. The pyrolysis of indene[34], for example, yields little 3,4-benzopyrene, although the yield of chrysene is high and ethylene is present in the exit gases.

Table 1. YIELDS OF 1,2-BENZANTHRACENE, CHRYSENE, PYRENE AND 3,4-BENZOPYRENE IN PYROLYTIC TARS

Hydrocarbon pyrolysed	1,2-Benzanthracene	Chrysene	Pyrene	3,4-Benzopyrene
Acetylene	0·4	0·5	6·5	2
Butadiene	0·31	0·39	1·0	0·34
Toluene	0·014	0·03	det.	0·002
Styrene*	—	c. 2·2	c. 1·9	0·02
Ethylbenzene	0·46	0·55	0·33	0·065
Propylbenzene	0·62	0·96	0·21	0·17
Indene	4·6	31·7	0·10	0·003
Butylbenzene	1·19	1·82	2·0	0·92
Phenylbutadiene	0·89	1·33	—	0·12
Tetralin	2·6	3·43	0·008	0·17

* This analysis was carried out before the development of the technique of chromatography on acetylated paper. The results are therefore not strictly comparable.

On the other hand, it seems that reaction of a C_4 unit (such as butadiene) with a pyrene intermediate may be an important route to 3,4-benzopyrene, in addition to that represented by (I) → (VII). Thus although the pyrene/3,4-benzopyrene ratio is very low for tetralin tar, it is relatively high for most of the other compounds examined. The variation is best explained by assuming that both mechanisms operate to a varying degree depending on the nature of the compound pyrolysed. With the exception of the tetralin tar, in which the benzopyrene may be formed almost exclusively by the route (I) → (VII), it will be noted that tars having high yields of 3,4-benzopyrene also have high yields of pyrene (for example, acetylene, butadiene, *n*-butylbenzene) and tars having low yields of 3,4-benzopyrene have low yields of pyrene (for example, indene).



A suitable pyrene intermediate could be formed as follows. Dimerization of butadiene gives vinylcyclohexene, and two vinylcyclohexene radicals (VIII) could give a hydropyrene (IX). Dehydrogenation of this would give pyrene (X); but addition of another molecule of butadiene followed by dehydrogenation would give 3,4-benzopyrene.

This work has been supported by the Damon Runyon Memorial Fund for Cancer Research Inc., to whom we express our thanks.

[1] Yamagiwa, K., and Ichikawa, K., *J. Cancer Res.*, 3, 1 (1918); *Mitt. Med. Fak. Tokio*, 15, 295 (1915).

[2] Cook, J. W., Hewett, C. L., and Hieger, I., *J. Chem. Soc.*, 395 (1933).

[3] Goulden, F., and Tipler, M. M., *Brit. J. Cancer*, 3, 157 (1949). Passey, R. D., *Brit. Med. J.*, ii, 1112 (1922).

[4] Berenblum, I., and Schoental, R., *Brit. J. Exp. Path.*, 24, 232 (1943).

[5] Buu-Hoi, Ng. Ph., *Nature*, 182, 1158 (1958). Schoental, R., *Nature*, 180, 606 (1957). Wynder, E. L., unpublished; quoted by Lyons, M. J., *Brit. J. Cancer*, 13, 126 (1959). Kotin, P., and Falk, H. L., *Cancer*, 12, 147 (1959). Kruber, O., and Oberkobusch, R., *Chem. Ber.*, 85, 433 (1952).

[6] Falk, H. L., and Steiner, P. E., *Cancer Res.*, 12, 30 (1952). von Haam, E., and Mallette, F. S., *Arch. Indust. Hyg.*, 6, 237 (1952).

[7] Falk, H. L., Steiner, P. E., Goldfein, S., Breslow, A., and Hykes, R., *Cancer Res.*, 11, 318 (1951).

[8] Cooper, R. L., *Chem. and Indust.*, 1364 (1953). Cooper, R. L., and Lindsey, A. J., *ibid.*, 1177, 1260 (1953). Clemo, G. R., *ibid.*, 957 (1953); 38 (1955). Waller, R. E., *Brit. J. Cancer*, 6, 8 (1952). Leiter, J., Shimkin, M. B., and Shear, M. J., *J. Nat. Cancer Inst.*, 3, 155 (1942). Shore, V. C., and Katz, M., *Analyt. Chem.*, 28, 1399 (1956).

[9] Kotin, P., *Cancer Res.*, 16, 375 (1956).

[10] Gilbert, J. A. S., and Lindsey, A. J., *Chem. and Indust.*, 927 (1956).

[11] Kuratsune, M., and Hueper, W. C., *J. Nat. Cancer Inst.*, 20, 37 (1958).

[12] Hougen, F. W., *Chem. and Indust.*, 192 (1954).

[13] Cahnmann, H. J., and Kuratsune, M., *Analyt. Chem.*, 29, 1312 (1957). Koe, B. K., and Zechmeister, L., *Arch. Biochem. Biophys.*, 41, 236 (1952).

[14] Sulman, E., and Sulman, F., *Cancer Res.*, 6, 366 (1946). Berankova, Z., and Sula, J., *Casopis Lekaru Ceskych*, 92, 195 (1953); *Chem. Abs.*, 49, 592 (1955). Bailey, E. J., and Dungal, N., *Brit. J. Cancer*, 12, 348 (1958).

[15] Campbell, J. M., and Lindsey, A. J., *Chem. and Indust.*, 64 (1955); 951 (1957).

[16] Campbell, J. M., and Lindsey, A. J., *Brit. J. Cancer*, 10, 649 (1956).

[17] Cooper, R. L., Lindsey, A. J., and Waller, R. E., *Chem. and Indust.*, 1305 (1953); 1418 (1954). Gilbert, J. A. S., and Lindsey, A. J., *Brit. J. Cancer*, 10, 642 (1956). Bonnet, J., and Neukomm, S., *Helv. Chim. Acta*, 39, 1724 (1956). Patton, H. W., and Touey, G. P., *Analyt. Chem.*, 28, 1685 (1956). Philippe, R. J., and Hobbs, M. E., *ibid.*, 28, 2002 (1956). Gilbert, J. A. S., and Lindsey, A. J., *Brit. J. Cancer*, 10, 646 (1956).

[18] Badger, G. M., Buttery, R. G., Kimber, R. W. L., Lewis, G. E., Moritz, A. G., and Napier, I. M., *J. Chem. Soc.*, 2449 (1958).

[19] Berthelot, M., *Ann. Chim.*, 9, 445 (1866).

[20] Kennaway, E. L., *Brit. Med. J.*, ii, 1 (1925).

[21] Badger, G. M., Lewis, G. E., and Napier, I. M., *J. Chem. Soc.* (in the press).

[22] Nieuwland, J. A., and Vogt, R. R., "The Chemistry of Acetylene" (Reinhold, New York, 1945).

[23] Fishel, J. B., and Haskins, J. F., *Indust. Eng. Chem.*, 41, 1374 (1949).

[24] Lam, J., *Acta Path. Microbiol. Scand.*, 39, 198 (1956).

[25] Lam, J., *Acta Path. Microbiol. Scand.*, 37, 421 (1955); 39, 207 (1956).

[26] Schroeter, G., *Ber.*, 57, 1990 (1924).

[27] Kennaway, E. L., *Biochem. J.*, 24, 497 (1930). Hieger, I., *ibid.*, 24, 505 (1930).

[28] Badger, G. M., and Kimber, R. W. L., *J. Chem. Soc.*, 2453 (1958).

[29] Badger, G. M., and Kimber, R. W. L., *J. Chem. Soc.*, 2455 (1958).

[30] Badger, G. M., and Spotswood, T. M. (unpublished work).

[31] Badger, G. M., and Buttery, R. G., *J. Chem. Soc.*, 2458 (1958).

[32] Badger, G. M., and Spotswood, T. M., *J. Chem. Soc.*, 1685 (1959).

[33] Badger, G. M., and Kimber, R. W. L., *J. Chem. Soc.* (in the press).

[34] Badger, G. M., and Kimber, R. W. L., *J. Chem. Soc.* (in the press).

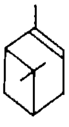
RADIOLYSIS OF TERPENE HYDROCARBONS: ISOMERIZATION AND POLYMERIZATION OF α- AND β-PINENE

By T. H. BATES and DR. T. FFRANCON WILLIAMS

Chemistry Division, Atomic Energy Research Establishment, Harwell

CERTAIN molecular rearrangements characteristic of reactions undergone by mono-terpenoids offer varied examples of processes occurring by carbonium ion mechanisms[1]. In view of recent interest[2-4] in the possibility that reactions induced by ionizing radiation in some organic systems occur in part by ionic species, it seems pertinent to describe some investigations on the radiolysis of α- and β-pinene. All the irradiations have been carried out using cobalt-60 gamma-rays on liquid samples of high purity *in vacuo*.

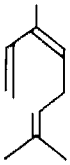
α-Pinene,



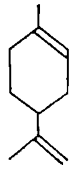
The products of irradiation at the ambient temperature of the source (about 30° C.) consist of hydrogen, isomers of α-pinene, and a low molecular weight ($\overline{M}_n = 428 \pm 9$) polymer corresponding to the average formation of a trimer. Products of molecular weight intermediate between hydrogen and C_{10} compounds are only formed in minute amounts by comparison with the above, as revealed by gas-liquid chromatographic analysis. Yields of hydrogen and polymer, the latter expressed in terms of monomer disappearance, are 0·56 and 5·0 molecules per 100 eV. respectively; the latter yield can only be considered approximate because of the difficulty of removing the last traces of solvent from the polymer.

Isomerization has been studied in detail by gas-liquid chromatography of the irradiated liquid using poly-propylene sebacate as a stationary phase at 90° C.; in this manner it was possible to analyse for concentrations of isomers lower than 0·1 per cent in the α-pinene. The identification of the individual isomers was accomplished by the collection of appropriate fractions on elution from the column and, after further purification, by examination of the infra-red and ultra-violet spectra of the isolated components. By these procedures,

ocimene

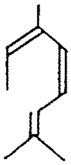


and dipentene



have been identified as the two main isomeric products with initial 100 eV. yields (*G* values) of 2·2 and 0·9 respectively. The rate of growth of ocimene concentration decreases with increasing irradiation dose, and there is evidence of the formation of

allo-ocimene



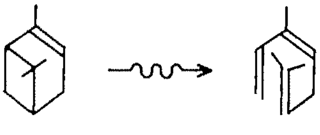
on prolonged irradiation exposure, presumably by further isomerization of the primarily formed ocimene. By contrast, the formation of dipentene is linear with dose up to a concentration of 1·0 per cent in the α-pinene.

Other isomerization or rearrangement products of similar molecular weight are formed in lower yields of which by far the most abundant ($G = 0·6$) is a compound '*X*' with a chromatographic retention time slightly less than that of dipentene, but we have not yet succeeded in identifying its structure; it can be stated, however, that it does not contain terminal group unsaturation (vinyl or vinylidene) and its ultra-violet spectrum does not exhibit evidence of extensive conjugation.

The irradiation of α-pinene at − 196° C. gives *G* values for the formation of ocimene, dipentene and '*X*' equal to 0·8, 1·3 and 0·3 respectively; thus in the solid state the isomerization proceeds more readily to dipentene but is appreciably less facile in favour of ocimene.

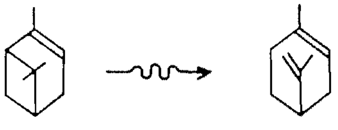
It is of related interest that the formation of ocimene, dipentene and allo-ocimene have been observed by Hawkins *et al.*[7] in the vapour phase thermal isomerization of α-pinene using short contact times on an electrically heated element. In the liquid phase it has also been shown[8,9] that the pyrolysis of α-pinene at temperatures exceeding 200° C. leads to the formation of α- and β-pyronenes by the cyclization of allo-ocimene, the latter being itself formed from the initial production of ocimene in the system. By contrast it has been found[10,11] that the homogeneous acid-catalysed isomerization of α-pinene gives mainly monocyclic terpenes, including dipentene, whereas the heterogeneous acid reaction on activated clays gives predominantly camphene; ocimene formation has not been reported under acidic conditions.

An interpretation of the radiolysis results to allow for ocimene production would be the unimolecular rearrangement of either electronically or vibrationally excited α-pinene molecules by the splitting of the *cyclo*butane ring without the intermediate secession of atomic hydrogen or free radicals; this process can be considered analogous to the mechanism of the thermal decomposition of *cyclo*butane to give two molecules of ethylene[12]. The excited molecules could arise in radiolysis either by direct excitation or by neutralization of the initially created positive ion; it is also feasible that the excited ion undergoes rearrangement to the ocimene structure before neutralization.

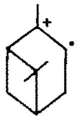

(1)

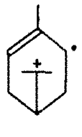
The lower yield of ocimene at − 196° C. relative to room temperature may not be solely due to the increased energy barrier to the isomerization at the lower temperature. Even allowing for the maximum $3n-6$ degrees of vibrational freedom, the energy difference per molecule between − 196° C. and 30° C. would not exceed 1·5 eV., whereas it has been calculated[13] from the Bethe theory that the average energy imparted by fast charged particles to a medium of hydrogen-like atoms is about 5 eV. per direct excitation. A calculation of the activation energy for the first-order thermal decomposition of α-pinene to ocimene and other products from the data given by Hunt and Hawkins[14] gives a value of 37·7 k.cal./mole or 1·6 eV./molecule. It is likely, therefore, that the frequency factor for the rearrangement reaction (1) is adversely affected by the steric confinements of the solid state at low temperature.

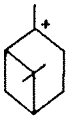
The process of dipentene formation is the result of a scission reaction at the gem-dimethyl substituted carbon atom in the *cyclo*butane ring; it can be represented formally as the transfer of a hydrogen atom from one of the methyl groups to the carbon atom at which the *cyclo*butane ring is severed leaving behind an *iso*propenyl group attached at the 4-position in the *cyclo*hexane ring.

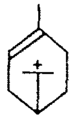

(2)

Before proceeding with a more detailed consideration of reaction (2) it is necessary to digress on the nature of the positive ion likely to be formed on irradiation of α-pinene. Chang, Yang and Wagner[5] have suggested that the molecular ion primarily formed on radiolysis of olefin systems is the radical ion produced by localization of the positive charge at the unsaturated carbon atoms; thus for α-pinene it would be represented by I.


I


II


III

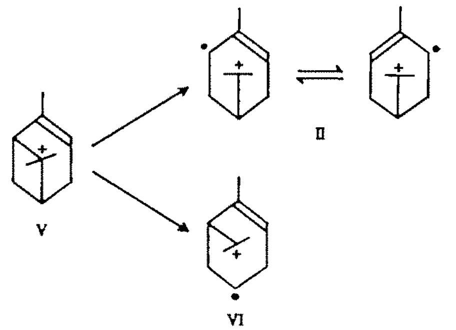

IV

On the basis of the well-understood preferential rearrangement[1] of the carbonium ion III (as produced by proton addition to α-pinene) to the form shown in IV, it can be argued that I would rapidly rearrange to the analogous form shown in II. The mass spectral pattern for α-pinene (A.P.I. Research Project 44, Serial No. 465) reveals that less than 5 per cent of the parent ion is detected, and the most abundant ion is of mass 93, which corresponds to the removal of the $(CH_3)_2C\langle$ group and a hydrogen atom from the parent. However, in the rarefied conditions of a mass spectrometer chamber and because of the relatively large time-interval before detection (10^{-5} sec.), the initial ion is much more prone to extensive decomposition by endothermic step-wise fragmentation than in the liquid phase; in the latter case it is suggested that the more relaxed conditions prevent the further decomposition of the rearranged ion II prior to the eventual neutralization process which has been estimated for some liquid systems to occur in 10^{-12}–10^{-13} sec. (ref. 15). A similar conclusion can be reached as to the likely nature of the positive ion species by comparison with mass spectral findings for alkanes containing quaternary substituted carbon atoms. As an example, the parent ion for neo-pentane is almost non-existent (about 0·01 per cent) in the mass pattern and the main peak is due to the tert-butyl carbonium ion, $C_4H_9^+$. In explanation, Field and Franklin[16] have calculated that the decomposition of the parent ion according to (3) is almost thermoneutral whereas an alternative mode of dissociation given by (4) is 72 k.cal./mole endothermic.

$$\text{neo} - C_5H_{12}^{+} \rightarrow t - C_4H_9^{+} + CH_3^{\cdot} \qquad (3)$$

$$\text{neo} - C_5H_{12}^{+} \rightarrow t - C_4H_9^{\cdot} + CH_3^{+} \qquad (4)$$

An ion dissociation process of type (3) involving negligible activation energy is expected to proceed within a period determined only by the frequency factor of the reaction ; for a simple bond dissociation in an ion, Stevenson[17] has indicated that the frequency factor is 10^{14} sec.$^{-1}$. Accordingly, even in the liquid state, reactions of type (3) may be expected to occur before neutralization, whereas endothermic processes are largely precluded by the short lifetime of the ion (about 10^{-12} sec.). A fuller discussion of the implications of fast ion dissociation reactions for the radiation chemistry of branched hydrocarbon systems, including polymers, will be given by one of us in a future publication[18]. The relevance of a reaction analogous to (3) for α-pinene can be seen by considering the mode of decomposition of the parent ion V ; in this instance it is possible to form two alternative carbonium ions by the scission of the *cyclo*butane ring on either side of the gem-dimethyl group, constituting the quaternary substituted carbon atom in the 'centre' of the molecule, as represented in (5) and (6).

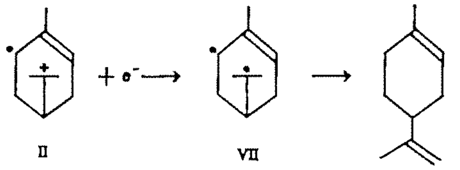


(5)

(6)

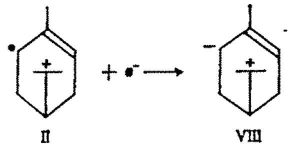
The removal of a methyl group in the above scission is discounted since the largest attached group is generally the most labile in the breakdown of a branched parent ion[18]. Concerning the alternative processes (5) and (6), the former will clearly be favoured by the greater resonance stability of the allylic radical as represented by the equivalent mesomeric structures shown for II. It can therefore be concluded that the most likely ion to be produced in the radiolysis of α-pinene can be represented by II whether the positive charge is initially considered to occur at the double bond or at the tetra-substituted carbon atom ; since these two locations represent regions of high electron density in the original molecule it follows that the positive charge would tend to concentrate preferentially at these locations.

The neutralization of the ion-radical II by the conjugate electron can be represented in three ways : first, by neutralization of the carbonium ion to give a biradical VII followed by disproportionation involving hydrogen atom transfer from one of the methyl groups to the ring position and the concomitant formation of an *iso*propenyl group as represented in (7).



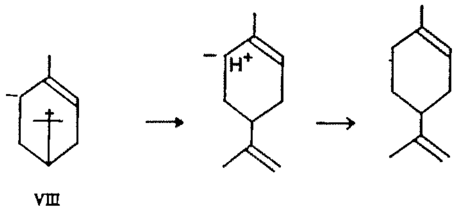
(7)

A criticism of (7) is that the ease of hydrogen atom transfer from the methyl group to the ring position may not be sterically favoured. Secondly, electron capture may proceed at the radical location in II to create an ion-pair VIII in the same molecule, as shown in reaction (8) :



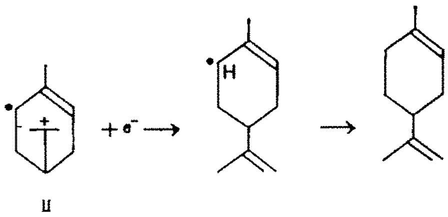
(8)

the postulated relative stability of VIII as an intermediate state is assumed to be derived from the delocalization of the positive charge on the carbonium ion in this instance, accruing from the inductive effect and hyperconjugation of the attached groups. The contribution of solvation forces to the increased stability of tri-substituted carbonium ions may also be of significance[19] although the low dielectric constant of α-pinene is not particularly favourable in this case. Apart from the obvious possibility of ionic combination to re-form α-pinene, there exists the likelihood of proton expulsion from the carbonium ion and concomitant capture of the proton by the negative ion held in close juxtaposition by the coulombic forces of the ion-pair ; these latter processes bear an obvious parallel to the classical S_N1 and *E*1 mechanisms originally invoked by Hughes and Ingold[19] to explain the reactivity of tertiary-butyl halides. So, by analogy, the process of dipentene formation as in (9) can be regarded as equivalent to the elimination reaction found to accompany substitution processes in carbonium ion reactions[20].



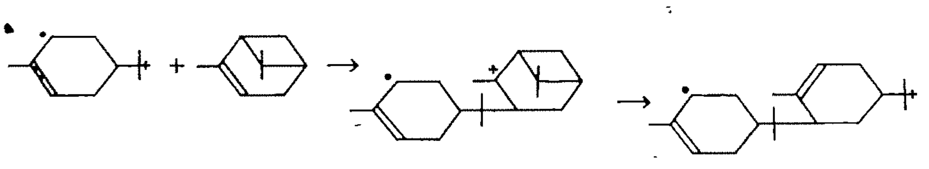
(9)

The third mechanism of neutralization of II is essentially a variant of the previous one in which the electron functions as a nucleophilic entity and attracts a proton from the carbonium ion, thus forming a hydrogen atom. Subsequent combination of the hydrogen atom and the radical would again lead to dipentene as in (10).



(10)

If prior to neutralization the carbonium ion II, or the ion-pair VIII, could transfer its proton to another molecule of α-pinene, then there would be the possibility of the isomerization of several α-pinene molecules per initial ion according to the usual acid-

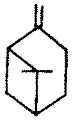


(11)

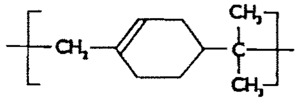
catalysed mechanism[1] of dipentene formation. However, consideration of the yields obtained suggests that the frequency of transfer is small compared with the initial number of ions formed; in this connexion the slight increase in yield at − 196° C. over room temperature conditions may be an indication of some migration in the solid state arising from a longer life-time of II before neutralization. The apparent absence of an isomer of dipentene in the products as would be formed by the alternative mode of scission of the *cyclo*butane ring in reaction (6) is in agreement with the mechanism proposed above.

The negligible yields of methane, ethane and other fragmentation products lead us to argue against extensive radical reactions in this system following from the creation of methyl radicals in a primary act. Polymer formation can be formulated as a consecutive ion-molecule reaction (11) in which the initiating species is the carbonium ion II and the termination process occurs, on average, after the addition of two molecules of α-pinene; the subsequent neutralization of the propagating carbonium ion IX could, by analogy with the isomerization process, give rise to either a diradical, an ion-pair or a radical plus hydrogen atom. If a diradical is formed the molecule could be stabilized by olefin group formation as proposed by Chang, Yang and Wagner[4]. The possibility of proton transfer from a propagating species IX, which thereby terminates, to another α-pinene molecule, thus inducing either a new polymerization chain or isomerization to dipentene, is precluded by the magnitude of the measured yields.

β-*Pinene*,



On irradiation, β-pinene polymerizes readily at ambient room temperature with a large yield, G_{initial} (-monomer) about 2,000, to very high conversions (90 per cent)[11]. If oxygen or water is present the polymerization is inhibited. The polymer was isolated in two fractions according to whether it was insoluble or soluble in the remaining monomer. In a typical experiment, the yield of precipitated polymer was slightly greater than that of the soluble fraction. The insoluble polymer consists of a white solid showing birefringence to polarized light and having a melting point exceeding 200° C., at which temperature it does not undergo obvious decomposition in the absence of oxygen; it is insoluble in most organic solvents of boiling point less than 100° C. Analysis of the carbon and hydrogen content on samples which had either been melted *in vacuo* after irradiation (ostensibly to remove any free radicals formed by irradiation of the precipitated polymer during the polymerization) or been kept in the absence of air gave exact concordance with the formula $(C_{10}H_{16})_n$; however, the analysis of samples further exposed to atmospheric oxygen for more than a week indicated that oxidation had occurred and this was confirmed by infra-red evidence of the formation of $>C=O$ groups on standing. Infra-red examination of the precipitated polymer in a potassium bromide disk immediately after irradiation revealed the spectrum to contain all the absorption bands listed[12] for a sample of β-pinene polymer obtained either by Friedel–Crafts or Ziegler type polymerization, supporting the structural assignment

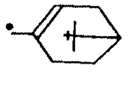


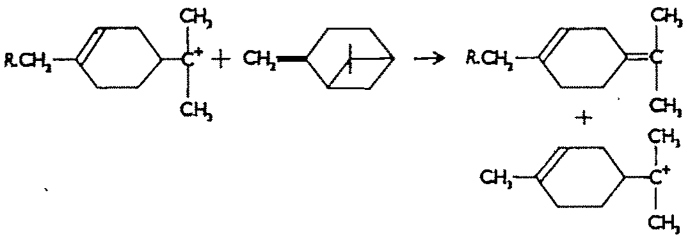
as the most probable repeating unit in the polymer structure. Other absorption bands not characteristic of the Friedel–Crafts polymer and also absent in a sample of commercially available β-pinene resin are found to be consistently present in all polymers formed by irradiation. The soluble polymer was found to have a softening point in the range 80–105° C. and the infra-red spectrum was similar to that of the precipitated fraction; molecular weight measurements by an ebullioscopic method in chloroform as a solvent gave a value of 550. For the total polymer, the molecular weight determinations are uncertain owing to its relative insolubility but a value of 1,450 can be inferred from the data for the portion of sample dissolving in chloroform at its boiling point.

Detailed information as to the polymerization kinetics is not as yet complete; but the results obtained hitherto using pure monomer, prepared by fractional distillation and passage down a silica gel column, suggest that the polymerization is reproducible and not largely affected in terms of yield per total dose either by dose-rate or cell diameter. Irradiation at a mean temperature of −40° C. resulted in a two-fold reduction of polymer yield by comparison with the room temperature results.

By comparison with the ease of the polymerization reaction, the isomerization induced by irradiation of β-pinene is of negligible occurrence and only very low yields ($G < 0{\cdot}1$) of dipentene and other isomers have been observed.

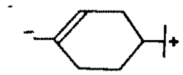
β-Pinene is recognized[13] as typical of a group of monomers that undergo polymerization by ionic initiators such as Friedel-Crafts catalysts but not by free radical agents; for example, the addition of carbon tetrachloride to β-pinene[14] initiated by benzoyl peroxide leads to an almost quantitative yield of 1 : 1 addition product without the formation of polymer, in contrast to the partial polymerization (telomerization) of vinyl monomers in similar circumstances[15].

By complete analogy with the previous discussion for α-pinene, the rearranged positive ion for β-pinene is given by $X =$  ; it is postulated that

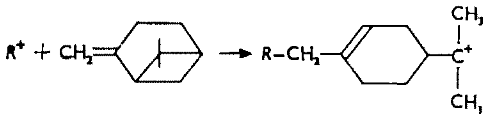


(12)

either this carbonium ion-radical X or the ion-pair

XI =  constitutes the original initiating species for polymerization. The results of this investigation show unequivocally that the high yield of relatively low molecular weight polymer fraction corresponds to the occurrence of a large number (about 100) of separate polymerization chains per 100 eV., and since the number of primarily formed initiators cannot attain such high values the obvious implication is that the polymerization is sustained by transfer of an initiating species from a propagating polymer chain to a monomer. Such transfer mechanisms are well known to occur in ionic polymerizations[26] by proton transfer and are illustrated in this instance by reaction (12).

The propagation step can be written for the general case of the ion R^+ as in (13) and involves the opening of the *cyclo*butane ring as previously conceived for the case of α-pinene.



(13)

For high polymerization yields to be effected by a cationic mechanism in radiation chemistry it is necessary either that the polymerization chain, including possible transfer, occurs in a time of about 10^{-11} sec., that is, before neutralization, or else the conjugate electron must be stabilized for sufficient time to allow the polymerization to proceed in a purely thermal manner before termination. Anderson[4] has suggested the former explanation for the polymerization of butadiene, whereas Dainton[6] and also Davison, Pinner and Worrall[3] have put forward the view that the electron is probably trapped by sub-microscopic solid particles in liquid isobutene. Another general possibility arising from this present work is that of the creation of sufficiently stabilized ion-pair initiators.

According to the mechanism depicted here, the crucial factor governing the magnitude of isomerization and polymerization in these monomers on radiolysis is the ease of transfer of a proton from a carbonium ion to the monomer.

We wish to thank Dr. W. Wild for his interest during the course of this work.

[1] Barton, D. H. R., and Harper, S. H., "Chemistry of Carbon Compounds", ed. Rodd, E. H., 2B, 573 (Elsevier Publishing Co., Amsterdam, 1953).

[2] Stevenson, D. P., *J. Phys. Chem.*, 61, 1453 (1957).

[3] Davison, W. H. T., Pinner, S. H., and Worrall, R., *Chem. and Indust.*, 1274 (1957); *Proc. Roy. Soc.*, A, 252, 187 (1959).

[4] Anderson, W. S., *J. Phys. Chem.*, 63, 765 (1959).

[5] Chang, P. C., Yang, N. C., and Wagner, C. D., *J. Amer. Chem. Soc.*, 81, 2060 (1959).

[6] Collinson, E., Dainton, F. S., and Gillis, H. A., *J. Phys. Chem.*, 63, 909 (1959).

[7] Hawkins, J. E., and Burris, W. A., *J. Org. Chem.*, 24, 1507 (1959).

[8] Fuguitt, R. E., and Hawkins, J. E., *J. Amer. Chem. Soc.*, 67, 242 (1945).

[9] Nitkin, V. M., *J. Gen. Chem.* (U.S.S.R.), 16, 1041 (1946); *Chem. Abstracts*, 41, 2712 (1947).

[10] Wystrach, V. P., Barnum, L. H., and Garber, M., *J. Amer. Chem. Soc.*, 79, 5786 (1957).

[11] Charlton, R. W., and Day, A. R., *Indust. Eng. Chem.*, 29, 92 (1937).

[12] Pritchard, H. O., Sowden, R. G., and Trotman-Dickenson, A. F., *Proc. Roy. Soc.*, A, 218, 416 (1953).

[13] Pollard, E., "Adv. in Biol. and Med. Phys.", 3, 53 (1953).

[14] Hunt, H. G., and Hawkins, J. E., *J. Amer. Chem. Soc.*, 72, 5618 (1950).

[15] Burton, M., Hamill, W. H., and Magee, J. L., Proc. Second U.N. Conf. on Peaceful Uses of Atomic Energy, Geneva, 29, 391 (1958).

[16] Field, F. H., and Franklin, J. L., "Electron Impact Phenomena and the Properties of Gaseous Ions", 172 (Academic Press, New York, 1957).

[17] Stevenson, D. P., *Rad. Res.*, 10, 610 (1959).

[18] Williams, T. F. (to be published).

[19] Ingold, C. K., "Structure and Mechanism in Organic Chemistry", 424 (Bell and Sons, Ltd., London, 1953).

[20] Hughes, E. D., and Ingold, C. K., *Trans. Faraday Soc.*, 37, 657 (1941).

[21] Bates, T. H., and Williams, T. F. (Brit. Patent applied for).

[22] Marvel, C. S., Hanley, J. R., and Longone, D. T., *J. Polymer Sci.*, 40, 551 (1959).

[23] Schildknecht, C. E., "High Polymers", 10, "Polymer Processes", 203 (Interscience, New York, 1956).

[24] Oldroyd, D. M., Fisher, G. S., and Goldblatt, L. A., *J. Amer. Chem. Soc.*, 72, 2407 (1950).

[25] Mayo, F. R., *Disc. Faraday Soc.*, No. 14, 231 (1953).

[26] Pepper, D. C., *Quart. Rev. Chem. Soc.*, 8, 88 (1954).

SILKWORM RAISING ON ARTIFICIAL FOOD

By TOSHIFUMI FUKUDA, MITSUMASA SUTO and YOSHIKICHI HIGUCHI

Sericultural Experiment Station, Suginami-ku, Tokyo

ATTEMPTS to rear silkworms, *Bombyx mori*, on an artificial food have been made for a long time. However, there are no reports that silkworm larvæ have been reared on artificial food only from hatching to spinning. Recently, Hamamura[1] and Ito[2] found that silkworms will eat agar-agar containing nutriments for two or three days, and pointed out that this phenomenon is of value for study of food selection of the silkworm larva. Yoshida *et al.*[3] have succeeded in rearing silkworms on artificial food, from hatching to the fourth day of the fifth instar (maximum). They could not, however, get the silkworms to produce cocoons. So we reared silkworms by improving the composition of the artificial food and the method of the silkworm raising devised by Yoshida *et al.*, and succeeded in making silkworm larvæ produce 36 cocoons, starting from 110 worms hatched from eggs. The silkworms pupated, and the fertilized moths laid their eggs.

The composition of the basal artificial diet is given in Table 1.

To this basal diet (8·5 gm.) was added 5 ml. of 20 per cent sucrose solution, and 10 ml. of the inhibitor solution. The inhibitor solution was prepared by

Table 1. COMPOSITION OF THE BASAL DIET

Powdered mulberry leaves*	5 gm.
Potato starch†	1·5 gm.
'Kinako' (a powder of parched soy bean)†	1 gm.
'Koridofu' non-fat (frozen soy bean-curds)‡	1 gm.

* Leaves picked from mulberry trees ('Kokuso' No. 19 and 'Ichinose') were dried at not more than 40° C. under vacuum, and then powdered to pass through an 80-mesh sieve.

† Potato starch and 'Kinako' respectively were passed through an 80-mesh sieve.

‡ The dried 'Koridofu' was treated with ether to remove fat, and then powdered to pass through an 80-mesh sieve.

dissolving 0·1 gm. of vitamin K_3, 0·2 gm. of sodium dehydroacetate and 0·2 gm. of sodium sorbate in 100 ml. of distilled water by heat. This inhibitor is necessary to stabilize the artificial diet, and to prevent its decomposition. The mixture was stirred well with a glass rod. The artificial food prepared was sterilized in an autoclave for 15 min., and stored in a refrigerator. The artificial food thus prepared remains good for a week.

A piece of wet filter paper was placed in the bottom of a Petri dish ready for raising the silkworms. This was covered with a piece of paraffin paper. The artificial food was placed on the paraffin paper, then the newly hatched worms (the hybrids between *Si* 115 × *Si* 124 and *Nichi* 122 × *Nichi* 124) were placed on it and reared there. The dish, covered with a lid, was placed in a sterilized box at a temperature of 25° C. and at 92–96 per cent humidity. The artificial food was cut in slices 0·1 mm.–0·3 mm. thick. Each slice prepared was sterilized in an autoclave for 15 min., and then stored in a refrigerator for 12 hr. before use. Slices were fed to the silkworms twice daily at 12-hr. intervals.

The time between hatching of silkworm larva and spinning a cocoon was 45 days. This is about twice as long as the same race reared on mulberry leaves. The pupal period was 14 days. Fig. 1 shows the silkworms at the eighth day of the fifth instar, three days before spinning, eating the artificial food. Among 110 newly hatched silkworms, 36 spun their cocoons, and 24 silkworms underwent the pupa stage (♀2 and ♂22) and 24 became moths (♀2 and ♂22). The weights of the matured larva, the pupa (at the sixth day after pupation), and the moth were respectively 1·13 gm., 0·62 gm. (♂), and 0·33 gm. (♂). Fig. 2 shows the matured larva, the pupa, the moth, the cocoon, and the eggs obtained by using artificial food. The weight of the cocoon fibres produced by one silkworm was 86 mgm. (130 mgm. maximum), and its value is about 20 per cent (about 40 per cent) of that in the case of the silkworm reared on mulberry leaves. The length of a silk filament unwound from one cocoon was about 450 m. In a matured larva, the pair of silk-glands developed quite well. The number of the eggs laid by one moth was 227. One egg was 1·291 mm. long by 0·952 mm. wide.

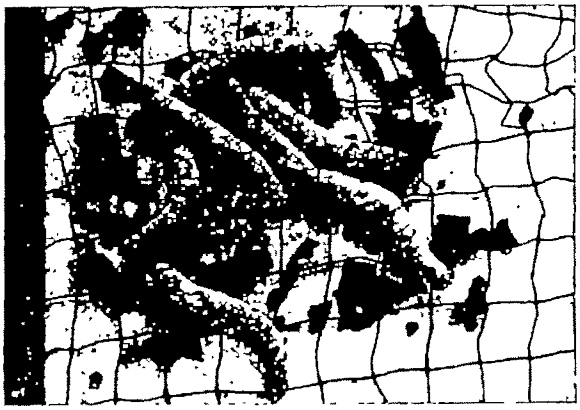


Fig. 1. Silkworms eating artificial food

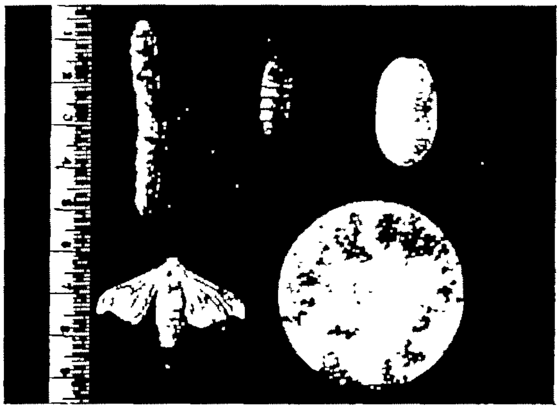


Fig. 2. Mature larva, pupa, moth, cocoon and eggs raised on artificial food

We succeeded in rearing silkworms, from hatching to the moth, on artificial food; but this fact does not mean that the artificial food used is the most suitable one for silkworm raising. The weight of the cocoon fibres obtained at present is not very much. By improving the composition of the artificial food used, however, it may be possible for the silkworm to produce a much larger amount of cocoon fibres and eggs. Concerning the artificial food, especially the powdered mulberry leaves, it is interesting to note that the nutritive value of the powdered leaves decreases remarkably when the powder has been at room temperature for a long time, stored in a glass bottle. In the case of silkworms at the first age reared on an artificial food containing this powder, a great part of the silkworms would not have been raised to the second age. This phenomenon seems to be of interest in relation to the food selection of the silkworm larva. In the artificial food used the powdered mulberry leaves is present in relative abundance (about 20 per cent). It seems to be desirable, if possible, to replace the mulberry leaf powder with some other simple nutriment.

We also tried to rear the wild silkworm (*Attacus ricini*) with artificial food, and succeeded in rearing it until just before the fifth instar, starting from the hatched silkworms. The artificial food used for the wild silkworms was one in which the powdered mulberry leaves were replaced by powdered castor-oil (*Ricinus communis*) leaves, which is used in artificial food for *Bombyx mori*.

We wish to thank Dr. Eikichi Hiratsuka, Dr. Tadao Yokoyama, Dr. Tokutaro Yoshida, Mr. Michio Matsuoka (Sericultural Experiment Station, Tokyo), Dr. Shojiro Ishii (National Institute of the Agricultural Science, Tokyo), Prof. Marcel Florkin (University of Liège, Belgium) and Prof. Jean Leclercq (University of Liège) for their kindness and advice. Our thanks are especially due to Mr. Koichi Kimura for helping us with the preparation of artificial food.

[1] Hamamura, Y., *Nature*, 183, 1746 (1959).

[2] Ito, T., *J. Insect. Physiol.* (in the press).

[3] Yoshida, T., Matsuoka, M., and Kimura, K., *Bull. Sericult. Exp. Sta.* (Tokyo) (in the press).

ENZYMATIC ACTIVATION OF A HORMONE-LIKE RESPONSE IN *HYDRA* BY PROTEASES

By Dr. HOWARD M. LENHOFF and JOHN BOVAIRD

Biochemistry Laboratories, Howard Hughes Medical Institute, Miami, Florida

THE mechanism by which excitatory compounds act on cells is not clearly understood. (In view of recent controversy[1], we use the general term 'excitatory compound' as a strictly operational expression to signify any specific substance which functions naturally in eliciting a co-ordinated biological response; thus hormones are the most studied group of excitatory compounds.) Some recent work, which has been concerned with the action of exogenous excitatory compounds on tissue slices[2], is in agreement with the belief that cellular integrity is essential for excitatory compounds to elicit their response[3]. As another approach to this problem, we have been studying the action of an exogenous excitatory compound on an intact, simple, aquatic animal which has not developed past the tissue-level of organization[4]. This system involves the action of reduced glutathione in eliciting the feeding reflex in *Hydra*. In this article we present results which demonstrate that certain proteases can simulate enzymatically the action of reduced glutathione on the live animals.

Small amounts of reduced glutathione have been shown to act as a 'feeding hormone' in eliciting the feeding reflex in *Hydra*[5] and in other hydrozoans[6]. As pointed out by Loomis[5], the feeding reflex involves the well-co-ordinated muscle movements necessary for the ingestion of prey by the *Hydra*. In Nature, the *Hydra* can carry out the feeding reflex only by puncturing the prey with spear-like nematocysts (stinging organoids). After the prey, such as a *Daphnia*, is punctured by the discharged nematocysts, fluids ooze from the wound into the water surrounding the *Hydra*. Reduced glutathione, which is present among these fluids, induces the *Hydra* to carry out the feeding reflex resulting in the ingestion of the wounded prey. Since reduced glutathione is present only in live or recently killed food, the carnivorous *Hydra*, which lacks the specialized sensory organs found in higher forms, is enabled to select living food for ingestion through the stimulation produced by reduced glutathione. Loomis[5] has demonstrated that the experimental addition of reduced glutathione to *Hydra* will induce the animal to ingest even dead food which is devoid of endogenous reduced glutathione.

In the experiments to be described, the feeding reflex is measured quantitatively by averaging the lengths of time (in minutes) during which the mouths of all the *Hydra* tested remained open in response to the protease. This is the procedure by which the normal response to reduced glutathione is measured[4]. Male *Hydra littoralis*, reproducing asexually in laboratory mass cultures[7], were used in all the experiments. The assay consisted of the following procedure: five *Hydra*, which had been starved for one day, were rinsed three times in 30-ml. aliquots of standard culture solution (see below) during a 20-sec. period; then, in one drop of culture solution, they were placed in 2 ml. of the solution to be tested ('test solution'), and were observed immediately through a binocular dissecting microscope. The lengths of time that the mouths of the *Hydra* remained open were recorded, and the average was taken. The test solution was contained in the spherical cavity (38 mm. diameter) of a 3 in. × 2 in. depression slide. The microscope was set at × 19·5 magnification.

The enzymes and proteins used were: papain (twice crystallized), trypsin (twice crystallized), pan-protease preparation, aminotripeptidase, crystalline soybean trypsin inhibitor, peroxidase, collagenase and hyaluronidase (Worthington Biochemical Corp., Freehold, N.J.); chymotrypsin, ficin, pepsin (twice crystallized), cathepsin C, carboxypeptidase, carbonic anhydrase, catalase, α-amylase, and egg albumin (Nutritional Biochemicals Corp., Cleveland, Ohio); urease (twice crystallized), casein and hæmoglobin (Mann Research Laboratories, N.Y.); cellulase, alcohol dehydrogenase (twice crystallized), lactic dehydrogenase, hexokinase and bovine serum albumin (Sigma Chemical Co., St. Louis, Mo.); elastase (Warner-Chilcott, N.Y.); muscle aldolase and α-glycerophosphate dehydrogenase (Southeastern Biochemicals, Inc., Augusta, Ga.), and gelatin (Eastman Chemicals, Rochester, N.Y.). The enzymes and proteins were used at a concentration of 0·1 mgm./ml. unless stated otherwise. All the enzymes were dissolved in the standard culture solution of 10^{-3} *M* calcium chloride and 10^{-4} *M* sodium bicarbonate at *p*H 7·3–7·8, and were dialysed overnight at 4° C. against four litres of this solution. The dialysis was carried out in order to remove any possible contaminating reduced glutathione.

The experiments are listed in Table 1. Experiment 1*a* is a control and shows that in the presence of 10^{-5} *M* reduced glutathione the *Hydra* kept their mouths open for about 21 min.; this was the normal feeding reflex. Results obtained using crystalline papain are given in Experiment 2. The dialysed enzyme (20 μgm./ml.) elicited only a negligible response (Exp. 2*a*). Since reducing agents are known to activate the proteolytic activity of papain[8], the enzyme was incubated with 10^{-3} *M* cysteine for 5 min. A feeding reflex of 20 min. duration resulted (Exp. 2*b*). Cysteine alone, as previously demonstrated by Loomis[5], also was shown here to be without effect (Exp. 1*b*). No response was elicited if the enzyme and cysteine mixture were heated for 5 min. at 100° C. (Exp. 2*c*). (It should be emphasized that the sulphydryl group has recently been shown to be unnecessary for the activity of reduced glutathione on the *Hydra*. These analogues, ophthalmic acid and norophthalmic acid, which have methyl and hydrogen respectively replacing the sulphydryl group of reduced glutathione, can induce the feeding reflex[9]. On the other hand, reduced aspartthione, which contains one less methylene group than reduced glutathione, is inactive[9]. Thus, it appears that the receptor is very specific for the molecular size and shape of reduced glutathione, and does not depend upon the sulphydryl moiety.) Ficin, another proteolytic enzyme activated by cysteine[10], also behaved similarly to papain (Exp. 3). The dialysed ficin did not elicit the response (Exp. 3*a*); addition of cysteine to the enzyme resulted in a significant response (Exp. 3*b*); and boiling destroyed the ability of ficin to elicit the feeding reflex (Exp. 3*c*).

Results obtained using crystalline trypsin are given in Exp. 4. Dialysed trypsin elicited a 17·8-min. response (Exp. 4*a*). The reaction was carried out at *p*H 5·7, which was found to be more favourable for the action of trypsin on the *Hydra*. The action of trypsin in eliciting the feeding reflex was inhibited by previously incubating the enzyme with crystalline soybean trypsin inhibitor (Exp. 4*b*). This action of the trypsin inhibitor was due to the inhibition of trypsin rather than to any deleterious action of the inhibitor on the *Hydra*; for trypsin inhibitor had no effect on the normal response stimulated by reduced glutathione. The activity of trypsin was reduced only slightly by heating at *p*H 5·7 for 5 min. at 100° C. This is in agreement with previous work concerning the relative heat stability of crystalline trypsin at an acid *p*H (ref. 11). However, boiling the enzyme solution at *p*H 7·5 for 5 min., and then adjusting the *p*H to 5·7, reduced the enzymatic activity, and only an 8-min. response occurred.

In summary, the results listed in Table 1 present evidence that the stimulation of the feeding reflex by papain, ficin, or trypsin followed closely the characteristics of the individual enzymes. Papain and ficin acted only in the presence of a reducing agent. Trypsin activity was inhibited by trypsin inhibitor, and was not inhibited by boiling this heat-stable crystalline enzyme at an acid *p*H. It is concluded that the feeding reflex was activated by the proteolytic activities of these enzymes.

In addition to papain, ficin and trypsin, other proteases elicited the feeding reflex in *Hydra*; the pan-protease preparation (*p*H 5·7), 24·5 min.; chymotrypsin, 8 min.; elastase, 1·4 min. Pepsin and cysteine-activated cathepsin *C* were without effect, as were the peptidases carboxypeptidase and aminotripeptidase. Egg albumin was observed on one occasion to elicit a questionable negligible response. None of the 18 other proteins mentioned could elicit a response. The results of this partial survey of proteins suggests that, under the conditions described in this communication, the activation of the feeding reflex is due to the enzymatic action of proteases, and not to any non-specific effect of proteins in general.

Table 1. ACTIVATION OF THE FEEDING REFLEX BY PROTEASES

The experiments were performed as described in the text. The reactions were carried out in the standard culture solution. All solutions were maintained at a near neutral *p*H except for those used in Exp. 4; the latter solutions were adjusted to *p*H 5·7

Experiment	Test solution	Average time mouth of *Hydra* open (min.)
1*a*	10^{-5} *M* reduced glutathione	20·6
b	10^{-5} *M* cysteine	0
2*a*	20 µgm./ml. papain	0·1
b	20 µgm./ml. papain + 10^{-5} *M* cysteine	19·8
c	20 µgm./ml. papain + 10^{-5} *M* cysteine, boiled 5 min. at 100° C.	0
3*a*	0·1 mgm./ml. ficin	0
b	0·1 mgm./ml. ficin + 10^{-5} *M* cysteine	12·3
c	0·1 mgm./ml. ficin + 10^{-5} *M* cysteine, boiled 5 min. at 100° C.	0·1
4*a*	0·1 mgm./ml. trypsin	17·8
b	0·1 mgm./ml. trypsin + 0·1 mgm./ml. trypsin inhibitor	0

The results presented in Table 1 may give the erroneous impression that the opening of the mouth which occurred in the presence of proteases was an abnormal response to a toxic compound. For example, some deleterious compounds have been observed to cause abnormal opening of the mouth, but they did not cause the characteristic feeding response. These poisoned 'gaping' *Hydra* could not carry out the highly co-ordinated movements necessary to ingest dead food (Lenhoff, H. M., unpublished work). In contrast, the *Hydra* reported in the positive enzyme experiments listed in Table 1 (Exp. 2*b*, 3*b* and 4*a*) were able to manipulate and ingest dead food which is devoid of any endogenous reduced glutathione. The ability to ingest food is the most important characteristic of the feeding reflex as determined by Loomis[9]. It should also be noted that the deleterious compounds which cause this gaping usually killed the *Hydra* within a few hours (Lenhoff, H. M., unpublished work). In contrast, the *Hydra* which had been exposed to the proteases for more than 24 hr. in the experiments reported here remained intact and alive.

Preliminary experiments have demonstrated that either trypsin or papain can stimulate isolated *Physalia* gastrozooids to carry out their characteristic feeding reflex (Lenhoff, H. M., unpublished work). Recently these structures have been shown to respond to reduced glutathione in a manner similar to *Hydra*[6].

It seems strange that a response which is so complex and highly co-ordinated as the feeding reflex can be set off by two different classes of substances: the normal excitatory compound—reduced glutathione, and proteolytic enzymes. A consideration of possible mechanisms by which proteases could activate the feeding reflex may give insight into the normal mechanism by which reduced glutathione acts. One possibility may be that the enzymatic cleavage of certain peptide bonds alters the permeability of the cell membrane and triggers the response. Another explanation is that key enzymes, which are needed to initiate the feeding reflex, may be released from their naturally occurring protein inhibitors. For example, proteases are known to activate deoxyribonuclease[12], fructose-1,6-diphosphatase[13], enzymes involved in blood clotting[14] and precursors of proteolytic enzymes[15]. Other enzymes have been shown to exist in combination with heat-labile protein inhibitors[16]. Lastly, co-factors could be released in the same fashion. In the present case, reduced glutathione released from the bound state could be such a co-factor.

As regards the site of action of the proteases, it should be borne in mind that the feeding reflex evoked by the proteases involves many interrelated processes. Most probably these processes could not be initiated by the action of the proteases on any one of the terminal proteins involved in the co-ordinated response. Therefore, it appears that the protease acts on some primary protein which sets off the chain of reactions involved in the complex feeding mechanism. A likely candidate is the reduced glutathione-receptor, or a protein closely associated with the receptor.

Finally, it does not seem inconceivable that the proteolytic activation of a response normally induced by an excitatory compound, such as occurs with *Hydra*, may be found to occur in other systems. The results presented in this communication make it tempting to speculate that a basic underlying mechanism by which some excitatory compounds act on cells involves a proteolytic step.

Note added in proof. After this article was submitted, other examples of systems in which proteases stimulate specific responses came to our attention. Trypsin has been shown to activate wound repair activities of corneal stroma cells; the enzyme was postulated "to lead to the release of some factor(s)" which stimulate these activities[17]. More recently, ficin has been reported to stimulate *in vitro* corticosteroid production by rat adrenal tissue[18]; *in vivo*, adrenocorticotrophic hormone carries out this function.

[1] Micklem, H. S., *Nature*, 183, 1835 (1959). Karlson, P., and Luscher, M., *Nature*, 183, 1835 (1959).
[2] Birmingham, M. K., Elliot, F. H., and Valère, P. H.-L., *Endocrin.*, 53, 687 (1953). Perón, F. G., and Koritz, S. B., *J. Biol. Chem.*, 233, 256 (1958).
[3] Hechter, O., *Vitamins and Hormones*, 13, 293 (1955).
[4] Lenhoff, H. M., and Bovaird, J., *Science*, 130, 1474 (1959).
[5] Loomis, W. F., *Annals N.Y. Acad. Sci.*, 62, 209 (1955).
[6] Lenhoff, H. M., and Schneiderman, H. A., *Biol. Bull.*, 116, 452 (1959).
[7] Loomis, W. F., and Lenhoff, H. M., *J. Exp. Zool.*, 132, 555 (1956).
[8] Balls, A. K., and Lineweaver, H., *J. Biol. Chem.*, 130, 669 (1939).
[9] Cliffe, E. E., and Waley, S. G., *Nature*, 182, 804 (1958).
[10] Walti, A., *J. Amer. Chem. Soc.*, 60, 493 (1938).
[11] Northrup, J. H., "Crystalline Enzymes", 90 (Columbia Univ. Press, N.Y., 1939).
[12] Zamenhof, S., and Chargaff, E., *J. Biol. Chem.*, 180, 727 (1949).
[13] Pogell, B. M., and McGilvery, R. W., *J. Biol. Chem.*, 197, 293 (1952).
[14] Kline, D. L., in Colowick, S., and Kaplan, N., "Methods in Enzymology", 2, 139 (Academic Press, New York, 1955).
[15] Dixon, M., and Webb, C., "Enzymes", 542 (Academic Press, New York, 1958).
[16] Swartz, M. N., Kaplan, N. O., and Frech, M. E., *Science*, 123, 50 (1956).
[17] Weimar, V., *Exp. Cell. Res.*, 18, 1 (1959).
[18] Koritz, S. B., and Péron, F. G., *J. Biol. Chem.*, 234, 3122 (1959).

STRUCTURE AND SYSTEMATIC POSITION OF THE AUSTRALIAN BROWN ALGA, *NOTHEIA ANOMALA*

By M. NIZAMUDDIN
University of Karachi
AND
DR. H. B. S. WOMERSLEY
University of Adelaide

NOTHEIA anomala Harvey and Bailey[1], 1851, was first collected by the United States Exploring Expedition at the Bay of Islands, New Zealand. It grows exclusively on *Hormosira banksii* f. *sieberi* at a low littoral level and in low rock pools on rough coasts, along southern Australia and in New Zealand. Previous studies of *Notheia* have been made by Barton[2], Mitchell[3], Gruber[4] and Williams[5].

The specific name is most applicable to this alga, which has previously always been classed in the Fucales, usually in a family with *Hormosira*. *Notheia* shows a group of three apical cells (which protrude at the branch apex and are not sunk in a depression as in the Fucales), conceptacles scattered over the thallus, and the supposed formation of oogonia with eight eggs, and according to Barton[2], of antheridia with numerous sperms. The branches, which issue from the conceptacles, are a further anomalous feature.

The discovery, while examining living material, that the 'eggs' are motile zooids, made a thorough investigation of *Notheia* necessary. This account gives preliminary results, which, while not complete, clarify many features and show that *Notheia* is not a member of the Fucales but is a distinctive type of the Heterogeneratae. The structure and reproduction will be discussed briefly here and will be described more fully elsewhere.

Each of three protruding apical cells segments latero-posteriorly, and the tissues derived from each apical cell can be recognized in both transverse and longitudinal sections for some distance from the apex, due to extensive mucilage development between the three sectors. Some 15–20 cells from the apex this distinction is lost. Derivatives of the apical cells segment periclinally to form rows of cells which develop three tissues—medulla, cortex and peripheral layer which remains meristematic. The development of the cells is largely filamentous and not parenchymatous; but in older medullary tissue divisions in different planes may occur giving a truly parenchymatous tissue. Increase in thickness of the thallus is largely due to the meristematic peripheral layer, the cells of which divide first by a longitudinal-oblique wall (not reaching the base of the cell), followed by a periclinal division near the base of the larger cell. This results in dichotomous branching, the cells remaining connected by large pit connexions, similar to those of the Florideae. This dichotomous branching is readily visible throughout the cortex in hand sections, but thin microtome sections obscure it.

Branching occurs largely but not entirely from within the conceptacles, resulting in a profusely and irregularly branched plant up to 12 cm. high. The plants originate from within or near the ostioles of conceptacles of *Hormosira* plants. The branches are constricted within and immediately outside the conceptacles, but broaden considerably 1–2 mm. outside; here the cortex is fully developed. Occasionally, however, true branches, up to three per plant, occur; here the thallus divides into two with no decrease in thickness or association with a conceptacle. The common branches may be referred to as 'conceptacular branches' and reasons will be advanced later for suggesting that these are new plants and not real branches.

Conceptacles occur profusely scattered over the thallus. They originate by enlargement and transverse division of a peripheral cell; the upper cell divides to form a hair and the lower divides longitudinally and is overgrown by surrounding cells to form the conceptacle. Most of the lining cells of the conceptacle produce paraphyses which protrude through the ostiole as a dense tuft.

Sessile reproductive organs occur on the wall of the conceptacles. Most common are those containing 8 zooids, while slightly smaller ones with 64 zooids vary from plentiful to absent in some conceptacles. The larger organs measure 48–78μ by 12–30μ and are not oogonia but are macrozoosporangia, liberating 8 pyriform macrozoospores through basal, or occasionally lateral or terminal, pores. The macrozoospores are first extruded in a gelatinous envelope, and when they escape are sluggishly motile by means of a long anterior flagellum and somewhat shorter posterior one, the attachment being lateral but close to the pointed apex. Macrozoospores contain 2–4 chromatophores, a single eye-spot and measure 12–27μ × 5–12μ.

The 64 zooids, formed in organs slightly smaller than the macrozoosporangia, are actively motile, almost colourless (with one pale chromatophore), with an eye-spot and two unequal flagella attached near the apex. They measure 6–10μ by 4–6μ. These bodies settle after one-half to several hours but have never been observed to develop further and their nature is still unknown.

During repeated observations no fusion between the large and small zooids has been observed, although they were moving close together.

The macrozoospores germinate in culture into branched, filamentous gametophytes, with erect colourless hairs. The cells of the prostrate parts measure about 12μ in thickness, are 2–4 times as long as broad and contain several brown chromatophores. Uniseriate, erect reproductive bodies are produced on older filaments, each cell producing a single zooid which is liberated apically through the series of fertile cells. These zooids are pyriform, about 8μ × 6μ and biflagellate with lateral, unequal flagella, similar to the macrozoospores. These gametophytes and reproductive cells are very similar to the gametophytes and uniseriate gametangia of *Spermatochnus paradoxus*[6].

Branched, filamentous growths such as those found in culture occur frequently within the conceptacles of *Notheia*, as was observed by Barton[2]. These filamentous growths are usually entirely within the conceptacle, ramifying among the paraphyses and lining cells, but with their colourless hairs sometimes protruding from the ostiole. Occasional empty uniseriate reproductive cells have been seen on them.

Satisfactory chromosome counts have not yet been obtained, but some 26–30 chromosomes have been observed in vegetative cells, about 20–24 in paraphyses and 12–15 in later divisions in the macrozoosporangium. The thallus of *Notheia* is probably diploid, and the macrozoospores and macrogametophyte haploid.

Until the nature of the microzooids and the zooids from the uniseriate gametophytic reproductive organs is known the full life-cycle of *Notheia* will remain uncertain. It seems likely that the macrogametophytes bear uniseriate gametangia producing a single gamete per cell. The behaviour of the microzooids towards these gametes has not yet been observed.

From the known facts, it appears likely that the macrozoospores germinate into macrogametophytes largely within the conceptacles, and possibly fertilization also occurs within the conceptacles, giving rise to a zygote which grows from the wall of the conceptacle. If macrogametophytes develop outside the conceptacles and fertilization occurs externally, the zygote probably is unable to develop without being associated with *Notheia* or *Hormosira*.

This speculation agrees with the development of new conceptacular branches. Commonly one, sometimes two or three, branches emerge from a conceptacle, and young stages have been observed by us and by previous authors[3,4] growing from the lining wall cells of the conceptacle. This would mean that the gametophytic stage of *Notheia* is entirely endophytic within the conceptacles, and that *Notheia* is essentially a simple or occasionally truly branched plant; the normal *Notheia* plant is actually a compound plant consisting of numerous individuals of possibly several successive generations. Occasional establishment of new *Notheia* plants from *Hormosira* conceptacles might occur by macrozoospores escaping from *Notheia* conceptacles and developing near or inside adjacent *Hormosira* conceptacles, with subsequent fertilization (?) and development of the zygote within the *Hormosira*. The one record of *Notheia* on *Xiphophora* may be a rare chance occurrence.

Notheia is clearly to be classed in the Heterogenerataе group of the brown algae, having different sporophytic and gametophytic generations. The development of the thallus is essentially filamentous, but probably with some true parenchymatous cell formation at older stages. It shows some relationship with certain members of the Chordariales, such as *Spermatochnus paradoxus*[6], which has somewhat similar apical cells and gametophyte, but the only member of this group showing conceptacle formation is the southern hemisphere *Splachnidium rugosum* (which has only one type of sporangium with numerous spores).

Notheia differs from all Chordariales, and in fact from all brown algae, in forming two types of zoospores (if the microzooids are in fact zoospores). Other distinctive features are the three apical cells, the cortex of dichotomous chains of cells with prominent pit connexions, the conceptacles and the endophytic gametophytes and development of new branches. The systematic position of *Notheia* must await knowledge of the full life-history but it certainly forms a distinctive family (Notheiaceae Kuckuck *ex* Schmidt), which may come within the Chordariales or may justify an order of its own.

Brown algae forming zoosporangia normally produce numerous zoospores. The reduction to eight macrozoospores is noteworthy, as well as the production of two morphologically distinct zoospores. *Notheia* may well indicate the possible origin of the Fucales, since were the macro- and micro-zooids to function as gametes (gametophytes being eliminated) and the apical cells become sunk in a depression, the resultant alga would undoubtedly agree well with the Fucales. It is quite possible that the microgametophyte has been eliminated already, and the microzooids function as male gametes; this, however, is still speculation and awaits further examination.

[1] Harvey, W. H., and Bailey, J. W., *Proc. Boston Soc. Nat. Hist.*, 3, 370 (1851).

[2] Barton, E. S., *J. Linn. Soc.* (Bot.), 34, 417 (1899).

[3] Mitchell, M. O., *Phycol. Mem.*, 2, 36 (1893).

[4] Gruber, E., *Bibl. Bot.*, 38, 1 (1896).

[5] Williams, M. M., *Proc. Linn. Soc. N.S.W.*, 47, 634 (1922).

[6] Papenfuss, G. F., *K. Fysiogr. Sällsk. Lund Förhandl.*, 5 (20), 1 (1935)

LETTERS TO THE EDITORS

ASTRONOMY

Light Curves of Meteors

THE luminosity equation for the trail of a meteor is[1]:

$$I = \tfrac{1}{2}\left(\frac{dm}{dt}\right) v^2 \tau \qquad (1)$$

where I is the luminous intensity at any point of the trail, $\left(\frac{dm}{dt}\right)$ is the rate of ablation of the meteoroid at that point, v is the velocity of the meteoroid, and τ is the luminous efficiency factor which determines what fraction of the kinetic energy of the ablated atoms is converted into visible light radiation. It is generally assumed that for bright photographic meteors $\tau = \tau_0 v$, where τ_0 is a constant[1,2]. The luminosity equation therefore becomes:

$$I = \tfrac{1}{2}\left(\frac{dm}{dt}\right) v^3 . \tau_0 \qquad (2)$$

This means that the maximum luminosity of the trail will correspond to the level of maximum rate of ablation of the meteoroid.

In a recent paper, Hawkins and Southworth[3] have pointed out on the basis of their study of a random sample of 360 meteor trails photographed with the Baker Super Schmidt cameras at New Mexico that the observed lengths of the trails are considerably shorter than that predicted by the theory. In one of a series of papers on "The Physical Theory of Meteors", Cook[4] had directed attention to the fact that the early portion of a bright meteor trail studied by him was fainter than predicted by the conventional theory. He worked out an improved theory on the reaction zone model taking into account the thermal radiation from the meteoroid, and found that the modified theory provided a completely satisfactory fit to the observed light curve. Öpik[5] has, however, taken exception to the procedure adopted by Cook, and has stated that there is no physical justification for it. In another paper of the series on "The Physical Theory of Meteors", Jacchia[6] has emphasized several anomalies shown by the light curves of faint meteors and has suggested that the theory of progressive fragmentation of the meteoroid along its trail affords a satisfactory explanation of these anomalies.

On the basis of the single-body theory and assuming that $\tau = \tau_0 v$, it can be shown that the equation for the light curve of a meteor is:

$$I = K_1(1 - x)^2 x \qquad (3)$$

where K_1 is a constant for an individual meteor, and $x = \frac{p}{p_e} = e^{-h/a}$, where p is the atmospheric pressure at the level corresponding to luminous intensity I, p_e is the pressure at the level corresponding to the end of the trail, h is the height interval between p and p_e and a is the mean scale height of the atmosphere at the levels appropriate to the meteor trail. This equation indicates that, irrespective of the original mass of the meteoroid, the level of maximum luminosity will be at a height of $a \log_e 3$ ($\sim 1{\cdot}1a$) above the level of complete ablation, and that the equivalent radius and mass of the meteoroid at the level of maximum luminosity will be 2/3 of its original radius and 8/27 of its original mass, respectively[1,2].

The equation for the light curve can be normalized by expressing the luminous intensity at any point of the trail in terms of the maximum luminous intensity. The corresponding equation expressed as magnitude difference is:

$$M - M_{\text{max.}} = \Delta M = -2{\cdot}5\left[2\log(1 - x) + \log x + \log\left(\frac{27}{4}\right)\right] \qquad (4)$$

Assuming a scale height value of $a = 6{\cdot}38$ km. the relation between ΔM and h is represented graphically by curve 1 of Fig. 1. This is identical with the theoretical curve in Fig. 5 of the paper of Hawkins and Southworth[3]. Following their procedure, the points corresponding to the beginning and end of the meteor trails have been plotted in Fig. 1 against the appropriate ΔM values. Almost all the points lie within the theoretical curve, showing that the actual lengths of meteor trails are appreciably shorter than what the theory indicates.

I have modified the conventional theory by assuming that τ is not a constant but varies along the trail of an individual meteor, being proportional to the density of the environment at every point of the trail. In this case the equations for I and ΔM become:

$$I = K_2(1 - x)^2 x^2 \qquad (5)$$

$$M - M_{\text{max.}} = \Delta M = -2{\cdot}5[2\log(1 - x) + 2\log x + \log 16] \qquad (6)$$

where K_2 is a constant for an individual meteor and the other symbols have the same meaning as before.

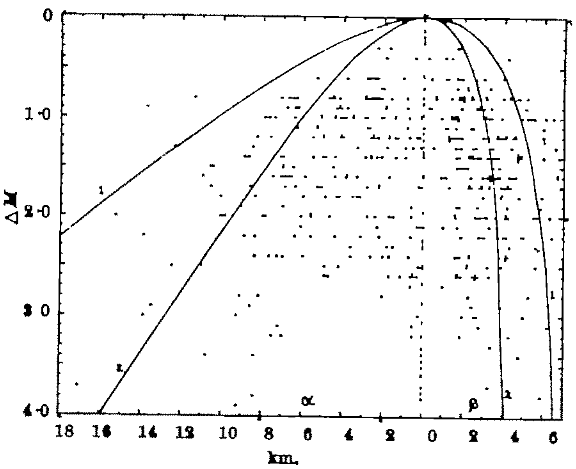


Fig. 1

It can be easily shown that the level of maximum luminosity—this is now different from the level of maximum rate of ablation which remains the same as before—is now at a height of $a \log_e 2 (\sim 0 \cdot 7a)$ above the end of the trail, and that the equivalent radius and mass of the meteoroid at this level will be half its original radius and 1/8 of its original mass, respectively. The relation between ΔM and h is now represented by curve 2 of Fig. 1, which gives a shorter trail for the meteor and the descending branch of which is nearly the median curve through the cluster of points corresponding to the ends of the meteor trails. It will be seen that the modified theory shows better agreement with observation, thus indicating that the interaction between the ablated meteor atoms and the air molecules, which is the primary cause of light emission, has to be explicitly taken into account in the luminosity equation.

The modified theory accounts satisfactorily for the observed light curve of the meteor trail studied by Cook[4]. This meteor appeared at a height of 114 km. at $M = +1 \cdot 9$; it attained maximum luminosity at a height of 84 km. at $M_{\text{max.}} = -5 \cdot 7$; it disappeared at a height of 78 km. at $M = -2 \cdot 6$. For the ascending part of the light curve we have, therefore, $\Delta M = 7 \cdot 6$ and $h_b - h_m = \alpha = 30$ km.; for the descending part $\Delta M = 3 \cdot 1$ and $h_m - h_e = \beta = 6$ km. The values of α and β according to the conventional and modified light curves for certain values of scale height are given in Table 1.

Table 1

		α				β		
a (km.)	ΔM	Conventional theory (km.)	Modified theory (km.)	Observed (km.)	ΔM	Conventional theory (km.)	Modified theory (km)	Observed (km.)
6 38	7·6	50·2	27 2	30 0	3·1	6·4	3 9	6 0
7·00		55·8	30 2			7 1	4 3	
8 00		62 8	34 0			8 0	4·9	

The scale height values considered here are of the correct order as given by the Rocket Panel[7]. We see that the agreement between the modified theory and observation is satisfactory while the conventional theory gives too high values for the length of the meteor trail.

It can be shown that the large scatter of the points corresponding to the beginning of the meteor trails in Fig. 1 and the comparatively smaller scatter of the points corresponding to the end of the trails lend support to Jacchia's fragmentation theory as the cause of meteor anomalies. Fuller details will be published elsewhere.

R. ANANTHAKRISHNAN

Dominion Observatory,
Ottawa.
June 30.

---

[1] Whipple, F. L., *Rev. Mod. Phys.*, 15, 246 (1943); *Bull. Amer. Met. Soc.*, 133, 13 (1952).

[2] Jacchia, L. G., Harvard Reprints, Series II-44 (1952).

[3] Hawkins, G. S., and Southworth, R. B., *Smithsonian Contrib. Astrophys.*, 2, 349 (1958).

[4] Cook, A. F., *Astrophys. J.*, 120, 572 (1954).

[5] Öpik, E. J., "Physics of Meteor Flight in the Atmosphere", 25, 63 (Interscience Pub., New York, 1958).

[6] Jacchia, L. G., *Astrophys. J.*, 121, 521 (1955).

[7] The Rocket Panel, *Phys. Rev.*, 88, 1027 (1952).

GEOPHYSICS

Longitude Effect in Temperate Zone Sporadic E and the Earth's Magnetic Field

A RECENT study[1] of the occurrence of sporadic E has shown that the percentage of the time $f_0E_s >$ 5 Mc./s. exhibits a marked longitude effect, having a maximum ($\sim$ 30 per cent) over south-east Asia and minima over South Africa ($\sim$ 3 per cent) and the north-east part of the United States ($\sim$ 6 per cent). That the effect is real, and not due to differences of equipment sensitivity, has been confirmed by very high-frequency forward scatter experiments over the Caribbean and the Philippines[2]. The suggestion was put forward that this longitude effect may depend in a complex manner on both geographical and magnetic latitudes or may be due to meteorological effects[3].

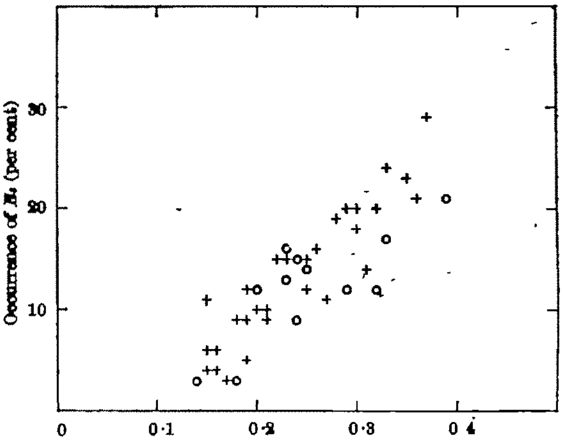


Fig. 1. Plot of percentage of time $f_0E_s > 5$ Mc./s. against horizontal component of the Earth's magnetic field. +, Northern hemisphere; O, southern hemisphere

The purpose of this communication is to point out that the horizontal component of the Earth's magnetic field has a similar variation at the Earth's surface. In Fig. 1 the percentage of the time $f_0E_s > 5$ Mc./s. for the thirty-one ionosonde stations mentioned by Smith[1] is plotted against the magnitude of the

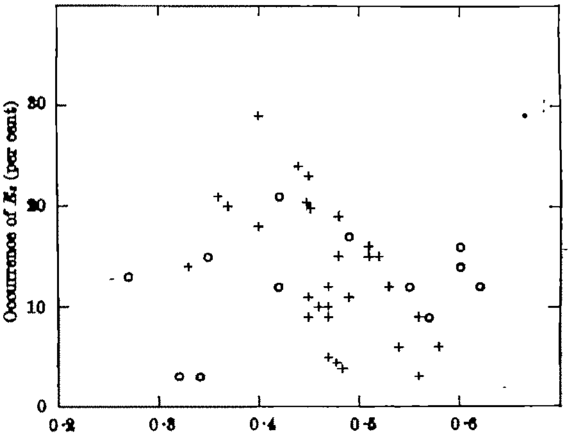


Fig. 2. Plot of percentage of time $f_0E_s > 5$ Mc./s. against total intensity of the Earth's magnetic field. +, Northern hemisphere; O, southern hemisphere

horizontal component. Results from both northern and southern hemispheres follow the same pattern.

That it is the horizontal component which is correlated with sporadic *E* appearances is confirmed by plotting the percentage time $f_oE_s > 5$ Mc./s. against the total intensity of the Earth's field (Fig. 2). There is no correlation between the two. There is some correlation between the occurrence of sporadic *E* and magnetic dip though this is almost entirely due to their correlation with the horizontal component.

It is of interest to inquire which of the various theories put forward to account for sporadic *E* depend only on the horizontal component of the Earth's magnetic field. Ionization by neutral particles or meteors does not depend on magnetic field at all but ionization by charged particles may be confined to a narrow region in the presence of a magnetic field. The total intensity, however, seems to be of importance here. Movement of existing ionization by winds or electric fields seems to be the most likely source of sporadic *E*, and is being studied further.

This work is part of the research programme sponsored by the Radio Research Board of the Commonwealth Scientific and Industrial Research Organization.

L. H. HEISLER
J. D. WHITEHEAD

Sydney Laboratory,
Radio Research Board,
Electrical Engineering Department,
University of Sydney.

---

[1] Smith, jun., E. K., "AGARDograph 34 Sporadic *E* Ionization", 1 (NATO Advisory Group for Aeronautical Research and Development, 1958).

[2] Smith, jun., E. K., and Finney, J. W., *J. Geophys. Res.*, 65, 885 (1960).

Geomagnetic Noise at 230 kc./s.

GEOMAGNETIC radio noise or 'hiss' usually occurs only in the audio region. During severe magnetic storms it has been reported up to 30 kc./s. on a sweep frequency analyser[1] and at 70 and 180 kc./s. on fixed tuned channels[2]. The latter report[2] was written after the records had been destroyed in a fire. New observations at up to 230 kc./s. are described here.

Observations were made simultaneously at the four frequencies 4, 9, 70 and 230 kc./s. (using two dual-beam cathode-ray oscillographs and photographic recording) over the period mid-September to mid-November, 1959. Geomagnetic noise was observed on three occasions only: 2245 U.T., October 31; 0430 U.T., November 3; and around 0330 U.T., November 6. The planetary magnetic index (k_p) ranged from 4 to 6 at these times. The noise burst observed on November 6 is reproduced in Fig. 1. This shows 9 and 230 kc./s. only, since the camera recording 4 and 70 kc./s. jammed on this occasion.

The general appearance of the noise burst—relatively gradual rise and decline of intensity (as distinct from the sharp 'on' and 'off' of man-made interference) and impulsive noise component superimposed on a steady or 'white' noise-level—is typical of geomagnetic noise bursts observed at audio-frequencies. The maximum noise-levels are seen to be 0·8 μV.m.$^{-1}$ (c./s.)$^{-\frac{1}{2}}$ at 9 kc./s. and 16 mμV.m.$^{-1}$ (c./s.)$^{-\frac{1}{2}}$ at 230 kc./s., corresponding to intensities of about 10^{-15} W.m.$^{-2}$ (c./s.)$^{-1}$ at 9 kc./s. and 3×10^{-19} W.m.$^{-2}$ (c./s.)$^{-1}$ at 230 kc./s. The intensities observed at 4 and 9 kc./s. at these times were typical of strong bursts at these frequencies. The 70 and 230 kc./s. intensities were of the same order as previously reported[2]. A striking feature of Fig. 1 is the close correspondence of amplitude fluctuations at the two frequencies. These appear simultaneous to the limit of reading of the time scale ($\sim$ 10 sec.).

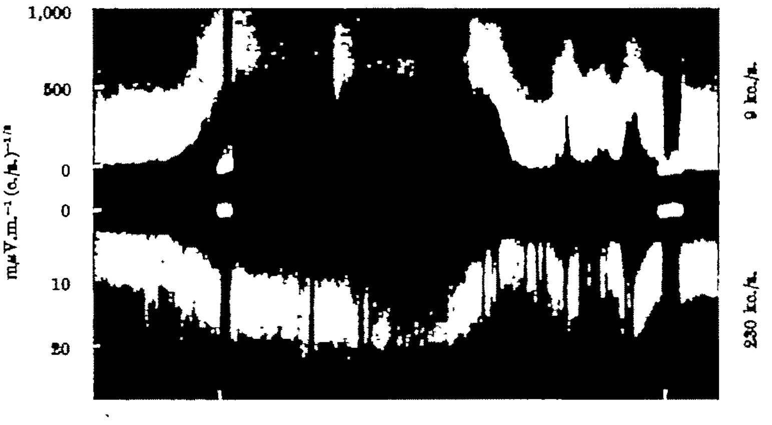


Fig. 1

A probable mechanism for generation of this noise is Čerenkov radiation from small clouds of charged particles travelling through the ionosphere and exosphere[1,2,3]. Radiation is produced at all frequencies for which the velocity of the particle clouds exceeds the group velocity of the radiation (Čerenkov condition). The close correspondence between the two frequency components observed suggests production by the same particle clouds and in the same geomagnetic tube of force since moving charged particles are effectively constrained to a tube of force.

Accordingly the tube of force ending at Hobart (geomagnetic lat. 52° S.) was considered, and the group velocities of 9 and 230 kc./s. radiation calculated[4] as a function of distance along this tube of force. Electron density as a function of radial distance was obtained from whistler data[5]. The assumption was made that the electron density in the exosphere is spherically distributed. At 9 kc./s. it was found that the group velocity would be everywhere less than 0·12 c. from the ionosphere to the equatorial plane (total distance 15,000 km.). At 230 kc./s. only radiation produced below the gyro-level is observable on the ground. From the ionosphere to the gyro-level (a distance of about 5,000 km.) the 230 kc./s. group velocity would be everywhere less than 0·17 c. Consequently, particle clouds travelling down this tube of force at 0·2 c. (say) could produce Čerenkov radiation at both frequencies. Since the travel-time even of 9 kc./s. radiation produced at 15,000 km. would be less than a second, bursts of radiation at the two frequencies would arrive at the ground simultaneously to our limit of reading.

Estimates of absolute intensities to be expected from the Čerenkov process depend too strongly on unknown factors (for example, size and number of clouds and cloud density) to be meaningful. But we can make an order-of-magnitude estimate of the relative intensities based on reasonable assumptions. If these unknown factors were the same for both frequencies we would find that the ratio of intensities produced at 9 and 230 kc./s. would be proportional to the path-length in wave-lengths for which the Čerenkov condition holds[3]. This indicates that the intensity produced at 230 kc./s. should be nearly ten times that at 9 kc./s. However, this ratio will be modified by the ear trumpet effect of the converging tube, giving enhancement proportional to the tube cross-section, which is in turn inversely proportional to the field-strength or gyro-frequency. For the tube of force under consideration this will enhance the ratio in favour of 9 kc./s. by a factor of five. Also if the attenuation in regions of high collision frequency is taken into account (from Helliwell's curves[4]) we find that 230 kc./s. will be attenuated by about eight times as many decibels as 9 kc./s. Agreement with the ratio of intensities observed at Hobart (3×10^3 or 35 db.) is reached for an assumption of about 5 db. for 9 kc./s. and hence about 40 db. for 230 kc./s.

Consideration of tubes of force ending farther south of Hobart require attenuations of 9 kc./s. considerably less than this, in keeping with observations of multi-echo whistler trains. Thus estimates based on this mechanism give reasonable agreement with observations of wide-band noise bursts for frequencies from a few kc./s. to a few hundred kc./s.

It is interesting to note that for this mechanism wide-band bursts will only be observed if the electron density distribution along a line of force is such that the plasma frequency is always greater than the gyro frequency for the range of frequencies observed. Since the electron density in the equatorial plane is obtained from whistler data this gives a lower limit to electron density at each point along the line of force.

My thanks are due to Mr. G. T. Goldstone, who built much of the equipment and assisted in the observations, and to Mr. P. S. Bowling who provided housing for the equipment in the field.

R. L. DOWDEN

Commonwealth Ionospheric Prediction Service,
Hobart, Tasmania. June 10.

---

[1] Ellis, G. R., *Plan. Space Sci.*, 1, 253 (1959).

[2] Dowden, R. L., *Nature*, 184, 803 (1959).

[3] Marshall, L., *Astrophys. J.*, 124, 469 (1956).

[4] Helliwell, R. A., "Low Frequency Propagation Studies, Part 1", ASTIA Document No. *AD*110184 (1958).

[5] Maeda, K., and Kimura, I., *Rep. Ionos. Res. Japan*, 10, 105 (1956).

[6] Ellis, G. R., *J. Atmo. Terr. Phys.*, 10, 302 (1957).

GEOLOGY

The American Oligocene

EAMES *et al.*[1] claim that the Oligocene is not represented in the marine sediments of the western hemisphere. This claim seems to conflict with the palæogeographic status of the region.

The Eastern Venezuela Basin may be taken as representative. In Trinidad the Lizard Springs, Navet, Cipero and Lengua formations form a continuous sequence of Palæocene to Miocene age. They are deep-sea deposits, essentially *Globigerina*-oozes, which accumulated along the axis of the basin.

If any appreciable time-interval is not represented in this sequence, its absence must be explained in one of three ways, namely: (1) sedimentation ceased temporarily; (2) sediments were deposited but were eroded subaerially; or (3) sediments were deposited but were removed by subaqueous processes.

Cessation of deep marine sedimentation scarcely merits consideration. The joint accumulation of fine terrigenous material and foraminiferal tests continues in basinal deeps regardless of orogenic and epeirogenic modifications of the peripheral land areas.

A pre-requisite for subaerial erosion would be uplift and emergence of the sea-floor. If this had occurred there would be abundant evidence of orogeny and regional unconformity. Even if the uplift had been epeirogenic, leaving few physical signs of unconformity, the subsidence which followed would leave the unmistakable evidence of shallow marine beds grading up into deep marine marls. The only such interruption of the deep marine sequence in Trinidad is the San Fernando formation, which is firmly correlated with the Upper Eocene (Jacksonian stage) of the region. The upper beds transitional from the shallow marine San Fernando formation to the deep marine Cipero formation are post-Eocene (*G. ampliapertura* zone).

(Eames *et al.* consider the rich Eocene faunas of the San Fernando formation re-worked in the basal Miocene. In more regional terms they imply that the "Jacksonian transgression" was an early Miocene event. The only reason given is their belief that the genus *Pliolepidina* is a Miocene index. It deserves note that in the Eastern Venezuela Basin there are extensive algal-orbitoidal reef limestones which contain *Pliolepidina* in association with such Eocene indices as *Tubulostium*, *Echinolampas*, *Oligopygus* and *Asterocyclina*. These are purely organic limestones with no clastic content except the finest of silt. The *Pliolepidinas* are definitely not re-worked, therefore this genus is unacceptable as a Miocene index in this region.)

Large-scale slumping is recognized throughout the sedimentary column in Trinidad. It is feasible, and even probable, that at any given locality some part or other of the sequence is missing by reason of submarine slumping, but it is scarcely feasible that one particular interval should be missing in this matter over the whole area. Even if this odd situation did exist on the basinal flanks the displaced beds would presumably be recognized in an allochthonous position towards the axis, and their true stratigraphic status would be established by faunal study.

In more regional terms the sequence of Upper Eocene overlain by the *G. ampliapertura* zone is known in a variety of facies ranging from shallow to deep marine. In all cases the same uniform change in the planktonic fauna defines the contact. This implies that, if there is a major hiatus between the two units, it is no more pronounced around the old land masses than in the basinal deeps, a conclusion contrary to the normal precepts of palæogeography. The Eocene top usually falls within a lithologically uniform sequence. Faunally the contact is mainly defined by extinction of a few Eocene species, not by a wholesale change of fauna. No fauna has been recorded which might fit between the suites of the Upper Eocene and the *G. ampliapertura* zone, themselves closely interconnected by evolutionary bonds. It is not realistic to postulate extensive re-working of the Eocene faunas, which are homogeneous except for an appreciable facies-variation consistent with basinal position. This latter remark applies to Trinidad, where the Upper Eocene faunas are certainly not re-worked in the ordinary usage of that word, though the type San Fernando formation might prove to be an enormous slumped mass. I have studied this interval in Ecuador, Colombia, Venezuela, Trinidad and Barbados in the New World, as well as in Egypt and France in the Old World, and have seen no significant variation from the pattern described. Published records confirm that the same is true in other countries. The one exceptional case is in Antigua, where the *G. ampliapertura* zone rests unconformably on volcanic rocks. The natural conclusion to be drawn is that sedimentation was regionally continuous from the Eocene into the *G. ampliapertura* zone, in which case the latter must be Oligocene.

This palæogeographic reasoning makes regional absence of the Oligocene unlikely in the marine sediments of the western hemisphere. Therefore an alternative explanation would be preferred for any palæontological argument which seems to point to that conclusion. In particular, Eames *et al.* note a new suite of planktonic foraminifera in the Oligocene of East Africa and infer absence of the Oligocene in America because this suite is not known there. An alternative inference is that the new fauna reflects climatic segregation of planktonic suites. Preference of certain species for certain latitudes is well established among the Recent planktonic foraminifera. The marine mid-Tertiaries in the region encompassed by Ecuador, the Gulf Coast States and Trinidad are readily correlated by the planktonic zonation of Bolli (1957) and earlier workers, but both south and north of this tropical belt the scheme tends to break down because the marker-species are scarce or absent. Likewise in the Mediterranean region almost the same zones are recognizable, but attempts to apply the zonation in northern Europe have failed because a different, boreal suite of plankton is present. It seems that a similar situation might well exist in the southern parts of Africa and South America. The observed affinities of this new fauna to Oligocene plankton in Germany and Russia, but apparently not in the Mediterranean countries, give some support to the concept of distinct tropical–subtropical and boreal–austral suites of planktonic foraminifera in the Oligocene.

No detailed comments are offered here on the status of larger foraminifera in this problem, but I opine strongly that the palæogeographical evidence for the presence of the Oligocene in America should outweigh strictly faunal evidence pointing to the contrary. The case of *Pliolepidina*, already cited, shows that like forms were not precisely coeval over the entire world. Regarding the Miogypsinidae, doubt is expressed as to their presence in the *G. ampliapertura* zone as I have never encountered them *in situ* below the *G. dissimilis* zone. Kugler (1954) has referred to them in the older zone, but specifies that he is writing of allochthonous material slumped into Miocene marls. The presence of the ancestral *Rotalia mexicana*-group in the *G. ampliapertura* zone in Ecuador, Colombia, Mexico and Puerto Rico makes the presence of Miogypsinidae at that level improbable.

Extensive bibliographical references to these matters are included in a paper about to be published[2].

R. M. Stainforth

Jusepin, Venezuela.

---

[1] Eames, F. E., *et al.*, *Nature*, 185, 447 (1960)

[2] Stainforth, R. M., *Rev. Micropaléont.* (in the press).

Following from Dr. R. M. Stainforth's comments on our communication, we would direct attention to the fact that it contained merely some of the conclusions reached in our study of "Mid-Tertiary Stratigraphical Palæontology", which will be published as an entire, illustrated book, and it is obvious that we could not give the full background in such a short space. However, the following is a very brief outline of part of the picture which has emerged from our studies.

The standard European stages of Upper Eocene, Oligocene and Lower Miocene ages may be traced from the European molluscan facies into the Mediterranean region, where they can be defined in terms of planktonic and benthonic foraminifera; these divisions can be recognized throughout the Middle East to the Far East, where the 'letter-stages' proposed by van der Vlerk for the Tertiary of Indonesia can be readily correlated with the European standard, and both may be correlated with the series of planktonic-foraminiferal zones erected by Bolli and others in the Caribbean. It is an inescapable fact that if the popular age-determinations of Central American middle Tertiary marine sediments are accepted, then that area is palæontologically out of step with the rest of the world. If sedimentation in Trinidad, for example, were really continuous from the Eocene to the Miocene (and the lower Cipero formation be regarded as Oligocene), then one can only conclude that the larger foraminifera (for example, *Miogypsina* s.s.), the planktonic foraminifera (for example, all species of the Globigerinidae which are stratigraphically relevant) and Mollusca (for example, by regional correlation, *Anadara*, *Chione*, *Timoclea*) occur at stratigraphically older horizons in America than anywhere else in the world. As there is no satisfactory evidence to the contrary, we believe that the occurrences of these fossils were isochronous, and that there occurred a major hiatus in the Caribbean sequence, a hiatus including at least the equivalent of the *Nummulites fichteli* beds of Europe ('c' and 'd' stages of the Far East), which contain (in Africa) a rich and distinctive assemblage of planktonic foraminifera, unrepresented in America. We have been able to trace the evolutionary history of many lineages of Globigerinaceae from the Upper Eocene to the Aquitanian in richly fossiliferous and well-dated sediments in East Africa; we have found that the Oligocene stages of these lineages are present in sediments of areas as far removed as western European and Indonesia–Australasia, but that these stages are conspicuously absent in America, between the Jacksonian and the Vicksburgian.

It has been known for decades that the Vicksburg formation rests disconformably on the Jackson, and that it contains in its lower beds (for example, the Red Bluff Clay) abundant re-worked fossils of the Eocene. It has been common knowledge that the sediments of Trinidad, far from constituting a "lithologically uniform sequence" as stated by Dr. Stainforth, have been repeatedly reported to contain boulder beds (with some 'boulders' up to 3,500 cu. ft. in volume), rubble beds with *Pholas*-bored pebbles, and re-worked fossils of Upper Cretaceous, Palæocene, Lower, Middle and Upper Eocene ages immediately above the horizon where we, on quite other (purely palæontological) grounds, would place the Miocene/Eocene unconformity. The San Fernando 'formation' we believe to be the basal bed of the Miocene transgression; far from being "firmly correlated with the Upper Eocene", as Dr. Stainforth suggests, our world-wide studies suggest that its fossil content is a mixed one, and that its youngest elements are characteristic of the Miocene. This does not conflict with the well-known fact that the lithology of the San Fernando 'formation', surrounding the re-worked boulders, is very close to that of the succeeding Cipero (into which it grades) but quite different from the underlying Navet; it is confirmed by our recognition of the lowest planktonic foraminiferal zones of the Cipero in acknowledged Aquitanian deposits elsewhere in the world.

It should be realized that many other widely held and long-established assumptions fundamental to mid-Tertiary dating in Central America (for example, the supposed Oligocene age of the Antigua Limestone coral fauna), when critically re-examined, prove to have little or no foundation in fact. The ages assigned to some species of several other groups of marine fossils (for example, Echinoidea, Bryozoa, Decapoda, etc.) from the Central American region will need revision in view of the evidence we shall present.

The known stratigraphical distribution of *Pliolepidina* depends on the interpretation of the morphology of that genus; we suspect that Dr. Stainforth has been led astray by W. Storrs Cole's misconceived treatment of *Lepidocyclina* and related genera. We redefine the relevant genera and restrict *Pliolepidina* to forms congeneric with *Multilepidina*, which is not known beneath the Miocene. It should be remembered in this context that no true *Nummulites* have ever been recorded above the Eocene in America, American post-Eocene *Nummulites*-like forms being referable to *Palaeonummulites* (which includes *Operculinella* and *Operculinoides*). With regard to the occurrences of *Echinolampas* and *Oligopygus*, *Echinolampas* ranges from Eocene to Recent, and *Oligopygus* occurs in the Eocene and also at levels at which Lower Miocene planktonic foraminifera occur, so that Dr. Stainforth's implication that they are Eocene indices does not seem wise. We should also like to place on record that the '*Rotalia*' *mexicana* group occurs as high stratigraphically as the Aquitanian in the Mediterranean region, and we believe it to range equally high in Central America. Also, it is mere hypothesis that this group (or even the genus *Neorotalia* to which it probably belongs) was ancestral to any of the Miogypsinidae, and even if this were found to be so, there would be no *a priori* reason to assume that the ancestral group would become extinct at the advent of its descendants.

The references for this study are so extensive, interrelated and mutually inconsistent (any brief selection would be misleading) that we can only refer the reader to the full discussion in our book, which contains a fully comprehensive bibliography, and which will soon be published.

F. E. Eames
F. T. Banner
W. H. Blow
W. J. Clarke

The British Petroleum Co., Ltd.,
Exploration Division,
B.P. Research Centre,
Chertsey Road,
Sunbury-on-Thames,
Middlesex.

Major Element Relationships in Tektites

The chemical composition of tektites is a major factor to be considered when investigating theories of tektite origin. Many investigators have remarked on the similarity of the composition of tektites to certain types of sedimentary rocks, and this fact has been held to be indicative of a terrestrial origin. Recent determinations[1] of the abundances of the alkali elements, lithium, sodium, potassium, rubidium and cæsium in australites showed that a close coherence existed between these five elements in different samples; in fact, the concentration of one alkali element was shown to be positively correlated with the concentration of any other to a high degree of significance.

Following on from this, it seemed worth while to investigate the possible correlations between the concentrations of other elements in tektites. This has been done, utilizing the published data for australites. A notable fact emerges, namely, that silica concentration is significantly negatively correlated with the concentrations of aluminium oxide, ferrous oxide, magnesium oxide, potassium monoxide and calcium oxide. By way of illustration we show the silica versus alumina graph (Fig. 1). The regression lines (silica on alumina and vice versa) have been drawn in, and it is interesting to note that both lines pass through 100 per cent silica to within 3 per cent. This fact, plus the presence of the well-known lechatelierite (fused silica) particles in tektites, suggested to us that tektite composition could perhaps be explained on the basis of a mixing process between

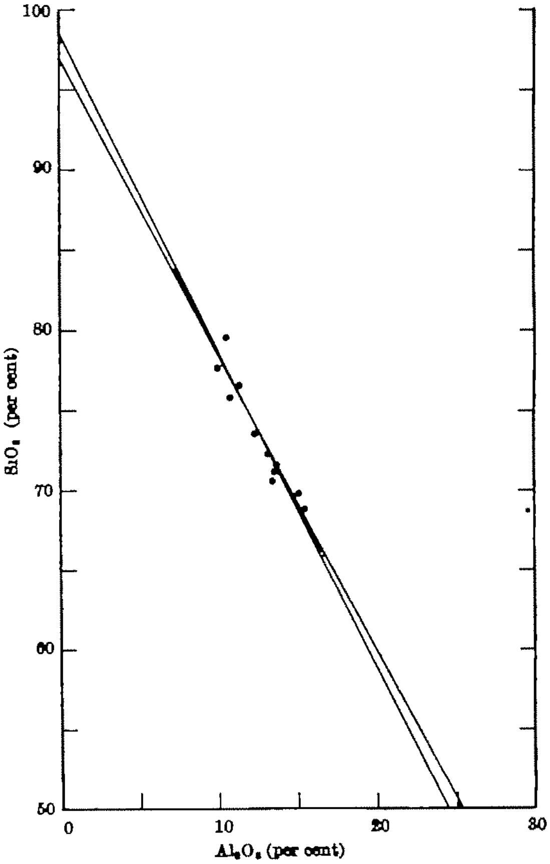


Fig. 1. Inverse relationship between silica (SiO_2) and alumina (Al_2O_3) for the australites. The regression lines are shown

silica and some other (unknown) material. A brief search suggested that the non-volatile (at 1,700° C.) constituents of ordinary shale would form a suitable 'unknown' material, and in Table 1 we give the chemical composition resulting from such a mixing process with a quartz : shale ratio of 1 : 3. Column 2 of the table must be compared with column 3, which gives the average tektite figures. The agreement is seen to be excellent, and it seems evident that a hypothesis that tektites are derived from a shale–quartz mix will explain the major element compositions of tektites. Shale and quartz are both extremely common terrestrial materials, and lack of availability will present no problem. The question of the mechanism of the mixing process remains. In this connexion we can present no evidence, though the Urey comet hypothesis[2] still seems to us to be a promising theory.

Table 1. COMPARISON OF COMPOSITION OF TEKTITES WITH THAT OF A MIXTURE OF SiO_2 WITH THE NON-VOLATILE (AT 1,700° C.) CONSTITUENTS OF SHALES

	1	2	3
SiO_2	64·32	73·24	73·73
TiO_2	0·72	0·54	0·86
Al_2O_3	17·05	12·79	12·47
FeO	6·72	5·04	4·92
MgO	2·70	2·03	2·12
CaO	3·44	2·58	2·50
Na_2O	1·44	1·08	1·32
K_2O	3·59	2·69	2·32
Total	99·98	99·99	100·24

Column 1. Composition of average shale from Pettijohn[3] (Table 61, p. 344) recalculated to 100 per cent following removal of water, carbon dioxide, SO_3 and organic matter.

Column 2. Composition of a mixture of three parts of column 1 with one part of silica.

Column 3. Average composition of 61 tektites from Barnes[4]. The analyses of Darwin glass and Libyan Desert glass quoted by Barnes[4] are excluded from this average.

The above results will be published in greater detail elsewhere, and discussed more fully.

R. D. CHERRY

Department of Physics,

S. R. TAYLOR
MAUREEN SACHS

Department of Geochemistry,
University of Cape Town.
June 30.

---

[1] Taylor, S. R., *Geochim. et Cosmochim. Acta* (in the press).

[2] Urey, H. C., *Nature*, 179, 556 (1957).

[3] Pettijohn, F. J., "Sedimentary Rocks", Second ed. (Harper and Bros. N.Y., 1957).

[4] Barnes, V. E., Univ. Texas Publications No. 3945, 477 (1940).

PHYSICS

A Comparison of Atomic Beam Frequency Standards

STANDARD frequencies obtained from various cæsium atomic beam frequency standards have been compared in a number of instances[1–4]. The results of Holloway *et al.*[1] showed agreement to about 2×10^{-10} between the commercial beam standards developed and manufactured by the National Company and the atomic standard at the National Physical Laboratory, Teddington, England[4].

Two dissimilar beam standards at the National Bureau of Standards have been compared over the past several months. Their frequencies agree to within $\pm 1{\cdot}5 \times 10^{-11}$ (standard deviation of the mean for the comparisons and estimated uncertainty due to effects of pertinent parameters).

These machines employ Ramsey-type excitation, the separation of the oscillating fields being 55 cm. in one case and 164 cm. in the other. Beam dimensions are 0·003 in. × 0·100 in. and 0·015 in. × 0·187 in., respectively. The hot wire detectors (20 per cent iridium–platinum alloy) are used in conjunction with conventional electrometer circuits. Typical signal-to-noise ratios range between 100 and 400. The uniform magnetic *C* field in the transition region is produced by passing a d.c. current of about 1 amp. through a conducting section of a cylindrical brass tube contained within a magnetic shield. A double shield is used on the longer machine and a single shield on the shorter.

There are a number of uncertainties in absolute frequency measurements introduced by the measuring devices themselves. Those effects contributing most significantly to the overall uncertainty of the measurements are: (*a*) the magnitude and non-uniformity of the *C* field; (*b*) a phase difference between the two oscillating electromagnetic field regions; (*c*) a lack of purity of the electromagnetic field exciting the atomic transition.

The magnitude of the *C* field was determined in four different ways: by calculation from the known geometry of the conducting strip and the current used; by direct measurement using a rotating-coil fluxmeter sensitive to 0·002 oersted; by measurement of the low-frequency $\Delta F = 0$, $\Delta m_F = \pm 1$ transitions which are strongly dependent on the magnitude of the field; and by measurement of other microwave transitions, such as the $(F = 4, m_F = 1) \leftrightarrow (F = 3, m_F = 1)$ transition, which are more sensitive to the field than the standard frequency transition. The uniformity of the *C* field was determined by measuring the low-frequency transitions, utilizing small coils located at each end of the resonant cavity and at the centre of the transition region. These localized field measurements indicate that the maximum *C* field variation along its length is ± 0·002 oersted. This non-uniformity can introduce at most an uncertainty of 4×10^{-12} in the measured frequency. At the time of the initial comparisons of the two standards the values of the *C* field magnitude as measured by the different methods agreed to within the precision of the measurements (± 0·002 oersted) for both machines. Since that time, however, the shielding properties of the mumetal shields have deteriorated to some extent, accompanied in the case of the longer machine by a discrepancy among the various types of field measurements of about 0·004 oersted at a field of 0·080 oersted. In order to reduce the resulting uncertainty in the frequency measurements to below 1×10^{-11}, smaller *C* fields (about 0·020 oersted) have been used in the more recent comparisons. Possible frequency shifts arising from the nearness of other transitions at these low fields have been calculated and found to be well below 1×10^{-11} for the degree of symmetry of position and amplitude observed for the nearby transitions.

The oscillating fields exciting the $(F = 4, m_F = 0) \leftrightarrow (F = 3, m_F = 0)$ transition are produced at the two ends of a single resonant U-shaped rectangular cavity operating in the $TE_{0,1,66}$ mode for the shorter machine and in the $TE_{0,1,160}$ mode for the longer machine. The cavities were precisely electroformed for symmetry about the coupling hole to the microwave transmission line from the frequency multiplier chain. The atomic beam grazes the shorted end walls of the U-shaped cavity. Provision for tuning the cavities in the event of large room-temperature changes is provided by a tuning plunger opposite the coupling hole.

Frequency uncertainties introduced by a phase difference between the two ends of the cavity were investigated by rotating the cavity 180°, that is, by interchanging the two oscillating field regions. No frequency shift was measurable under this operation for either machine.

If the electromagnetic field exciting the transition is not pure, that is, if this signal is frequency modulated, rather large frequency uncertainties are possible in the measurements. The exciting radiation is ordinarily produced by frequency multiplication by a factor of 1836 from a stable quartz crystal oscillator. Side-bands in the power spectrum introduced in the oscillator or first stages of the frequency multiplier chain are enhanced significantly by the multiplication process. What is worse, side-bands resulting from frequency modulation are not, in general, symmetrically placed about the 'primary' signal. The power spectrum of the exciting radiation for the Bureau standards was examined using an ammonia maser stabilized frequency multiplier chain as a spectrum analyser[5]. The signal was found to have a bandwidth of about 6 c./s. at 9,000 Mc./s., was symmetrical and contained no observable side-bands. Any shift introduced from this source would be much less than the precision of measurement. In general, however, side-bands will be present to some extent. In one experiment where side-bands were deliberately introduced, the measured frequency was shifted by 3×10^{-9}.

The effects discussed above are those that we consider to contribute most significantly to the uncertainty of absolute frequency measurements if adequate care is not taken in construction and testing. We have found it possible to reduce these uncertainties to a level below 1×10^{-11}.

Initial comparisons of the two standards were made during a ten-day period with each daily comparison consisting of an average of from 15 to 25 measurements with each standard. If $\Delta\nu_i$ denotes the zero-field frequency difference between the two machines for the ith day, then the measured average difference for the ten-day period was:

$$<\Delta\nu>_{av} = \frac{1}{n}\sum_{i=1}^{n} \Delta\nu_i = 0, \text{ where } n = 10$$

The standard deviation of the mean for this particular test was:

$$\sigma_M = \frac{1}{\nu}\left[\frac{\sum_{i=1}^{n} (\Delta\nu_i - <\Delta\nu>_{av})^2}{n(n-1)}\right]^{1/2} = \pm 1{\cdot}6 \times 10^{-11}$$

The estimated uncertainties introduced by the effects discussed above fall within this precision. During later tests on the standards a more complete set of comparisons was obtained consisting of 18 separate comparisons taken over a period of one month. The average zero-field frequency difference for this period was 9×10^{-12} with a standard deviation of the mean of 6×10^{-12}. To this standard deviation was added the maximum uncertainty in frequency contributed by the C field (9×10^{-12}), giving $\pm 1{\cdot}5 \times 10^{-11}$ as the limits quoted for the agreement of the two machines. The uncertainty introduced by the discrepancy in the C field measurements noted above was reduced to less than 1×10^{-11} by using low fields. Since this discrepancy seems to be associated with a noticeable deterioration of the C field shielding, it is likely that for most precise results the shields will have to be exchanged periodically for newly annealed ones.

One indication of the reproducibility of measurements made with the longer machine was obtained by comparing eight separate sets of measurements of 'Atomichron 106' during an 8-hr. period. Each set or sub-group consisted of 15 measurements taken in a period of about 15 min. The standard deviation of the mean for each sub-group was 1×10^{-11}, while the standard deviation of the mean for the average of all the results was 5×10^{-12}. A similar experiment was conducted in which an extremely low-drift crystal oscillator with its crystal immersed in liquid helium was measured instead of the 'Atomichron'. These measurements gave 7×10^{-12} as the standard deviation of the mean for each sub-group and 2×10^{-12} as the standard deviation of the mean for the average of all the results taken during the period of several hours. The various parameters affecting the frequency measurements, then, are sufficiently constant that measurements can be made to a precision of 2×10^{-12} in periods of several hours or longer; however, uncertainty in the exact values of some of the parameters limits the accuracy to about $1{\cdot}5 \times 10^{-11}$.

The longer of the two machines is the present United States Frequency Standard. The shorter machine is an alternate standard[3]. The frequency assumed for the $(F = 4, m_F = 0) \leftrightarrow (F = 3, m_F = 0)$ transition of cæsium in zero field is 9192631770·0 c.p.s. The best comparison between cæsium and Ephemeris Time at present is that given by Markowitz, Hall, Essen and Parry as 9192631770 ± 20 c.p.s.[6].

Corrections for the 60 kc./s. standard frequency broadcasts of Station *WWVB* (formerly *KK2XEI*), Boulder, Colorado, are made each week and are available upon request.

We believe that the experiments demonstrate that with adequate care in construction and testing, atomic beam standards can be expected to agree in frequency without special recipes in design, and indeed they behave precisely as one would predict from theory—one need only know the values of the pertinent parameters to sufficient accuracy. This information must be obtained from appropriate tests.

R. E. BEEHLER
R. C. MOCKLER
C. S. SNIDER

National Bureau of Standards,
Boulder, Colorado.

---

[1] Holloway, J., Mainberger, W., Reder, F. H., Winkler, G. M. R., Essen, L., and Parry, J. V. L., *Proc. Inst. Radio Eng.*, 47, 1732 (1959).

[2] McCoubrey, A. O., Inst. Rad. Eng. Trans. on Instrumentation, *PGI*, I-7, 203 (1958).

[3] Mockler, R. C., Beehler, R. E., and Barnes, J. A., "Quantum Electronics—A Symposium", edit. by Townes, C. H., 127 (Columbia University Press, 1960).

[4] Essen, L., and Parry, J. V. L., *Phil. Trans. Roy. Soc.*, A, 250, 45 (1957).

[5] Barnes, J. A., and Heim, L. E., "A High Resolution Ammonia Maser Spectrum Analyzer" (to be published).

[6] Markowitz, W., Hall, R. G., Essen, L., and Parry, J. V. L., *Phys. Rev. Letters*, 1, 105 (1958).

Isotopic Analysis of Silicon by Solid-Source Mass Spectrometry using Negative Ions

An A.E.I. mass spectrometer, type *M.S.2/S.*, fitted with an electron multiplier and having a triple tungsten filament as source for the thermal ionization of solids is being used for measurements of the abundance of silicon isotopes.

The instrument normally records the amplified current peaks of positive ions. In the case of silicon, it has not been possible so far to detect a positive ion from thermal ionization, but after reversing the polarity of the accelerating voltage and magnetic field of the instrument, negative ions have been measured corresponding to SiO_3^- at values of m/e of 76, 77 and 78.

The filament source is loaded with an alkali silicate, and the best results are obtained from cæsium silicate. This is in accordance with the ionization potential of cæsium, which is the lowest for the natural alkali element series; thus no ions are obtained from sodium silicate and only small peaks from potassium silicate.

D. C. Newton
J. Sanders
A. C. Tyrrell

The Plessey Co., Ltd., Caswell,
Towcester, Northants.

July 21

High-Energy Oxygen Ions in Carbon Dioxide Mass Spectra

Mass spectra of carbon dioxide have been recorded using a low accelerating voltage and magnetic scanning. Under these conditions, a variant of those due to Mohler *et al.*[1], ions with more than thermal energies will appear as satellite peaks in the spectra. The energies of the ions can then be derived from the separation of the peaks by the use of the mass spectrometer focusing equation.

A high-energy state in oxygen ions has been observed as a satellite on the high-mass side of the main peak due to thermal energy oxygen ions. The energy of this state in oxygen ions was found to be $3 \cdot 5_1$ V. when the energy of the ionizing electrons was 70 V. The apparent appearance potential was 35 V. (the voltage scale being corrected by the known value for the thermal energy peak of the oxygen ion[2].

These values would suggest that the ions were due to the dissociation of doubly charged ions[1]; those possible are O_2^{2+}, CO^{2+} or CO_2^{2+}. It will be seen that the appearance potential is lower than those found for O_2^{2+} from oxygen (50 V.) and for CO^{2+} from carbon monoxide, namely, 42 V. (ref. 2). Ions of O_3^+ were not detected under the present conditions; and thus if the mechanism is $O_2^{2+} \rightarrow 2\,O^+$, a previous reaction similar to one suggested by Ogryzlo and Schiff[3], namely, $CO_2 + O \rightarrow CO + O_2$, seems preferable to a rearrangement reaction involving O or a secondary reaction induced by pressure. The CO_2^{2+} mechanism, namely, $CO_2^{2+} \rightarrow CO^+ + O^+$, is the most probable, as CO_2^{2+} ions exist in the mass spectrum and the appearance potential of the O^+ ion state is comparable to that of CO_2^{2+} ions, about 36 V. by comparison with the known value for A^{2+} ions[2]. This reaction was also postulated by Newton[4] to explain other phenomena in the mass spectra of carbon dioxide. However, if the reaction is indeed $CO_2^{2+} \rightarrow CO^+ + O^+$, a definite energy-state would be expected in the CO^+ ions.

Only the main ion peak, together with high-energy tailing, was apparent in the C^+, CO_2^{2+} and CO^+ ion peaks. The main excitation energy found for O^+ ions from carbon monoxide under these conditions (70 V. ionizing electrons, 230 V. accelerating voltage) was $2 \cdot 4_2$ V., compared with Hagstrum's value of 1·5 V. by the retarding potential method and Berry's value of 0·65–2·5 V. by the deflexion method[2]. When ionizing electrons of 70-V. energy were used, the O^+ ion peak from oxygen showed a high-energy tail but no evidence of a discrete high-energy state.

The ratio between the ions of high-energy state and the thermal energy ions was affected by variations in the ion repeller voltage, which altered the time of residence of the ions in the ion chamber. Low voltages, down to 0·5 V., favoured the high-energy state, presumably because the time available for dissociation was increased, whereas higher voltages, up to 8 V., resulted in the predominance of the thermal-energy ions.

The mass spectrometer is a 10-cm. radius 90° deflexion A.E.I. instrument with a source of Nier type.

This communication is published by permission of the Director of the Central Electricity Research Laboratories, Leatherhead.

R.-M. S. Hall

Central Electricity Research Laboratories,
Leatherhead, Surrey.

---

[1] Mohler, F. L., Dibeler, V. H., and Reese, R. M., *J. Chem. Phys.*, **22**, 394 (1954).

[2] Values taken from Field, F. H., and Franklin, J. L., "Electron Impact Phenomena" (Academic Press, New York).

[3] Ogryzlo, E. A., and Schiff, H. I., *J. Chem. Phys.*, **32**, 628 (1960).

[4] Newton, A. S., *J. Chem. Phys.*, **20**, 1330 (1952).

METALLURGY

Formation of Fayalite in Roast Reduced Jaspilite

A magnetizing roasting treatment of a fine-grained hæmatite-quartzite known as jaspilite, occurring in South Australia, is at present being evaluated[1]. When heated in reducing gases at appropriate temperatures, 550–650° C., the hæmatite in jaspilite is converted to magnetite. Extensive microcracking also occurs in the quartz matrix (Fig. 1*A*). This cracking allows freer access of reducing gases to the hæmatite particles undergoing reduction and facilitates grinding prior to magnetic concentration[2].

In contrast to prior investigations[3], roast reduction treatments much above 650° C. have led to lower rates of reduction, lower recoveries of magnetite, and less apparent cracking.

One reason for this, other than the effect of increased temperature in reducing the tendency of quartz to crack and part from the hæmatite, has been found to be the formation of fayalite ($2FeO.SiO_2$), by a solid-state diffusion reaction at the operating temperature.

That fayalite will form when hæmatite is reduced in the presence of silica at higher temperatures, 800–1,000° C., has previously been reported[4,5]. Indeed,

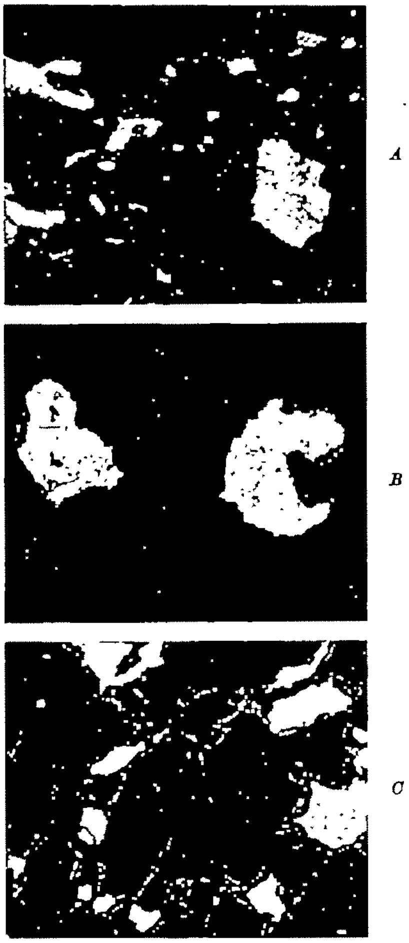


Fig. 1. Roast reduced jaspilite, vacuum mounted in epoxy resin, polished and examined, unetched, in reflected light : *A*, reduced in hydrogen at 550° C. for 10 min. Magnetite (grey) in a matrix of cracked quartz (dark grey) (× *c.* 330); *B*, reduced in 4 per cent carbon monoxide, 6 per cent carbon dioxide and 90 per cent nitrogen at 900° C. for 160 min. Fayalite forms at the magnetite-quartz, not at the hematite-quartz interfaces (× *c.* 660); *C*, reduced in hydrogen at 950° C. for 45 min. Over-reduction to wustite and fayalite. The fayalite fills cracks in the quartz. The resulting voids near the wustite have been filled with mounting resin (× *c.* 330)

Darken[6] has shown that, in the presence of an excess of silica, fayalite, not magnetite, becomes the stable phase under the reducing conditions normally employed.

This present work has shown that fayalite, formed at as low a temperature as 650° C., has the capacity to bond the magnetite and quartz, sealing the interface (Fig. 1*B*) and thus, by hindering access of reducing gases to the interior reduction zone, decreases the rate of reduction. Fayalite was identified by X-ray diffraction and by refractive index measurements.

The dihedral angle of fayalite in quartz has been found to be low, and at higher temperatures fayalite diffuses into, and fills, the microcracks (Fig. 1*C*). Non-magnetic fayalite adhering to silica and magnetite adds to the difficulties in effecting high recoveries of a high-grade concentrate in subsequent grinding and magnetic separation.

Further details of this work, including a discussion of the kinetics and mechanism of reduction cracking, will be published elsewhere.

The permission of the director of research, Dr. H. K. Worner, to publish this communication is gratefully acknowledged.

J. B. Lean
K. J. Tucker
B. O. Holland
T. R. Thomson

The Broken Hill Pty. Co., Ltd.,
Central Research Laboratories,
Shortland, 2N,
New South Wales.

[1] Edwards, J. B. J., and Salamy, S. G., Amer. Inst. Mech. Eng., Annual Meeting, New York, Feb., 1960 (to be published).

[2] Salamy, S. G., Broken Hill Pty., Tech. Bull., 4, (1), 2 (1960).

[3] DeVaney, F. D., *Trans. Amer. Inst. Mech. Eng.*, 193, Mining Engineering, 1219 (1952).

[4] Van Hofsten, G., *VARM Bergsmans Ann.*, 59 (1951).

[5] Baldwin, B. G., *J. Iron and Steel Inst.*, 177, 312 (1954).

[6] Darken, L. S., *J. Amer. Chem. Soc.*, 70 (6), 2046 (1948).

Stabilization of Austenite by Hydrogen

Attempts to study the possible effects of hydrogen on the austentite–martensite transformation in steels have always to reckon with the difficulty of retaining adequate amounts of hydrogen in them, regardless of the amounts initially present. The austenitizing and heat treatment of steels are generally carried out at virtually atmospheric pressures or in vacuum. As the diffusion-rates of hydrogen at elevated temperatures are considerable, the amount of hydrogen retained in the austenite, prior to its being heat-treated, is generally small. It is also not so much in excess of the solubility limits as to render it likely that the hydrogen atoms play a part similar to that played by carbon atoms, which are generally retained in appreciable amounts and in a state of considerable supersaturation when the matrix changes to the body-centred structure. In the comparatively small amounts, therefore, in which hydrogen is retained in normally austenitized and heat-treated steels the likelihood of its affecting the stability of austenite may well be negligible (Ramachandran, E. G. and Dasarathy, C., unpublished work).

If, however, either a mode for austenitization and subsequent heat treatment of a steel with any specified, high amount of hydrogen can be devised, so as to retain adequate hydrogen in the austenite, or the hydrogen content of a normally heat-treated steel is increased when it is still austenitic and at a stage prior to its transformation to martensite, it may be possible to detect the effects of hydrogen on the austenite–martensite transformation. As austenitization in hydrogen at such high pressures as to ensure its adequate retention is, however, difficult to carry out (there is no guarantee even then, that hydrogen is not nearly completely lost by the austenite when it is cooled in salt, lead, oil or aqueous baths to transform to martensite) the first course does not appear to be feasible. The failure, therefore, by Ko and Edmondson[1] to detect any stabilization of austenite in a nickel steel, even when it was cathodically impregnated with hydrogen at room temperature but transformed after austenitization, 24 hr. after the impregnation, at 1,100° C. for 30 min. in vacuum, may well be understood.

The second alternative is quite feasible and allows the effect of hydrogen, when suitably introduced, on the stability of austenite to be studied, as may be seen from the following results, obtained on a 1·1 per cent carbon, 2·83 per cent chromium steel and a 18–8 low carbon (0·08 per cent) unstabilized stainless steel.

A. Chromium steel, austenitized in argon at 980° C. for 1½ hr. M_s temperature, 93° C. (approx.)

Heat treatment	Hardness (V.P.N., 30 kgm. load) (Mean of four impressions)
1. Quenched from 980° C. in boiling water at 98° C., held for 90 sec., and quenched in an aqueous solution of 10 per cent sulphuric acid, held at 18° C.	755
2. Quenched from 980° C. in an aqueous solution of 5 per cent sulphuric acid held at 98° C. for 15 sec., during which, using the bath as electrolyte, the specimen was cathodically impregnated, transferred to boiling water at 98° C. for 75 sec. and afterwards quenched in an aqueous solution of 10 per cent sulphuric acid, held at 18° C.	710
3. Quenched from 980° C. in an aqueous solution of 5 per cent sulphuric acid held at 98° C., subjected thrice to hydrogen impregnation and removal cycle as in 2 and finally quenched in an aqueous solution of 10 per cent sulphuric acid, held at 18° C.	710

B. Stainless steel, austenitized in argon at 1,050° C. for ½ hr. Approximate M_s temperature, −130° C.

Heat treatment	Hardness (V.P.N., 30 kgm. load) (Mean of four impressions)
1. Quenched from 1,050° C. in water at 18° C.	155
2. Quenched from 1,050° C. in water at 18° C., held at room temperature for 40 min., quenched in liquid air (−196° C.) and upquenched to water at 18° C.	169
3. Quenched from 1,050° C. in water at 18° C., transferred to an aqueous solution of 5 per cent sulphuric acid and cathodically impregnated for 40 min., quenched in liquid air and upquenched to water at 18° C.	164
3a. Above specimen aged at room temperature for 60 hr.	162
4. Quenched from 1,050° C. in water at 18° C., cathodically impregnated for 40 min., as in 3, transferred to boiling water at 98° C. for 75 sec., quenched in liquid air and upquenched to water at 18° C.	158

The above stabilization of austenite by hydrogen and the conditions under which it is detectable can be theoretically worked out from the concepts regarding austenite stabilization put forward originally by Cohen *et al.*[2], and amplified by us[3,4] and will be discussed in a subsequent communication.

We thank Dr. B. R. Nijhawan, director of the National Metallurgical Laboratory, Jamshedpur, for discussion and permission to publish this communication.

E. G. RAMACHANDRAN
C. DASARATHY

National Metallurgical Laboratory,
Jamshedpur, India. May 5.

---

[1] Ko, T., and Edmondson, B., *Acta Met.*, 2, 235 (1954).

[2] Cohen, M., Machlin, E. S., and Paranjpe, V. G., "Thermodynamics in Physical Metallurgy", 162 (A.S.M., 1949).

[3] Ramachandran, E. G., and Dasarathy, C., *Acta Met.*, 8, 274 (1960)

[4] Ramachandran, E. G., and Dasarathy, C., *Acta Met.* (in the press)

Retained Austenite and the Tempering of Martensite

THE decomposition of retained austenite as the second stage in the tempering of quenched steels is well recognized, and has been explored extensively. However, the role of retained austenite in the first stage tempering reaction has not been studied widely. That this may not be a passive role is suggested by the infrequent reports that a change in austenite chemistry by carbon enrichment accompanies this stage of tempering[1-3].

The first-stage tempering reaction takes place within the martensite platelets and occurs quite rapidly without the need for an induction period[4,5]. This process appears to occur discontinuously by the precipitation of ϵ carbide and the creation of a low-carbon martensite containing approximately 0·25 per cent carbon[3-5]. That is, the original supersaturation of the martensite is not relieved completely during the first-stage reaction. Normally, it is not until the third stage of tempering that the supersaturation of this low-carbon martensite is reduced further by the precipitation of the more stable carbide—cementite.

The reason for a matrix carbon content in the 0·2–0·3 per cent carbon range has received two divergent interpretations based on metastable equilibrium concepts. One view[4,5,7] ignores any interaction between martensite and retained austenite and assumes that the matrix carbon content is dictated by a metastable equilibrium between ϵ carbide and the low-carbon martensite. Alternatively[6], the matrix carbon content may be determined by a metastable equilibrium between ferrite (low-carbon martensite) and supercooled (retained) austenite. The latter concept is based on extrapolation of the ferrite (*GP*) and austenite (*GS*) solubility curves on the Fe—C equilibrium diagram. In effect, these two interpretations represent alternate means whereby the supersaturation of martensite may be lowered. In this sense, they compete with the more stable equilibrium involving cementite, and kinetic factors will determine the relative importance of each of the three reactions in the overall decomposition sequence. The part played by the ϵ carbide and cementite reactions is recognized clearly as the first and third stages of the tempering process; however, interaction with the retained austenite requires further clarification.

One of the critical points in deciding between these two interpretations of the matrix carbon content centres around the extrapolation of the ferrite and austenite solubility lines. It seems likely that these curves will exhibit retrograde behaviour[6] so that the solubility of carbon in ferrite (in metastable equilibrium with austenite) should be much less than 0·25 per cent carbon. Under this condition, it must be presumed that the 0·25 per cent carbon-level is controlled by metastable equilibrium with ϵ carbide. Nevertheless, when a martensite plate is surrounded by austenite, this low-carbon martensite should transfer much of its excess carbon to the austenite in an effort to achieve the lower carbon content demanded by the ferrite–austenite equilibrium. Thus, it should be possible to distinguish between these two interpretations of the matrix carbon content by studying the influence of retained austenite on the first stage tempering reaction.

According to this concept, martensite plates surrounded by austenite should lower their carbon content (below 0·25 per cent carbon) much more rapidly than those surrounded by other martensite plates. To check this possibility, two samples of a 9395 steel (composition: 0·95 per cent carbon, 0·22 per cent silicon, 0·60 per cent manganese, 3·07 per cent nickel, 1·23 per cent chromium, 0·13 per cent molybdenum) were prepared with different austenite–martensite ratios. Both samples were quenched in water after 24 hr. at 2,400° F. This produced 40–50 per cent martensite. One of these

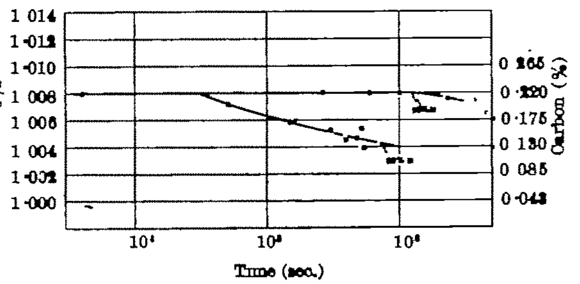


Fig. 1. Percentage of carbon in martensite as a function of holding time at 270° F.

samples was cooled immediately in liquid nitrogen which increased the amount of martensite to 90 per cent. The oscillating crystal technique of Kurdyumov and Lysak[5] was employed to determine the carbon content of the martensitic matrix after appropriate tempering treatments at 270° F. Fig. 1 illustrates the influence of retained austenite on the carbon content of the matrix of tempered martensite.

In this steel, the first stage tempering reaction initially yields a matrix composition of 0·22 per cent carbon regardless of the amount of retained austenite. However, the matrix carbon content of crystals containing 50 per cent martensite was lowered below this level much more rapidly than that of crystals containing 90 per cent martensite. X-ray diffraction studies demonstrated that virtually no additional transformation of austenite accompanied these tempering treatments and that the retained austenite was enriched significantly in carbon. Thus, it is apparent that austenite does act as an effective sink to drain the excess carbon from the martensitic matrix.

The partition of carbon from martensite to austenite indicates that the composition of the low-carbon martensite must be attributed to the metastable equilibrium involving ε carbide rather than the one involving retained austenite. In fact, it seems likely that re-solution of ε carbide helps to maintain the carbon-levels at the values reported in Fig. 1. Furthermore, this interpretation is consistent with the observation[10] that steels containing less than 0·2 per cent carbon do not undergo the normal first stage tempering reaction involving the precipitation of ε carbide.

The partition of carbon from martensite to austenite may contribute significantly to property changes associated with tempering. Generally, this has not been recognized in the analysis of reaction curves obtained by measuring property changes such as electrical resistivity, change in length, evolution of heat, etc. It is apparent that tempering is more complicated than the current theoretical treatments predict, so that a re-examination of tempering kinetics in the light of this and other phenomena may provide a deeper and more satisfying understanding of the theory of tempering processes.

These results also have an important bearing on the bainitic mode of austenite decomposition. The presence of ε carbide in low-temperature bainite[6] suggests that this transformation product passed through a decomposition sequence closely related to that in the formation and tempering of martensite. However, the demonstration that the matrix of low-temperature bainite contains approximately 0·1 per cent carbon rather than 0·25 per cent carbon appears to deny this relationship and suggests that bainite may bypass the tetragonal state characteristic of martensite[7].

This apparent anomaly is removed by the results presented in Fig. 1. Since bainite plates grow slowly[8], partition of carbon from bainite to austenite can accompany the growth process. In this light, it is suggested that low-temperature bainite forms initially (at the advancing tip of the plate) as a supersaturated ferrite with a carbon content which may not differ greatly from that of the parent austenite. Much of this supersaturation is lost rapidly by the precipitation of ε carbide which locally could result in a matrix carbon content in the 0·2–0·3 per cent carbon range. However, as growth of the plate continues, the excess carbon can escape to the surrounding austenite in much the same way as that demonstrated for the tempering of martensite in the presence of large amounts of retained austenite.

Thus, the low carbon content of the matrix of bainite is quite consistent with a supersaturated ferrite mechanism for the mode of formation of bainite.

We wish to express our appreciation to the Office of Naval Research, U.S. Navy, for support of this work.

S. MATAS

Republic Steel Corporation,
Cleveland, Ohio.

R. F. HEHEMANN

Case Institute of Technology,
Cleveland, Ohio.

[1] Krainer, H., *Arch. Eisenhüttenwesen*, **22**, 53 (1951).

[2] Lashko, N. F., *Zhurnal Tekhnicheskoi Fiziki*, **24**, 884 (1954). Brutcher Translation No. 3718.

[3] Kriesement, O., *Arch. Eisenhüttenwesen*, **29**, 723 (1958); **27**, 731 (1956).

[4] Roberts, C. S., Averbach, B. L., and Cohen, M., *Trans. Amer. Soc. Met.*, **45**, 576 (1953).

[5] Kurdyumov, G., and Lysak, L., *Zhurnal Tekhnicheskoi Fiziki*, **19**, 525 (1949). Brutcher Translation No. 2041.

[6] Austin, A. E., and Schwartz, C. M., *Proc. Amer. Soc. for Testing Materials*, **52**, 592 (1952); **55**, 623 (1955).

[7] Werner, F. E., Averbach, B. L., and Cohen, M., *Trans. Amer. Inst. Mining and Met. Eng.*, **206**, 1484 (1956).

[8] Ko, T., and Cottrell, S. A., *J. Iron and Steel Inst.*, **172**, 307 (1952).

[9] Zener, C., *Trans. Amer. Inst. Mining and Met. Eng.*, **167**, 550 (1946).

[10] King, H. W., and Glover, S. G., *J. Iron and Steel Inst.*, **193**, 123 (1959).

CHEMISTRY

Recombination of Oxygen Atoms in the Gas Phase

THE rate of gas phase recombination of oxygen atoms at 10° C. in a flow system has been measured. The experimental method was essentially that described by Schiff[1]. Oxygen atoms were produced from electrolytic gas containing a small percentage of water vapour by passage through a microwave discharge. The decay of oxygen atom concentration along the axis of a cylindrical 'Pyrex' tube, 4 cm. in diameter and 100 cm. long, was followed by a movable isothermal probe similar to that used by Schiff[1]. Linear flow-rates in the range 60–250 cm./sec. and total pressure of 0·3–2 mm. mercury were employed. The initial atom concentration, estimated from the power input to the probe, was of the order 5–10 per cent.

The decay process was found to be first-order in oxygen atoms, but second-order in oxygen molecules.

This conclusion is in agreement with that of Schiff and supports his proposed mechanism :

$$\begin{array}{lr} O + O_2 + O_2 \rightarrow O_3 + O_2 & k_1 \\ O + O_3 \rightarrow 2O_2 & k_2 \\ O \rightarrow \tfrac{1}{2}O_2 \text{ wall} & k_3 \end{array}$$

If a stationary state is assumed for $[O_3]$, then :

$$\frac{-\,d[O]}{dt} = [O]\left\{2k_1[O_2]^2 + k_3\right\}$$

The theoretical model employed by us in evaluating k_1 and k_3 assumes one-dimensional flow and includes axial diffusion but neglects radial diffusion (on the grounds that the radial concentration gradient is probably very small[3]).

For a first-order reaction, the equation of continuity for the reacting species for a steady state is :

$$-D\frac{d^2n}{dx^2} + V_0\frac{dn}{dx} + k_e n = 0 \qquad (1)$$

where D is the binary diffusion coefficient, V_0 is the linear flow speed, n is the concentration of the reactive species and k_e is the rate constant for the reaction. This equation neglects the small change in V_0 over the reaction zone. The solution of (1) subject to the boundary conditions :

$$n = 0 \text{ at } x = \infty,\ n = n_0 \text{ at } x = 0$$

is

$$n = n_0\, e\, \frac{-kx}{V_0}$$

where

$$k_e = k\left(1 + \frac{kD}{V_0^2}\right) \qquad (2)$$

k/V_0 is thus the slope of the conventional log n versus distance plot shown in Fig. 1. For the proposed mechanism $k_e = (2k_1[O_2]^2 + k_3)$. When $\frac{kD}{V_0^2} \ll 1$, $k \simeq k_e$. Plots of $kv[O_2]^2$ and $k_e v[O_2]^2$ are shown in Figs. 2 and 3. Fig. 2 shows a distinct deviation from linearity, which is largely eliminated in Fig. 3, in which a value of $D = 2 \cdot 69 \times 10^2/p$ (p = pressure in mm. of mercury) has been used. This value of D has been estimated by Andrussov[3] on a theoretical basis.

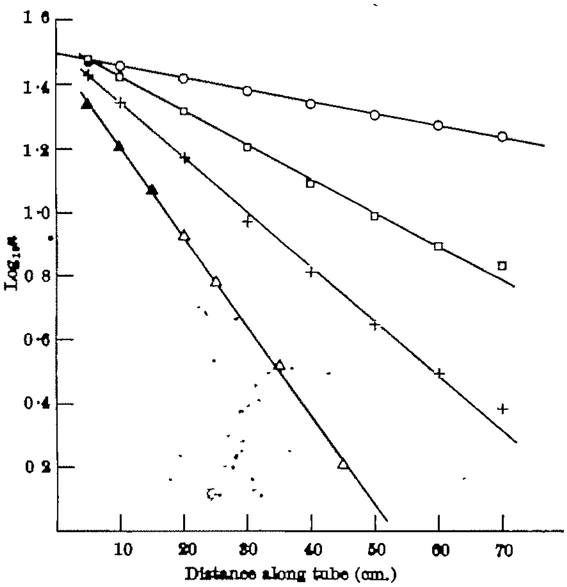


Fig. 1. Plot of log n versus distance for different total pressures. ○, p = 0·335 ; ■, p = 0·625 ; +, p = 0·797 ; △, p = 1·015 mm. mercury

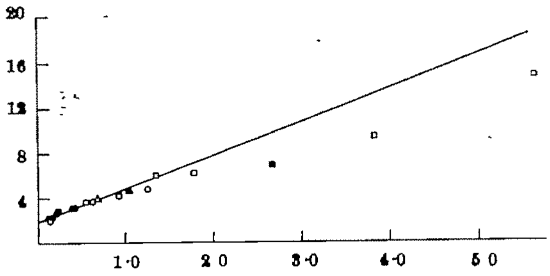


Fig. 2. Plot of k versus Po_2^2 (no diffusion correction), where the mass flow-rates of oxygen are as follows. △, 3 19 × 10^{19} molecules/sec. ; ○, 3·82 × 10^{19} molecules/sec. ; ■, 4 87 × 10^{19} molecules/sec.

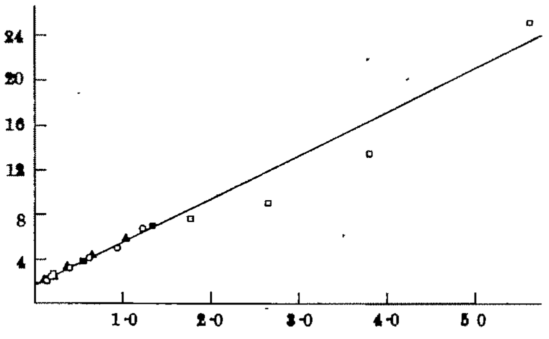


Fig. 3. Plot of k_e versus Po_2^2 (diffusion correction made). The oxygen flow-rates are as for Fig. 2

The values of k_1 and k_3 obtained from the data incorporated in Fig. 3 using equation (2) were :

$$k_1 = 6 \cdot 0 \times 10^{14} \text{ c.c.}^2 \text{ mole}^{-2} \text{ sec.}^{-1}$$
$$k_3 = 1 \cdot 7 \text{ sec.}^{-1}$$

The value of k_3 can be readily converted into a dimensionless recombination coefficient $\gamma = 2k_3R/\bar{c}$ (where R is the radius of the tube and $\bar{c}$ is the mean speed of the atoms), whence $\gamma = 1 \cdot 1 \times 10^{-4}$.

If no correction for diffusion were made and k_e were put equal to k (as was done by Schiff), then the corresponding approximate values from the data in Fig. 2 would be :

$$k_1 = 4 \cdot 6 \times 10^{14} \text{ c.c.}^2 \text{ mole}^{-2} \text{ sec.}^{-1}$$

$$k_3 = 1 \cdot 9 \text{ sec.}^{-1}\ (\gamma = 1 \cdot 2 \times 10^{-4})$$

Schiff found $k_1 = 1 \cdot 0 \times 10^{14}$ c.c.^{2} mole^{-2} sec.$^{-1}$ and $\gamma = 0 \cdot 77 \times 10^{-4}$.

A recent investigation of the kinetics of this reaction followed by paramagnetic resonance has been made by Strandberg *et al.*[4]. If their data are analysed on the basis of the theoretical model used here, the reaction appears to be roughly first-order with k in the range 22·0–38·0 sec.$^{-1}$, the total oxygen pressure being 5 mm. mercury. Correcting for diffusion according to equation (2), k_e is found to be in the range 27–42 sec.$^{-1}$. Using Strandberg's quoted values of $\gamma = 3 \cdot 2 \times 10^{-4}$, $R = 0 \cdot 5$ cm., k_1 is evaluated by us as 0·6–1·8 × 10^{14} c.c.^{2} mole^{-2} sec.$^{-1}$.

Other recent values of k_1 reported in the literature are : 2 × 10^{14} (Kaufmann[5]) ; 0·79 × 10^{14} (Benson and Axworthy[6]) ; ∼ 10 × 10^{14} (Steinberg *et al.*[7]).

A comprehensive theoretical treatment of the appropriate flow problem, including the effects of viscosity, pressure gradients, axial and radial diffusion and chemical reaction, is extremely difficult to handle, but the simplified model presented here appears to describe the experimental situation fairly adequately in this case. It appears important to us that some correction for axial diffusion along these lines should be made when the quantity $\frac{kD}{V_s^2} > 0{\cdot}1$.

P. G. DICKENS
R. D. GOULD
J. W. LINNETT
A. RICHMOND

Inorganic Chemistry Laboratory,
South Parks Road,
Oxford.

[1] Schiff, H. I., Elias, L., and Ogryzlo, E. A., *Canad. J. Chem.*, 37, 1680 (1959).

[2] Dickens, P. G., Schofield, D., and Walsh, J., *Trans. Farad. Soc.*, 56, 225 (1960).

[3] Andrussov, L., *Z. Electrochem.*, 54, 566 (1950).

[4] Krongelb, S., and Strandberg, M. W. P., *J. Chem. Phys.*, 31, 1196 (1959).

[5] Kaufman, F., *Proc. Roy. Soc.*, A, 247, 123 (1958).

[6] Benson, S. W., and Axworthy, A. E., *J. Chem. Phys.*, 26, 1718 (1957).

[7] Hacker, D. S., Marshall, S., and Steinberg, M. (to be published at Eighth Int. Symp. on Combustion, 1960).

Use of Reflectance Measurements in assessing the Colour Changes of Ageing Bloodstains

IT is well known that the colour of bloodstains changes from red to brown with increasing age; but the rate at which these changes occur and the factors which influence this rate are not so well established[1–3]. This is probably in part due to the use of subjective visual assessment of the changes. Extraction of the bloodstains and subjecting the extracts to spectrophotometric analysis suffers from the defect of being destructive of the stain and is sometimes complicated by simultaneous extraction of dye and dirt from the stained object. There is also evidence that the extraction methods may accelerate the colour changes (Kind, S. S., unpublished results).

The value of being able to assess the age of bloodstains, even within wide limits, can on occasion be useful. For example, a person accused of assault may allege that bloodstains present on his clothing are his own, of long standing, and resulted from a cut while shaving. Age assessment may help here if grouping tests prove of no assistance.

The development of photo-electric colorimeters of high sensitivity and precision, the readings of which can be readily converted to the C.I.E. system of colour specification[4], offers a method of non-destructive testing, based on the surface colour of the stain, and free from any subjective judgment.

To test this view, stains were prepared as follows. Sufficient fresh venous blood was collected from six male individuals (age-range 17–45 years) to cover an area rather greater than 4 cm. × 2·5 cm. in the middle of a Whatman No. 1 filter paper circle. When dry the circle was then cut exactly to 4 cm. × 2·5 cm. to eliminate differential shrinkage of the paper which otherwise made it difficult to press the stained area flat without any wrinkling. The samples were then fixed with small pieces of adhesive tape to the back of a black metal mask with an aperture 3·0 cm. × 2·0 cm. cut in it. Marked into the metal of the mask was a rectangle of exactly the same size as the stained paper so that the samples could be placed in exactly the same position on the 'Colormaster' differential colorimeter on each occasion that their colour was measured. Over the back of the samples and the mask a piece of black velvet fixed to black 'Perspex' was placed. This served to exclude light reflected from the back of the samples and to keep them flat.

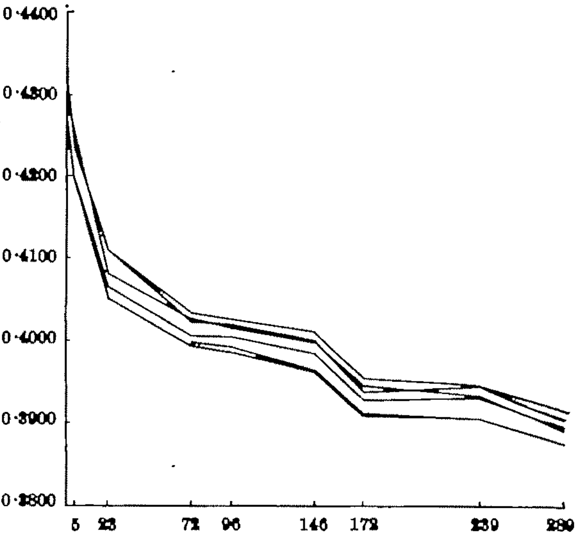


Fig. 1. The ordinate refers to the x co-ordinate on the C.I.E. system. The abscissa refers to the duration of the experiment in hours

The C.I.E. chromaticity co-ordinate x obtained for the six stains is presented in graphical form (Fig. 1). The chromaticity co-ordinate y showed little change over the period of the experiment apart from a slight but steady increase (mean 0·3280 increasing to 0·3330) and the luminance factor after an initial small drop in the first 24 hr. remained constant. The precision of a single reading was estimated by taking 12 successive sets of readings of the red, green and blue reflectance values on one bloodstain, the sample being removed and replaced on the mask between each set. The means and standard deviations obtained are shown in Table 1.

Table 1

	Mean reflectance (per cent)	Standard deviation
Green	13·046	0·013
Red	17·752	0·018
Blue	8·832	0·011

This shows very high precision quite adequate for the purpose in hand.

From Fig. 1 it can be seen that the changes in colour can best be followed from the x chromaticity co-ordinate and that the greater part of the change takes place in the first three days. Afterwards the rate of change is small, and is such that the daily change would only be detectable by a trained observer who had both the changed and unchanged colour before him at one time. It therefore seems unlikely that it is possible to tell the age of bloodstains by visual means alone with any certainty.

The conditions of temperature, humidity and lighting under which the stains are kept doubtless have an effect on the rate of colour change. In these experiments the stains were kept in the dark at room temperature (about 18° C.) between measurements. The use of high-precision colorimetry would seem to offer a basis for preparing master curves of colour changes against time for different environmental conditions and thus by measuring the rate of change of the colour of an unknown sample to estimate its age by extrapolation. Not enough results are, however, available from the present investigation to enable this to be done.

I wish to thank Mr. S. S. Kind, of the Home Office Forensic Science Laboratory, Harrogate, for helpful discussions.

D. PATTERSON

Department of Colour Chemistry and Dyeing,
University of Leeds,
Leeds, 2.

---

[1] Polson, C. J., "Essentials of Forensic Medicine", 206 (English University Press, 1955).

[2] Taylor, A. S., "Principles and Practice of Medical Jurisprudence", 1, 357 (1956).

[3] Glaister, J., "Medical Jurisprudence and Toxicology", 304 (1957).

[4] Glasser, L. G., and Troy, D. J., *J. Opt. Soc. Amer.*, 42, 652 (1952).

Determination of Fatty Acids of Lower Molecular Weight by Gas Chromatography

ANALYTICAL methods for the qualitative and quantitative analysis of fatty acids have been concerned primarily with the fatty acids of higher molecular weight because of their importance in health and nutrition. Small quantities of fatty acids as the methyl esters can be separated by the gas-liquid partition chromatography of James and Martin[1,2]. The fractionation is based on the length of the carbon chain with the more recent development, including fractionation on the basis of unsaturation[3-5]. These methods, however, do not provide for the convenient analysis of the acids of lower molecular weight in a mixture of fatty acids. By modification of the method of Craig and Murty[5] it is possible to separate and identify the fatty acids of lower molecular weight with the same column as that used for the separation of the acids of higher molecular weight.

An 'Aerograph' gas chromatographic instrument, model A-100, was employed for the fractionation of the methyl esters of the fatty acids. The stainless steel column, ¼ in. outer diameter and 10 ft. long, was packed with 'Chromasorb', 60–80 mesh (Johns-Manville, Celite Division, New York), impregnated with polyester butanediol succinate[5]. 5 gm. of the polyester dissolved in 200 ml. of acetone were added to 25 gm. of 'Chromasorb'. The acetone was removed by heating on a steam-bath, after which the mixture was dried in an oven at 110° C. for 6 hr. A filament current of 210 m.amp. was maintained on the standard 'Aerograph' four-filament detector. A 'Varian' 10 mV. recorder was modified with a range selector switch to give a 1 mV. full-scale sensitivity.

The original procedure was modified for the separation of the lower molecular weight esters. A known mixture of fatty acids, consisting of acetic, propionic, *iso*butyric, butyric, 2-methyl butyric, *iso*valeric, valeric, *iso*caproic, caproic, œnanthic, and caprylic acids, were converted to the corresponding methyl esters by reaction with diazomethane, using the microtechnique of Roper and Ma[6]. Since these esters would be characterized by lower boiling points, the column was maintained at a temperature of 92° C. with helium used as the carrier gas at a flow-rate of 40 ml. per min.

A chromatogram showing the separation of these lower molecular weight fatty acid esters is shown in Fig. 1. Using this technique, it is possible to separate the lower molecular weight fatty acids in approximately 28 min.

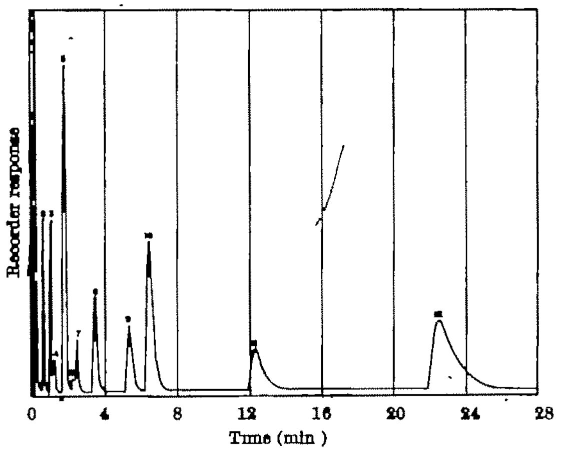


Fig. 1. Separation of lower molecular weight fatty acid esters. 1, Solvent (diethyl ether); 2, methyl acetate; 3, methyl propionate; 4, methyl *iso*butyrate; 5, methyl butyrate; 6, methyl-2-methylbutyrate; 7, methyl *iso*valerate; 8, methyl valerate; 9, methyl *iso*caproate; 10, methyl caproate; 11, methyl enanthate; 12, methyl caprylate. Efficiency: 3,320 theoretical plates (methyl caprylate)

The separation of the higher molecular weight fatty acids can be accomplished by raising the temperature to 216° C. and increasing the flow-rate to 60 ml. per min. The column is brought to equilibrium and another sample injected into the column.

By comparing the peak area of an ester such as methyl caprylate which appears on both chromatograms it is possible to establish a quantitative relationship between the lower and higher molecular weight fatty acids. If no peak overlaps, the addition of a known amount of methyl caprylate will establish a reference point.

MARIE L. VORBECK
LEONARD R. MATTICK
FRANK A. LEE
CARL S. PEDERSON

New York State Agricultural Experiment Station,
Cornell University,
Geneva,
New York.

---

[1] James, A. T., and Martin, A. J. P., *Biochem. J.*, 50, 679 (1952).

[2] James, A. T., and Martin, A. J. P., *Analyst*, 77, 915 (1952).

[3] Orr, C. H., and Callen, J. E., *J. Amer. Chem. Soc.*, 80, 249 (1958).

[4] Lipsky, S. R., *Chem. Eng. News*, 36 (No. 5), 48 (1958).

[5] Craig, B. M., and Murty, N. L., *J. Amer. Oil Chem. Soc.*, 36, 549 (1959).

[6] Roper, R., and Ma, T. S., *Microchem. J.*, 1, 581 (1957).

BIOCHEMISTRY

Microbiological Transformation of Terpenes: Hydroxylation of α-Pinene

THE microbiological transformations of steroids and alkaloids have opened up a new line of approach towards the synthesis of many biologically active compounds. Relatively little is known, however, about the capability of micro-organisms to transform the simple terpenoid compounds. Recently, Bradshaw *et al.*[1,2] have studied the microbiological transformation of camphor.

The yields of essential oils from some oil-bearing plants are known to be considerably enhanced if the plants are infected by micro-organisms[3]. The present communication deals with the microbiological transformations of α-pinene by moulds.

A preliminary screening of fungi on Czapek–Dox medium enriched with yeast-extract, corn-steep liquor and 0·5 per cent α-pinene (I) resulted in the selection of a strain of *Aspergillus niger* for further studies. A 24-hr. shake culture of this strain metabolized 0·5 per cent pinene in 4–8 hr.

In a typical fermentation the mould was grown in shake cultures for 24 hr. *d*-α-Pinene (I) was added to the culture (0·5 ml. per 100 ml. of the medium) and the fermentation was continued for 4 hr. (The purified sample of α-pinene employed in these experiments had a rotation of $[\alpha]_D^{25}$ + 24·5°. This rotation would correspond to a mixture of 70 per cent *d*- and 30 per cent *l*-α-pinene.) After this period a second lot of pinene (0·5 per cent) was added and the fermentation was allowed to proceed for another 4-hr. period. The culture was filtered. The mycelial pellets were extracted with a little acetone and the acetone extract was added to the culture filtrate, which was then extracted first with ether (extract *A*) and then with butanol (extract *B*). Extract *A* was washed free from acids by aqueous sodium carbonate and evaporated to yield a pale yellow oil. Unreacted pinene was removed from this oil by a countercurrent distribution between hexane and 90 per cent aqueous ethanol. The ethanolic layers containing the oxygenated conversion products of pinene were carefully evaporated. The oily residue yielded on distillation, under reduced pressure, a clear, colourless oil and a semi-crystalline residual mass.

The distillate was further fractionated into an alcohol (II) and a ketone (III) by bisulphite treatment. The residue in the distillation flask, as well as the butanol extract (extract *B*), yielded a crystalline diol (IV) on chromatography over alumina.

Alcohol II: b.p. 140° (bath temp.)/16 mm. $[\alpha]_D^{25}$ + 64° (alcohol); molecular formula $C_{10}H_{16}O$ (found, C, 78·62, H, 10·6); infra-red absorption 3,420 cm.$^{-1}$ (OH). It gave a crystalline *p*-nitrobenzoate, m.p. 90° $[\alpha]_D^{25}$ + 14° (alcohol).

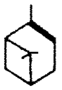
On mild chromic acid oxidation in pyridine or by oxidation with solid manganese dioxide in chloroform the alcohol (II) yielded the ketone (III) in nearly quantitative yields.

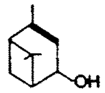
Ketone (III): b.p. 130° (bath temp.)/14 mm. $[\alpha]_D^{25}$ + 223° (ethanol); molecular formula $C_{10}H_{14}O$ (found, C, 79·82, H, 9·51); ultra-violet absorption $\lambda_{max.}$ 253 mμ ($\epsilon_{max.}$ 6,480); infra-red absorption 1,665 cm.$^{-1}$ (conjugated C═O) and 1,615 cm.$^{-1}$ (double bond). It formed a semicarbazone m.p. 203–205°.

From these properties the ketone (III) was identified as *d*-verbenone. For comparison *d*-verbenone was synthesized according to the method of Badoche[4]. A comparison of the physical properties, ultra-violet and infra-red spectra of verbenone and its semicarbazone with those of the ketone (III) and its corresponding derivative conclusively established the identity of compound III. There was no depression in the mixed melting point of the semicarbazones. The alcohol (II) could, therefore, be characterized as *cis d*-verbenol on the basis of its optical rotation and the melting point and the optical rotation of its *p*-nitrobenzoate[5].

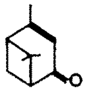
Diol (IV): m.p. 144–145° $[\alpha]_D^{25}$ + 152° (ethanol); molecular formula $C_{10}H_{18}O_2$ (found, C, 70·66; H, 10·7); strong infra-red absorption at 3,260 cm.$^{-1}$ (OH). It was identified as *d*(+)-*trans*-sobrerol on the basis of the following properties:

It showed no depression in the mixed melting point with synthetic *trans* sobrerol prepared by acid-catalysed rearrangement of α-pinene epoxide[6]. The physical properties and the infra-red spectra of (IV) were identical with those of the synthetic product. Both were converted to the identical ketone, hydroxycarvotonacetone (V) ($\lambda_{max.}$ 232 mμ, $\epsilon_{max.}$ 9,200), on oxidation with manganese dioxide.

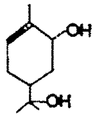

I
α-Pinene



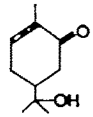
II
cis-Verbenol



III
Verbenone



IV
trans-Sobrerol



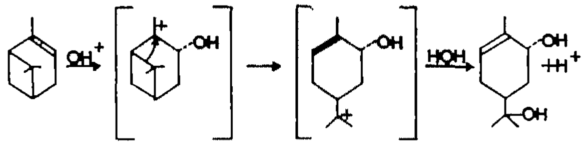
V
Hydroxycarvotonacetone

Under optimum conditions the yields of these products on the basis of the pinene utilized were 20–25 per cent verbenol, 2–3 per cent verbenone and 2–3 per cent sobrerol. The major fraction of the pinene metabolized appears to have been broken down to smaller fragments and probably oxidized to carbon dioxide and water.

Verbenone, verbenol and sobrerol have been identified among the auto-oxidation products of α-pinene. The major product of auto-oxidation is, however, verbenone with only small amounts of the alcohol, whereas verbenol is the major metabolite obtained by microbiological oxidation. Moreover, in the biological process these products were obtained in optically pure form, presumably from *d*-α-pinene.

The formation of *cis*-verbenol may be accounted for either by a free-radical attack at the allylic position, or by removal of a hydride ion from the same position through the mediation of an electrophilic species, such as an incipient OH⁺.

d-*trans*-Sobrerol may be presumed to be derived from *d*-α-pinene by a postulated attack on the 1,2 double bond by an electron deficient oxygen (OH⁺, etc.) in the following manner:



A detailed report on these investigations will be published elsewhere.

We wish to express our thanks to Drs. S. C. Bhattacharyya and V. Jagannathan for their interest in this work and helpful suggestions.

P. K. BHATTACHARYYA
B. R. PREMA
B. D. KULKARNI
S. K. PRADHAN

Division of Biochemistry,
National Chemical Laboratory,
Poona, 8,
India.

[1] Bradshaw, W. H., Conrad, H. E., Corey, E. J., Gunsalus, I. C., and Lednicer, D., *Fed. Proc.*, 18, 196 (1959).

[2] Bradshaw, W. H., Conrad, H. E., Corey, E. J., Gunsalus, I. C., and Lednicer, D., *J. Amer. Chem. Soc.*, 81, 5507 (1959).

[3] Bose, S. R., *Science and Culture*, 4, No. 2 (1938).

[4] Badoche, M., *Bull. Soc. Chim. France*, 764 (1953).

[5] Schmidt, H., Schulz, L., and Doll, W., *Chem. Zentr.*, 2, 2037 (1940).

[6] Moore, R. N., Golumbic, C., and Fisher, G. S., *J. Amer. Chem. Soc.*, 78, 1173 (1956).

Excretion of Catechol after Ingestion of Quinic and Shikimic Acids

THE detection of catechol in acid-hydrolysed normal human urine and cow's urine was reported recently by von Euler and Lishajko[1]. The origin of the catechol was not known. The excretion of hippuric acid in the urine of man after oral ingestion of calcium quinate was reported by Lautemann in 1863[2]. It occurred to us that if an aromatic ring can be formed in the animal body from quinic acid (1 : 3 : 4 : 5-tetrahydroxy*cyclo*hexane carboxylic acid), then urinary catechol might have a similar origin. Further, an exogenous (dietary) precursor is implicated since we are unable to detect catechol in the urine of rats fed a highly purified diet. Quinic and shikimic acids are known to be present in edible plants.

Adult albino rats were fed a purified diet (sucrose, casein, salts, oil, vitamins) and given quinic acid by stomach tube (100 mgm./rat). A 48-hr. urine sample was collected and subjected to two-dimensional paper chromatographic analysis. The lower phase of a chloroform/acetic acid/water (2 : 1 : 1) mixture was used in the first direction followed by 20 per cent potassium chloride in the second direction. Each developed chromatogram was air-dried and carefully examined under short-wave ultra-violet light and then sprayed with diazotized sulphanilic acid followed by 20 per cent sodium carbonate. Thus the positive identification of a urinary metabolite was based on its R_F values in two dimensions, its behaviour under ultra-violet light and its colour with diazotized sulphanilic acid–sodium carbonate.

In our chromatographic system[3] hippuric acid is located at R_F 0·60 × 0·87, gives no colour with the diazotized sulphanilic acid reagent and absorbs ultra-violet light. The only notable deviation from normal in the case of the ether extract of the acidified urine of rats given quinic acid by stomach tube was a marked increase in the size of the area corresponding to hippuric acid. Catechol was not detected. Similarly, catechol was not detected after acid hydrolysis (2 *N* hydrochloric acid reflux, 30 min.) of the ether extract, suggesting that this fraction does not contain an ether-soluble conjugate of catechol. Finally, the ether-extracted urine was acid-hydrolysed and re-extracted with ether. When this ether extract was examined chromatographically, catechol was readily detected at R_F 0·50 × 0·74. Catechol absorbs ultra-violet light and when sprayed with the diazotized sulphanilic acid reagent undergoes a very characteristic colour change from red to green to blue-black. Another characteristic of catechol is its tendency to darken on an unsprayed chromatogram, presumably due to spontaneous oxidation.

When shikimic acid was administered to rats by stomach tube (100 mgm./rat) the same results were obtained as described above for quinic acid. Thus catechol was clearly present on the chromatogram of the acid-hydrolysed ether-extracted urine. In addition, an unidentified metabolite of both quinic and shikimic acids having the same chromatographic characteristics as vanillic acid was detected in the urine after hydrolysis.

Rats were also fed quinic acid mixed in the purified diet at a level of 3 per cent. Catechol was readily detected free (unconjugated) as well as conjugated in the urine. According to Garton and Williams[4], catechol is formed and excreted principally as a monoglucuronide or monosulphate derivative in the urine of rabbits receiving benzene by stomach tube.

It is difficult to estimate the amount of catechol excreted in urine, due to its instability, especially when subjected to acid hydrolysis. A minimal amount of 2 mgm. of catechol was excreted during a period of two days by two rats ingesting a total of 1·5 gm. of quinic acid in the diet.

Whether aromatization of quinic and shikimic acids to form catechol is dependent on intestinal micro-organisms is not known. Ayengar *et al.*[5] reported that "extracts of rabbit-liver acetone powder catalysed the formation of catechol from 3,5-*cyclo*hexadiene-1,2-diol", but not from D-quinic acid. Mitoma *et al.* isolated an enzyme system from guinea pig liver which was able to aromatize *cyclo*hexanecarboxylic acid[6].

From these results it is tempting to conclude that the catechol in human and cow urine may be formed from quinic acid and related substances in the diet.

A. N. BOOTH
D. J. ROBBINS
M. S. MASRI
F. DEEDS

Western Regional Research Laboratory,
Agricultural Research Service,
U.S. Department of Agriculture,
Albany,
California.

[1] Euler, U. S. v., and Lishajko, F., *Nature*, 183, 1123 (1959).

[2] Lautemann, E., *Liebigs Ann.*, 125, 9 (1863).

[3] Booth, A. N., Emerson, O. H., Jones, F. T., and DeEds, F., *J. Biol. Chem.*, 229, 51 (1957).

[4] Garton, G. A., and Williams, R. T., *Biochem. J.*, 43, 206 (1948).

[5] Ayengar, P. K., Hayaishi, O., Nakajima, M., and Tomida, I., *Biochim. Biophys. Acta*, 33, 111 (1959).

[6] Mitoma, C., Posner, H. S., and Leonard, F., *Biochim. Biophys. Acta*, 27, 156 (1958).

Staining for Iodine in Chromatograms of Human Plasma : an Artefact due to Thiourea or Thiouracils

UNTIL the report by Werner and Block[1], it was generally thought that at most only very small quantities of iodinated tyrosines are present in normal human serum. This conclusion was based on ^{131}I-chromatographic studies using plasma extracts from subjects given radioiodine. Werner and Block report, however, that when the iodine distribution in normal human serum is analysed chemically by the ceric–arsenite reaction[2], approximately half the circulating iodine is present in the form of mono-iodotyrosine or di-iodotyrosine, although the radioactivity in the same chromatogram is distributed according to the results of other workers. Hitherto these results have been very difficult to understand, and they are inconsistent with the rapid deiodination seen when iodotyrosines are injected[3]. We have recently confirmed Werner and Block's results indicating a discrepancy between the distribution of stable and radioactive iodine, when using very similar methods to estimate the distribution of iodinated amino-acids in human serum. Our extraction and chromatographic techniques differed from those of Mandl and Block[4] only in that the acidified serum was extracted three times with butanol and that the chromatogram was unidimensional and run in acid-butanol / 2 *N* acetic acid (1 : 1). We find that when

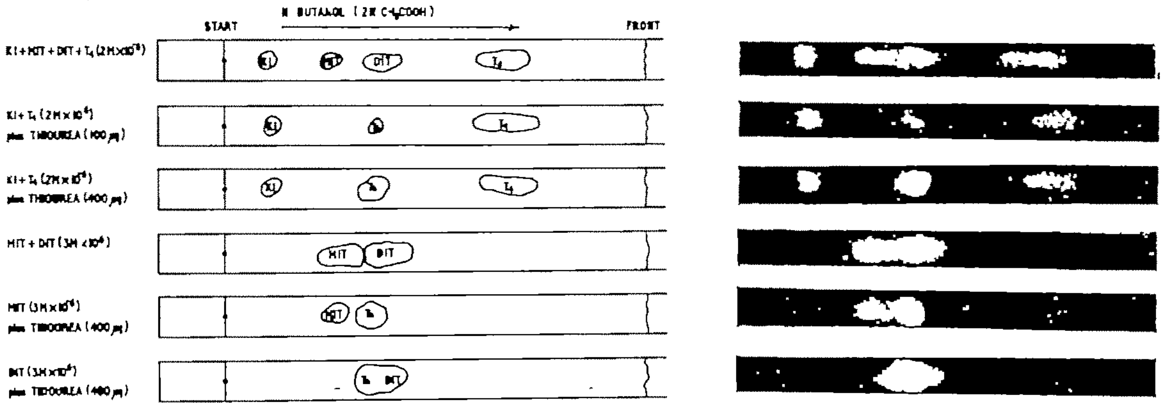

N BUTANOL (2N CH3COOH)
START
FRONT
KI+MIT+DIT+T4 (2M×10⁻⁴)
KI
MIT
DIT
T4
KI+T4 (2M×10⁻⁴) plus THIOUREA (100 μg)
KI+T4 (2M×10⁻⁴) plus THIOUREA (400 μg)
Th
MIT+DIT (3M×10⁻⁴)
MIT
DIT
MIT (3M×10⁻⁴) plus THIOUREA (400 μg)
DIT (3M×10⁻⁴) plus THIOUREA (400 μg)

Fig. 1. Chromatograms stained for iodine by the ceric–arsenite reaction: influence of thiourea on iodotyrosine positions

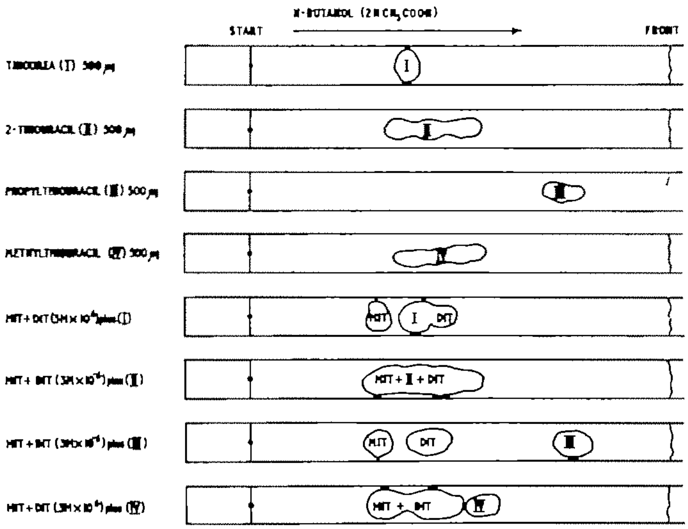

N-BUTANOL (2N CH3COOH)
START
FRONT
THIOUREA (I) 500 μg
I
2-THIOURACIL (II) 500 μg
II
PROPYLTHIOURACIL (III) 500 μg
III
METHYLTHIOURACIL (IV) 500 μg
IV
MIT+DIT (3M×10⁻⁴) plus (I)
MIT
I
DIT
MIT+DIT (3M×10⁻⁴) plus (II)
MIT+II+DIT
MIT+DIT (3M×10⁻⁴) plus (III)
MIT
DIT
III
MIT+DIT (3M×10⁻⁴) plus (IV)
MIT + DIT
IV

Fig. 2. Behaviour of some thiouracil derivatives on chromatograms stained for iodine by ceric–arsenite

the chromatogram of serum collected 48 hr. after a 100 μc. dose of iodine-131 is scanned for radioactivity little or no counts are recordable in the mono- or di-iodotyrosine positions, whereas when the same chromatograms are evaluated chemically for iodine by the ceric–arsenite reaction, iodotyrosines appear to be present in considerable quantity.

However, activation analysis by neutron bombardment in the Medical Research Council cyclotron to produce iodine-128 did not reveal any iodine in the region of the chromatogram corresponding to the positions of mono- and di-iodotyrosine. 5–10 ml. of normal serum had been run on paper from which the spots were cut. Evaluated by the fading with ceric–arsenite the chromatogram showed an iodine distribution of 20·5 per cent as iodide, 8 5 per cent as mono-, and 19·6 as di-iodotyrosine, whereas activation analysis produced iodine-128 from the iodide spot but less than 0·2 μgm. iodine/100 ml. serum from either of the apparent iodotyrosine spots (the thyronine region was not tested).

Further work suggests that the staining in the mono- and di-iodotyrosine regions of the chromatogram developed with ceric–arsenite may be due to the presence of thiourea. This substance had been added in μgm. quantities at all stages of the chemical processing in order to prevent any artefacts from the oxidation of iodide to iodine. In our chromatographic system thiourea, 2-thiouracil or methyl thiouracil has recently been found to run in the position of either mono- or di-iodotyrosine or between them, depending on the presence or absence of the iodotyrosines (Figs. 1 and 2); propylthiouracil runs in the position of the thyronines.

Careful study by direct colorimetry of the effect of thiourea on the time-course of the ceric–arsenite reaction shows that although there is some rapid initial fading this is virtually imperceptible when small (less than 100 μgm.) quantities of thiourea are used. Furthermore, the subsequent rate of fading is almost indistinguishable from that given by iodide, especially with small thiourea concentrations (Fig. 3).

From this we conclude that the apparent presence of mono- and di-iodotyrosine on chromatograms stained for iodine when prepared from normal human serum by our initial procedure may be an artefact due to added thiourea. Preliminary studies with activation analysis and an improved chromatographic technique have as yet failed to reveal detectable amounts of iodotyrosines in normal fasting human serum. Thus we cannot confirm the conclusions of Werner and Block, and we suggest that the apparent iodotyrosine staining which they find may have been

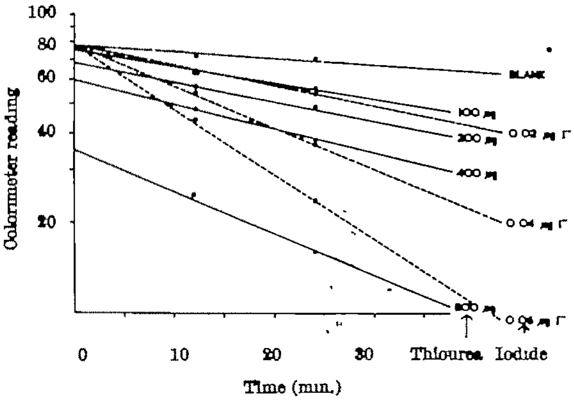


Fig. 3. Effect of thiourea on the time course of the ceric–arsenite reaction

an artefact due to thiouracil added during their extraction procedure.

A. DIMITRIADOU*
T. RUSSELL FRASER
J. D. H. SLATER

Postgraduate Medical School of London.

P. C. R. TURNER

Medical Research Council
Radiotherapeutic Research Unit.

---

* Supported by a grant from the Wellcome Trust.

[1] Werner, S. C., and Block, R. J., *Nature*, 183, 406 (1959).

[2] Bowden, C. H., and Maclagan, N. F., *Biochem. J.*, 56, 7 (1954).

[3] Stanbury, J. B., Kassenaar, A. A. H., Meijer, J. W. A., and Terpstra, J., *J. Clin. Endocrinol.*, 16, 1216 (1956).

[4] Mandl, R. H., and Block, R. J., *Arch. Biochem.*, 81, 25 (1959).

Inhibition of Glucuronosyl Transferase by Progestational Agents from Serum of Pregnant Women

GLUCURONIDE conjugates are formed by the condensation of an alcohol or acid aglycone with uridine diphosphoglucuronic acid by the enzyme, glucuronosyl transferase[1]. A functional immaturity of this enzyme system and perhaps a deficiency of uridine diphosphoglucuronic acid has been observed in new-born animals[2]. Since indirect-reacting bilirubin is converted to bilirubin glucuronide by means of glucuronosyl transferase[3], Billing *et al.*[4] have suggested that physiological hyperbilirubinæmia of the new-born infant might be the result of a deficiency of this enzyme system. Recently, Lathe and Walker[5] reported inhibition of bilirubin conjugation in liver slices by serum of pregnant women. This communication reports studies aimed at identifying the inhibitor substances and assessing their importance in hyperbilirubinæmia of the new-born.

The effect of a final serum concentration of 14 per cent upon *o*-aminophenol conjugation by rat liver homogenate was studied using the method of Levvy and Storey[6]. The results (Fig. 1) indicated inhibition of 64·0 ± 21·8 per cent, 42·8 ± 22·5 per cent, and 48·2 ± 20·0 per cent by serum from pregnant women, immediately *post-partum* women, and new-born infants respectively, in contrast to inhibition of 1·3 ± 1·0 per cent and 26·8 ± 9·8 per cent by serum from adult males and adult non-pregnant females. Analyses of serial determinations indicate a gradual increase of *o*-aminophenol inhibition as term is approached, and a rapid fall after delivery.

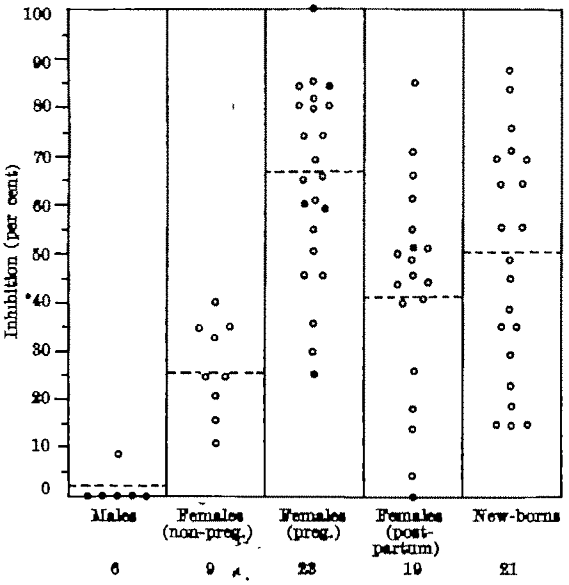


Fig. 1. Inhibition of *o*-aminophenol conjugation by various types of sera. Incubation mixture consisted of: 0·5 *M tris* buffer, pH 8·0, 0·1 ml.; 0·5 *M* magnesium chloride, 0·1 ml.; 1·1 × 10^{-2} *M* uridine diphosphoglucuronic acid, 0·1 ml.; 1·25 × 10^{-2} *M* *o*-aminophenol in 0·01 *M* ascorbic acid, 0·2 ml.; 10 per cent rat liver homogenate, 1·0 ml.; and serum, 0·22 ml. Incubation was carried out at 37° C. for 30 min.

The neutral lipids extracted from one litre of pooled serum from pregnant women were chromatographed on a silica column using gradient elution with benzene–ethyl acetate[7]. Four fractions were obtained which resulted in inhibition of *o*-aminophenol conjugation. The fraction showing most of the inhibitory activity contained a material which was chromatographed on propylene glycol-treated paper using toluene as developer; its migration corresponded to pregnanediol-3α,20α. On repeated recrystallization from ethanol, hexagonal prisms were obtained which showed a change in crystal structure at 210–220° C. and melted at 239·5–240° C. (Koffler micro-melting point). Authentic pregnanediol-3α,20α melted at 239·5–240° C. and a mixed melting point with the isolated crystals was 237·5–238·5° C. Infra-red spectra of the isolated material and pregnanediol are identical. On the basis of migration on paper and colour tests, other fractions are thought to contain *allo*-pregnanetriol and pregnanolone. All three compounds were found to inhibit conjugation *in vitro*.

Table 1. INHIBITION BY PROGESTINS OF PHENOLPHTHALEIN CONJUGATION BY RAT LIVER MICROSOMAL FRACTION

Compound	Final concentration (γ/ml.)	Inhibition (per cent)
17α-Ethyl-19-*nor*testosterone	0·8	50
Progesterone	6·0	50
Pregnanediol	4·0	30
17α-Ethinyl-19-*nor*testosterone	10·0	36
Androstenedione	8·0	27
17α-Ethyl-Δ^{5-10}-19-*nor*androstanediol	12·0	27
17α-Ethinyl-Δ^{5-10}-19-*nor*androstanediol	18·0	27
17α-Hydroxyprogesterone	16·0	15
17α-Methallyl-19-*nor*testosterone	32·0	50

Each flask contained microsomes equivalent to 0·3 gm. liver, 750γ phenolphthalein, 400γ uridine diphosphoglucuronic acid, 0·05 *M tris* buffer at pH 7·6, 0·012 *M* magnesium chloride, 0·015 *M* nicotinamide, 0·06 *M* potassium chloride, and is incubated at 37° C. for 30 min.

With these findings, it was decided next to test a series of progestational agents of physiological importance. 17α-ethyl-19-*nor*testosterone, progesterone, pregnanediol, 17α-hydroxyprogesterone, and 17α-methallyl-19-*nor*progesterone, 17α-ethinyl-19-*nor*testosterone, 17α-ethyl-Δ^{5-10}-19-*nor*androstanolone, 17α-ethinyl-Δ^{5-10}-19-*nor*androstanolone, 17α-hydroxyprogesterone, in order of decreasing effectiveness, were found to inhibit glucuronide formation as shown in Table 1.

With progesterone, inhibition was found using *o*-aminophenol, phenolphthalein, and bilirubin as substrates in both homogenates and microsomal fractions prepared from rat and guinea pig liver.

These observations may help to explain the jaundice which has been observed with prolonged administration of 17α-ethyl-19-*nor*testosterone and other steroids. High levels of progestins in maternal serum during pregnancy could play a part in the physiological hyperbilirubinæmia of the new-born.

This investigation was aided by grants from the Association for the Aid of Crippled Children, the U.S. Public Health Service (A-2222) and the Smith, Kline and French Foundation. We are indebted to Dr. E. G. Daskalakis for the authentic pregnanediol-$3\alpha,20\alpha$ and for help with the paper chromatography, and to Eva Gawronska Kot and Dorothy Poppish for technical assistance.

DAVID YI-YUNG HSIA
ROBERT M. DOWBEN
RALPH SHAW
Departments of Pediatrics and Medicine,
Northwestern University Medical School,
and
Children's Memorial Hospital,
Chicago.

AARON GROSSMAN
Department of Pediatrics,
Chicago Medical School,
and
Cook County Hospital,
Chicago.

[1] Dutton, G. J., and Storey, I. D. E., *Biochem. J.*, 57, 275 (1954). Storey, I. D. E., and Dutton, G. J., *ibid.*, 59, 279 (1955). Dutton, G. J., *ibid.*, 64, 693 (1956).

[2] Karunairatnam, M. D., Kerr, L. M. H., and Levvy, G. A., *Biochem. J.*, 45, 496 (1949). Brown, A. K., and Zuelzer, W. W., *J. Clin. Invest.*, 37, 332 (1958). Lathe, G. H., and Walker, M., *Biochem. J.*, 70, 705 (1958). Dutton, G. J., *ibid.*, 71, 141 (1959).

[3] Schmid, R., *Science*, 124, 76 (1956). Schmid, R., Hammaker, L., and Axelrod, J., *Arch. Biochem.*, 70, 285 (1957). Cole, P. G., Lathe, G. H., and Billing, B. H., *Biochem. J.*, 57, 514 (1954). Billing, B. H., Cole, P. G., and Lathe, G. H., *ibid.*, 65, 774 (1957). Grodsky, G. M., and Carbone, J. V., *J. Biol. Chem.*, 226, 449 (1957).

[4] Billing, B. H., Cole, P. G., and Lathe, G. H., *Brit. Med. J.*, ii, 1263 (1954).

[5] Lathe, G. H., and Walker, M., *Quart. J. Exp. Phys.*, 43, 257 (1958).

[6] Levvy, G. A., and Storey, I. D. E., *Biochem. J.*, 44, 295 (1949).

[7] Savard, K., "Recent Prog. Hormone Res.", 9, 185 (1954).

Plant-Growth Activity of α-Alkylphenylacetic Acids and 1,2-Benzo-1-*cyclo*alkene-3-carboxylic Acids

1,2,3,4-Tetrahydro-1-naphthoic acid (1,2-benzo-1-*cyclo*hexene-3-carboxylic acid) was found to have a high plant-growth activity. Its lower homologue, 1-indanocarboxylic acid (1,2-benzo-1-*cyclo*pentene-3-carboxylic acid) was reported later to be considerably active though less than the former[1]. In the homologous series of these two acids, the 1,2-benzo-1-*cyclo*alkene-3-carboxylic acids, the spatial relation of the carboxyl group to the ring system is influenced by the alicyclic ring structure. On the other hand, in the α-alkylphenylacetic acids, which may be regarded as the 'open forms' of the above acids, it is unnecessary to consider such an influence on the carboxyl group. In order to examine the effect on plant-growth activity of such a difference in the structure, we tested activities of these series of compounds in the pea straight-growth test.

In the α-alkylphenylacetic acids, the terminal of the alkyl chain is considered to lie preferably far from both the benzene ring and the carboxyl group in order to reduce steric repulsions to a minimum. The chain of *n*-alkanes has been shown by Bonham and his co-workers[3] to exist predominantly in all-*trans* configuration or in those which involve at least one *gauche* conformation. Therefore, the spatial relation of the carboxyl group to the ring may not change appreciably, even if the length of the side-chain changes. The carboxyl group in this series emerges considerably from the plane of the benzene ring. Fitting of the molecule to the site of action may, however, be interfered with when the molecular dimension increases due to elongation of the side-chain. The molecular dimensions of *n*-butylphenylacetic and *n*-amylphenylacetic acids, which are inactive, may be too large for fitting.

In the 1,2-benzo-1-*cyclo*alkene-3-carboxylic acids, increasing the carbon atoms in the alicyclic ring may not affect the molecular dimension so remarkably as in the above-mentioned series, because of their 'condensed ring structure'. The spatial configuration of the carboxyl group, on the other hand, may be affected considerably. Judged from the ultra-violet spectra and the molecular model, the carboxyl group of benzo*cyclo*butene- and indan-carboxylic acids takes a fixed conformation rising considerably from the plane of the benzene ring. The carboxyl of tetrahydro-naphthoic acid, which is more active than the two lower homologues, emerges from the ring plane more conspicuously when it takes a quasi-axial conformation, one of the two conformations inferable. The carboxyl group of benzo-*cyclo*heptene- and -*cyclo*octene-carboxylic acids, which are inactive, is presumed to be in a favourable equatorial conformation owing to hydrogen crowding of the ring and restriction of rotation of the group as suggested by Huisgen[4] concerning the conformation of 1,2-benzo-1-*cyclo*heptenyl- and -1-*cyclo*octenyl-3-methyltosylates.

Thus, the grade of activity of the two series of compounds may be explained by the steric circumstances of the molecule, as in the hydrogenated 1-naphthoic acids[5].

On the other hand, since the hydrophil–lipophil balance may not differ significantly between the corresponding members of the two series possessing the same number of carbon atoms, the abrupt drop

Table 1. PLANT-GROWTH ACTIVITY IN THE PEA STRAIGHT-GROWTH TEST*

Acids	Concentration (mol./l.)							
	0	5×10^{-7}	5×10^{-6}	5×10^{-5}	$1\cdot5\times10^{-4}$	$2\cdot5\times10^{-4}$	5×10^{-4}	$1\cdot5\times10^{-3}$
1,2-Benzo-1-*cyclo*butene-3-carboxylic (m.p. 74·5°–75·5°)	100	100	108	142	144	143	144	127
1-Indanocarboxylic (m.p. 57·5°–58·5°)	100	—	99	138	140‡	139	134	127§
1,2,3,4-Tetrahydro-1-naphthoic (m.p. 83°–84°)	100	100	120	143	141	140	137	112
1,2-Benzo-1-*cyclo*heptene-3-carboxylic (m.p. 117°–118°)	100	—	100	99	100‡	100	103	104§
1,2-Benzo-1-*cyclo*octene-3-carboxylic (m.p. 109°–110°)	100	—	98	96	95	91	90	—
α-Methylphenylacetic (b.p. 160°–163°/25 mm.)	100	100†	108	141	137	139	129	115
α-Ethylphenylacetic (m.p. 40°–41°)	100	100	109	137	137	135	128	114
α-*n*-Propylphenylacetic (m.p. 51°–52°)	100	—	102	119	131	131	118	106
α-*n*-Butylphenylacetic (b.p. 149°–151°/4 mm.)	100	—	99	97	96	94	94	—
α-*n*-Amylphenylacetic (m.p. 35°–36°)	100	—	101	99	93	92	91	—

* The results observed for α-alkylphenylacetic acids agree with those of Veldstra, who used the pea curvature tests (ref. 2).
† At $2\cdot5\times10^{-6}$ mol./l.
‡ At 1×10^{-4} mol./l.
§ At 1×10^{-3} mol./l.

of activity in each series from the C_{11}-acid to the C_{12}-acid may be understood by an increase in lipophilic nature beyond optimum, like toxicity in the homologous series of plasmoquin, bactericidal activity in *n*-alkanols, etc.[6]. Consequently, it cannot be decided whether this abrupt change is attributable to molecular form or hydrophil–lipophil-balance, though the plant-growth activity may be conditioned by the above two factors as suggested by Veldstra[7]. From this point of view it is hoped to obtain information about the activity of homologues of 1,4-dihydro-1-naphthoic acid, which are considered to have a higher chance of having their carboxyl group in the axial positions, owing to the smaller amount of hydrogen crowding.

KAZUYOSHI KAWAZU
TOSHIO FUJITA
TETSUO MITSUI
Department of Agricultural Chemistry,
JIRO KATO
MASAYUKI KATSUMI
Department of Botany,
Kyoto University,
Kyoto. June 8.

---

[1] Fredga, A., *Ber.*, 89, 322 (1956). Burström, H., and Hansen, B. A. M.' *Physiol. Plant.*, 9, 502 (1956). Heacock, R. A., Wain, R. L., and Wightman, F., *Ann. App. Biol.*, 46, 352 (1958).

[2] Veldstra, H., "The Chemistry and Mode of Action of Plant Growth Substances", edit. by Wain, R. L., and Wightman, F., 125 (Butterworths Sci. Pub., London, 1955).

[3] Bonham, R. A., Bartell, L. S., and Kohl, D. A., *J. Amer. Chem. Soc.*, 81, 4765 (1959).

[4] Hulsgen, R., *Angew. Chem.*, 69, 356 (1957).

[5] Fujita, T., Imai, S., Koshimizu, K., Mitsui, T., and Kato, J., *Nature*, 184, 1415 (1959).

[6] Bovet, J., and Altman, R. F. A., *Bull. Soc. Path. Exot.*, 27, 236, 729 (1934). Ferguson, J., *Proc. Roy. Soc.*, B, 127, 387 (1939).

[7] Veldstra, H., "Ann. Rev. Plant Physiol.", 4, 151 (1953).

Evidence for Multiple Nature of Cellulase of *Myrothecium verrucaria*

CONFLICTING views are held on the multiple nature of cellulase of *M. verrucaria*. Paper and column chromatography[1,2], zone electrophoresis[3] and electrophoresis-convection[4] of crude preparations of the cellulase indicated the multiple nature of this enzyme system. On the other hand, by fractionating the cellulase by precipitation techniques, Whitaker[5] obtained a preparation homogeneous in the ultracentrifuge and on electrophoresis, which exhibited all the activities tested of the crude enzyme concentrated in about the same ratios. He maintains that 1,4-β-linked oligo- and poly-glucosides are hydrolysed by one enzyme[6] which possibly forms stable complexes with metabolic products, thus giving rise to a number of components with cellulolytic activity[6,7].

In our investigations ion-exchange chromatography was used as a means to purify and/or fractionate the cellulase of *M. verrucaria*. 'Amberlite *IRC*–50' (120–200 mesh) was equilibrated with the buffer from which the cellulase was to be adsorbed. The cellulase was applied at the top of the column in a small volume of the buffer, and afterwards washed down with the same buffer. The column was operated at a speed of about 15 ml./cm.^{2} per hr. Elution was performed with buffers of increasing *p*H and/or molarity. The effluent was collected in fractions which were analysed for cellulolytic activity towards sodium carboxymethylcellulose.

Table 1

	Relative hydrolytic activity per mgm. nitrogen of the various fractions of cellulose towards					
	o-Nitrophenyl-β-D-glucoside	Cellohexaose	Soluble cellodextrin	Sodium carboxymethylcellulose	Swollen cellulose	Cellulose
Original enzyme	100	100	100	100	100	100
Fraction						
A	5	60	50	40	30	15
B	0	110	100	60	45	0
C	5	220	210	170	120	90
D	25	100	80	120	120	100
E	40	180	110	160	140	130
F	260	160	100	140	100	130

The cellulase used was a culture filtrate of *M verrucaria* grown on cellulose powder, which was concentrated about tenfold in a Bartholomew evaporator, afterwards dialysed against running tap-water (using collodion membranes), ultrafiltered, dialysed against distilled water and freeze-dried.

Cellulolytic activity towards sodium carboxymethylcellulose was measured by incubating 5 ml. of a 0·7 per cent solution of the substance (degree of substitution, 0·8) in buffer (*p*H 5·6) with 1 ml. enzyme solution for 1 hr. at 30° C. Reducing groups formed in 1 ml. of the incubation mixture were measured and expressed as 'mgm. glucose'. The amount of enzyme producing 0·4 'mgm. glucose' under these conditions was denoted 1 cellulase unit. The enzyme solutions tested were always diluted so as to contain 1 cellulase unit or less per ml.

The results of some preliminary experiments were as follows. No adsorption of cellulase was found from a buffer solution of *p*H 6·0 (0·048 *M*). Almost all the cellulase was adsorbed from a solution buffered at *p*H 4·2 (0·048 *M*), but the cellulase could be eluted only very incompletely.

At *p*H 5·2 (0·048 *M*) 70–75 per cent of the cellulase was adsorbed. Elution with buffers of higher *p*H and/or molarity gave recoveries of 80–90 per cent of the activity towards sodium carboxy-methylcellulose. On rechromatography under identical conditions of the cellulase which was not adsorbed, 90 per cent passed through the column.

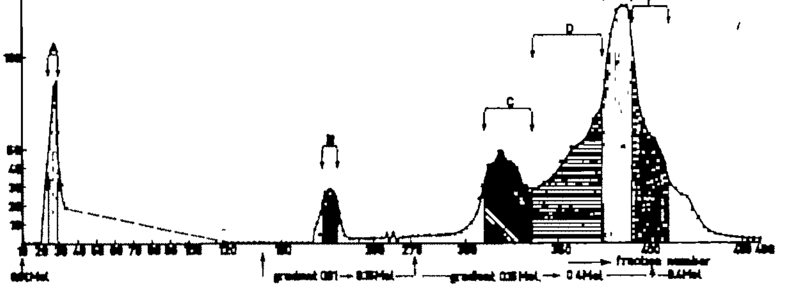


Fig. 1. Fractionation of 500 mgm. cellulase over a column of 'Amberlite *IRC*–50' (diam. 15 mm., length 73 mm.) equilibrated with phthalate buffer *p*H 5·2 (0·01 *M*) and eluted with the same buffer of increasing molarity. Fractions of 5 ml. were collected and the activity of each fraction towards sodium carboxy-methylcellulose was measured and expressed in cellulase units (see text)

The best results have been obtained so far with a column buffered with phthalate buffer pH 5·2 (0·01 *M*), eluting with the same buffer of increasing molarity. Fig. 1 shows the fractionation obtained. Peak *A* contains the cellulase not adsorbed. The fractions were combined as denoted in Fig. 1. Recovery of total activity applied to the column: for peak *A*, 6 per cent; *B*, 3·2 per cent; *C*, 10·1 per cent; *D*, 17·3 per cent; *E*, 17·7 per cent; *F*, 11·2 per cent; other fractions, 11·2 per cent. Total recovery 77 per cent.

Of the combined fractions *A–F* and of the original enzyme, dilutions were made containing the same activity towards sodium carboxy-methylcellulose (10 cellulose units/ml.) and of these the hydrolytic activity was measured towards the substrates: *o*-nitrophenyl-β-D-glucoside (niphegluc), cellohexaose, soluble cellodextrins, phosphoric acid swollen cellulose and α-cellulose. Protein concentrations were determined by the micro-Kjeldahl method. Table 1 shows the relative activities per mgm. nitrogen of the fractions when the activity of the original enzyme towards the substrate is given the value 100.

These results show that the fractions obtained by ion-exchange chromatography differ in the ratios of their activities towards a series of substrates of varying degree of polymerization. Especially fraction *B* is of great interest, as it does not hydrolyse niphegluc (nor cellobiose) nor α-cellulose, whereas its activity towards substrates of medium size (cellohexaose, cellodextrins) is as high as that of the original enzyme. Fraction *C* shows an increase in activity towards medium size substrates relative to the original enzyme. Most of the activity towards *o*-nitrophenyl-β-D-glucoside (and cellobiose) is present in fraction *F*. In our opinion these results strongly indicate the multiple nature of cellulase of *M. verrucaria*. Better resolution of the enzymes should be possible by refining the chromatography technique.

More details of this work, and further progress, will be published shortly.

We are indebted to Dr. P. Kooiman of the Laboratory of Technical Botany, Delft, who kindly provided the samples of cellohexaose and soluble cellodextrins.

P. Y. F. PRINS-VAN DER MEULEN
G. J. SCHURINGA

Central Laboratory T.N.O.,
Delft.

[1] Reese, E. T., and Gilligan, W., *Arch. Biochem. Biophys.*, 45, 74 (1953).

[2] Gilligan, W., and Reese, E. T., *Canad. J. Microbiol.*, 1, 90 (1954).

[3] Miller, G. L., and Blum, R., *J. Biol. Chem.*, 218, 131 (1956).

[4] Grimes, R. M., Duncan, C. W., and Hoppert, C. A., *Arch. Biochem. Biophys.*, 68, 412 (1957).

[5] Whitaker, D. R., *Arch. Biochem. Biophys.*, 43, 253 (1953).

[6] Thomas, R., and Whitaker, D. R., *Nature*, 181, 715 (1958).

[7] Reinouts van Haga, P., *Nature*, 182, 1232 (1958).

PHYSIOLOGY

Effects of Ataractic Drugs on the Blood-Pressure and Heart-Rate of Dogs

THE assessment of the hæmodynamic effects of ataractic drugs, such as the phenothiazine derivatives, has, in the past, always been carried out in anæsthetized or curarized animals[1-4]. Since the action of the ataractic drug may modify, or be modified by, the effect of the anæsthetic or neuromuscular blocking agent, it has been difficult to assess whether the hæmodynamic changes observed have been due to the ataractic drug itself. It is therefore of interest to record a method of assessment which has been used for studying the effects produced by several phenothiazine derivatives in normal conscious dogs, and which has been shown to produce results which do not entirely agree with those obtained in anæsthetized animals.

Three healthy young dogs weighing 15–20 kgm. were surgically prepared with exteriorized carotid arteries and trained to lie quietly on a table while experimental procedures were being carried out. Standard limb lead electrocardiograms, and the blood-pressure obtained by puncture with a needle of the exteriorized carotid artery, were recorded simultaneously on a direct-writing multichannel recorder (Cambridge Instrument Co., Ltd.). The drugs were administered as a 1 per cent solution by intravenous injection through a previously inserted Mitchell needle at a dose-rate of 1 mgm. per kgm. body-weight. Recordings were taken before, during and after injection and every 5 min. thereafter until the maximum effect was observed (usually about 20 min. from the time of injection). Control experiments in which only saline was injected were also performed.

Seven phenothiazine derivatives were administered, in turn, to each dog:

(1), 2-chloro-10-(3-dimethylaminopropyl) phenothiazine hydrochloride (chlorpromazine hydrochloride)
(2), 10-(3-dimethylamino-2-methylpropyl) phenothiazine tartrate (trimeprazine tartrate)
(3), 10-(1-methyl-3-piperidylmethyl) phenothiazine (pecazine)
(4), 10-(2-dimethylaminopropyl) phenothiazine hydrochloride (promethazine hydrochloride)
(5), 10-(3-dimethylaminopropyl) phenothiazine hydrochloride (promazine hydrochloride)
(6), 10-(3-dimethylamino-2-methylpropyl)-2-methoxyphenothiazine hydrochloride (methotrimeprazine hydrochloride)
(7), 10-(3-dimethylamino-2-methylpropyl)-2-ethylphenothiazine hydrochloride (ethylisobutrazine in the United States, 6484 *R.P.*).

The results showed that all these drugs caused significant initial tachycardia (drugs 3, 5 and 7, $P < 0·001$; drugs 1 and 2, $P < 0·01$ and drugs 4 and 6, $P < 0·02$), but after 20 min. the changes in heart-rate were no longer significant. All the drugs appeared to produce an immediate effect on blood pressure, but on analysis it was shown that only drugs 1 and 7 caused significant hypotension ($P < 0·01$), while drug 3 brought about a significant rise in blood-pressure ($P < 0·01$). After 20 min. only drugs 1 and 7 were producing marked hypotension ($P < 0·001$), while drug 5 was causing a moderate decrease in blood-pressure ($P < 0·02$).

These results did not appear to agree with those which have been reported in anæsthetized animals and further experiments were performed to assess the effect of pentobarbitone anæsthesia on the response of blood-pressure and heart-rate to chlorpromazine. These experiments showed that the decrease in blood pressure from the pre-anæsthetic control-level, seen after the administration of chlorpromazine, was proportional to the depth of anæsthesia at the time of injection of this drug. Furthermore, the maximal effect on blood-pressure was obtained within 20 min. in the conscious dog, but under anæsthesia the maximum effect was not apparent until at least 30 min. after the injection of the drug. Anæsthesia also greatly reduced the immediate increase in heart-rate produced by chlorpromazine.

This investigation was carried out with the financial assistance of May and Baker, Ltd. The statistical

analyses were carried out by Dr. R. C. Campbell and Dr. J. T. Abrams.

L. W. HALL
D. E. STEVENSON

School of Veterinary Medicine,
University of Cambridge.

[1] Courvoisier, S., Fournel, J., Ducrot, R., Kolsky, M., and Koetschet, P., *Arch. int. Pharmacodyn.*, 92, 305 (1950).

[2] Moyer, J. H., Kent, B., Knight, R., Morris, G., Huggins, R., and Handley, C. A., *Amer. J. Med. Sci.*, 227 (1954).

[3] Spurr, G. B., Horvath, S. M., and Farrand, R. A., *Amer. J. Physiol.*, 186, 525 (1956).

[4] Maxwell, G. M., Rowe, G. G., Castillo, C., Schuster, B., White, D. H., and Crumpton, C. W., *Anesthesiol.*, 19, 64 (1958).

[5] Romagnoli, A., and Melville, K. T., *Can. Anaes. Soc. J.*, 5, 137 (1958).

Influence of the Ionic Strength of the Medium on the Anaphylactic Sensitization of Isolated Tissues *in vitro*

THE technique of *in vitro* sensitization of living tissues has permitted us to study various factors affecting the process of anaphylactic sensitization. The influence of the time of incubation, concentration of antibody, temperature, *p*H and composition of the medium has been already reported[1-4]. In this communication we present the results concerning the dependence of the sensitization on the ionic strength of the incubating antibody solution.

The experiments were performed with the guinea pig ileum, passively sensitized *in vitro* by incubation with rabbit, anti-egg albumin antibody, according to the technique previously described[2,3]. The antibody solution was prepared not in the usual Tyrode solution but in a medium almost free of electrolytes and made isotonic by the addition of dextrose. The composition of the medium was: dextrose 50 gm., sodium bicarbonate 42 mgm., distilled water 1 litre. Its *p*H, in equilibrium with air at 37° C., was approximately 7. Prior to sensitization the strips of intestine were washed with isotonic dextrose. During the period of incubation, the ionic concentration of the medium rose to, but never exceeded, $0 \cdot 002\mu$ (expressed as sodium chloride), presumably due to release of ions from the isolated intestine. When the influence of the ionic strength (μ) was investigated, varying amounts of sodium chloride, potassium chloride, calcium chloride, magnesium sulphate or potassium bromide were added. The salt concentration has been determined by conductivity measurements. In some experiments, dextrose was replaced by fructose, lactose, saccharose or arabinose.

The degree of sensitization was evaluated by the height of the contraction of the intestine produced in normal Tyrode solution after the addition of the specific antigen, and compared with that produced by a known dose of histamine.

Pieces of guinea pig intestine from the same animal were sensitized with the same amount of antibody in normal Tyrode solution and in dextrose medium. The intensity of the anaphylactic response of the intestine has been established as a function of the time of incubation in both media. It was found that the degree of sensitization was markedly increased in the medium with low electrolytic concentration. The results are shown in Fig. 1.

Dextrose can be replaced by fructose, saccharose, lactose or arabinose with identical results. This would suggest that the increased velocity of sensitization is related to the low concentration of electrolytes in the medium. To confirm this hypothesis we have studied the influence of various electrolytes at different concentrations, and in order to compare their respective effects, we have established, in every case, the time necessary to attain the same degree of sensitization. It was found that, for a given electrolyte, this time increased with its concentration. Furthermore, when different electrolytes were compared at the same ionic strength, their effect was found sensibly the same, regardless of their chemical nature. This result has been verified with sodium chloride, potassium chloride, calcium chloride, potassium bromide

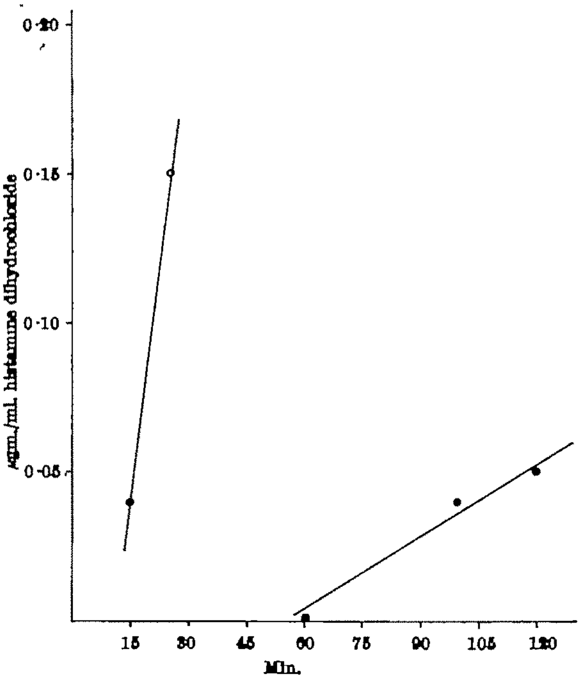


Fig. 1. Isolated guinea pig intestine sensitized passively *in vitro* at 37° C. with the same concentration of rabbit anti-egg albumin antibody (2 µgm. N/ml.). ●, sensitization in normal Tyrode solution ($\mu = 0 \cdot 15$); ○, sensitization in isotonic dextrose ($\mu = 0 \cdot 002$). Ordinate, height of the contractions expressed in histamine equivalent; abscissa, time of the incubation with the antibody

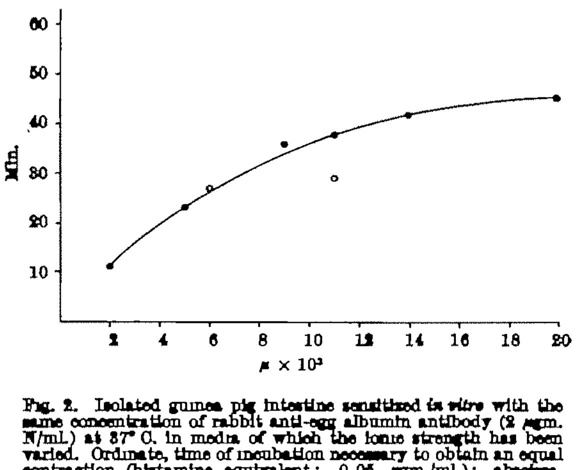


Fig. 2. Isolated guinea pig intestine sensitized *in vitro* with the same concentration of rabbit anti-egg albumin antibody (2 µgm. N/ml.) at 37° C. in media of which the ionic strength has been varied. Ordinate, time of incubation necessary to obtain an equal contraction (histamine equivalent: 0·05 µgm./ml.); abscissa, ionic strength of the incubating medium. In all experiments, the passive sensitization has been achieved in isotonic dextrose of which the ionic strength has been altered with sodium chloride (●), or magnesium sulphate (○)

and magnesium sulphate. A typical experiment is shown in Fig. 2.

The fact that the velocity is dependent on the ionic strength of the medium suggests that electrical interactions between globulin molecules or between antibody and cell play some part in the process of sensitization. Accordingly, it may be expected that modification of the *p*H would modify the rate of sensitization and the dependence of this rate on ionic strength. Preliminary experiments have shown that at low values of μ (of the order of 0·003) the sensitization process is highly dependent on the *p*H of the incubating solution.

R. Binaghi
M. Liacopoulos-Briot
B. N. Halpern
P. Liacopoulos

Centre de Recherches Allergiques et Immunologiques
de l'Association Claude Bernard,
Hôpital Broussais,
96 rue Didot,
Paris.

[1] Halpern, B. N., Liacopoulos, P., Liacopoulos-Briot, M., and Binaghi, R., *C.R. Acad. Sci., Paris*, **247**, 1798 (1958).

[2] Halpern, B. N., Liacopoulos, P., Liacopoulos-Briot, M., van Neer, F., and Binaghi, R., *C.R. Soc. Biol., Paris*, **153**, 7 (1959).

[3] Halpern, B. N., Liacopoulos, P., Liacopoulos-Briot, M., Binaghi, R., and van Neer, F., *Immunology*, **2**, 351 (1959).

[4] Binaghi, R., Halpern, N. B., Liacopoulos, P., and Neveu, T., *Nature*, **184**, 1805 (1959).

Use of Diodone in Renal Studies in Sheep

Diodone (3,5-di-iodo-4-pyridone-N-acetic acid), shown by Elsom *et al.*[1], Landis *et al.*[2], and Smith *et al.*[3] to be an effective agent for the estimation of renal plasma flow and tubular function, has been used extensively in physiological studies. In 1945, Smith *et al.*[4] showed that *p*-aminohippuric acid was in some ways superior to diodone for these estimations in man because the urine and plasma blanks are small, and because diodone penetrates human red blood cells whereas *p*-aminohippuric acid does not. The red cells of dogs are permeable to both reagents.

Sheep, unlike the dog and man, normally excrete considerable quantities of hippuric acid in the urine[5]. The possibility that this endogenous hippuric acid may interfere with the estimation of *p*-aminohippuric acid is not remote when sheep are employed as experimental subjects.

A study was made of the permeability of the sheep's red blood cells to diodone by administering to six adult merino ewes, as an initial intravenous priming injection, 1·5 ml. 35 per cent diodone, and following this by a continuous intravenous infusion of 0·7 per cent diodone at the rate of 4 ml./min. over a period of 2 hr. At no time during or after the injection did the animals give any indication of being adversely affected by the diodone. Blood and urine (catheter) samples, taken at 30-min. intervals, were analysed for diodone[6] and *p*-aminohippuric acid[4].

Comparison of concentrations in the whole blood and the plasma indicated the passage of little, if any, diodone into the erythrocytes (Table 1). This was substantiated by the absence of diodone in the separated, saline-washed cells from three sheep subsequent to injection.

Analyses of the blood and urine samples collected during the periods in which diodone was administered failed to detect any reaction indicative of *p*-aminohippuric acid in any of the blood samples. A reaction of the same type as that given by *p*-aminohippuric acid, however, was always detectable in the urine; the concentration of this substance, which varied considerably with animals and with samples from the same animal, indicated excretions, which ranged from 0·2 mgm. to 1·1 mgm. for a 30-min. period. This is of the same order as that found by Smith *et al.*[4] to be excreted in similar circumstances by man and the dog. Thus the blanks arising from this substance are unlikely to interfere with the employment of *p*-aminohippuric acid for the determination of renal clearance tests in sheep.

It has also been established that the red cells of sheep are impermeable to circulating diodone, and thus differ from human red cells and from those of the dog.

B. J. Potter

Division of Biochemistry and General Nutrition,
Commonwealth Scientific and Industrial
Research Organization,
University of Adelaide.

[1] Elsom, K. A., Bott, P. A., and Shiels, E. H., *Amer. J. Physiol.*, **115**, 548 (1936).

[2] Landis, E. M., Elsom, K. A., Bott, P. A., and Shiels, E. H., *J. Clin. Invest.*, **15**, 397 (1936).

[3] Smith, H. W., Goldring, W., and Chasis, H., *J. Clin. Invest.*, 17, 263 (1938).

[4] Smith, H. W., Finkelstein, N., Aliminosa, L., Crawford, B., and Graber, M., *J. Clin. Invest.*, **24**, 388 (1945).

[5] Lewin, K., *Z. Klin. Med.*, **42**, 371 (1901).

[6] Alpert, L. K., *Bull. Johns Hopkins Hosp.*, **68**, 522 (1941).

Lack of Hæmatopoietic Potency of Liver of Mice fed on a Meat Diet

Recently, Adler[1] reported that mice fed on a diet composed of meat only develop an anæmia which is generally fatal but is cured by beef liver. Ilan, Kende and Guggenheim[2] have found that treatment of mice while subsisting on the meat diet with *para*-

Table 1. Showing Degree of Entry of Diodone into Erythrocytes of Sheep. Diodone Values (mgm./100 ml.) taken at 30-min. Intervals of Time

Animal No.	Plasma				Whole blood				Calculated whole blood*				Entry of diodone into erythrocytes (per cent)			
	30	60	90	120	30	60	90	120	30	60	90	120	30	60	90	120
2	1·92	1·73	1·97	1·78	1·15	1·08	1·15	1·10	1·22	1·10	1·24	1·14	—	—	—	—
81	1·78	1·48	1·56	1·56	1·14	0·97	1·01	1·01	1·18	0·97	0·99	1·00	—	—	2	1
31	0·88	1·32	1·58	1·65	0·51	0·86	0·99	1·14	0·58	0·87	1·06	1·12	—	—	—	1·9
58	1·96	1·83	1·69	1·69	1·32	1·25	1·12	1·14	1·29	1·21	1·14	1·14	2·3	3·3	—	—
60	2·06	2·02	1·96	1·40	1·29	1·29	1·24	0·93	1·29	1·29	1·26	0·92	—	—	—	1·1
9	1·86	1·70	1·70	1·57	1·16	0·95	0·95	0·99	1·15	1·08	1·08	1·01	0·9	—	—	—

* Calculated whole blood = Plasma value × hæmatocrit value (for plasma).

aminobenzoic acid, folic acid, vitamin B_{12}, liver extract, pyridoxine, iron, vitamin A, antibiotics (*per os*) or a combination of some of these substances neither prevents the anæmia nor the mortality nor does it improve growth. Some of these substances have, however, a slight effect in preventing anæmia. It could furthermore be shown that livers of mice suffering from 'meat anæmia' contained much more vitamin B_{12} than those of non-anæmic controls. It has been assumed that an essential hæmatopoietic factor, which is not vitamin B_{12}, folic acid or any other known hæmatopoietic factor, is absent from beef muscle; another possibility is the presence in beef muscle of an inhibitor of hæmatopoiesis.

We wish to report some further experiments conducted with the purpose of studying the effect of an addition of liver to the diet. 42 mice rendered anæmic by feeding the meat diet for 6 weeks were divided into 4 groups. One group served as control and continued on the meat diet. The diet of the three other groups consisted of three parts beef muscle and one part liver. The source of the liver of one of these groups was beef, that of the second, normal mice, and that of the third, anæmic mice. This dietary treatment lasted for 3 weeks. Table 1 presents figures for mortality, change in weight, erythrocytes and hæmoglobin. It shows that replacement of one of four parts of beef muscle by beef liver cured the anæmia completely and induced a considerable increase in body-weight. Liver of normal mice had a definite but smaller effect, and liver of anæmic mice resulted in no improvement.

Table 1. MORTALITY, WEIGHT CHANGES, RED BLOOD CELL COUNTS AND HÆMOGLOBIN OF ANÆMIC MICE FED ON LIVER INCORPORATED INTO A MEAT DIET

Source of liver	Period of treatment	Mortality	Weight (gm.)	Erythrocytes (10^6/cu. mm.)	Hæmoglobin (gm./100 ml.)
None, control (10)	Pre-treatment	—	14·6 ± 1·4	3·04 ± 0·13	6·6 ± 0·8
	3 weeks	7/13	13·4 ± 1·7	2·84 ± 0·54	3·5 ± 0·8
Beef liver (6)	Pre-treatment	—	17·0 ± 1·8	2·26 ± 0·10	5·8 ± 0·9
	3 weeks	2/6	21·0 ± 0·9	6·82 ± 0·23	15·8 ± 0·5
Normal mouse liver (13)	Pre-treatment	—	18·4 ± 0·6	3·14 ± 0·40	5·2 ± 0·54
	1 week	0/13	17·5 ± 0·6	3·65 ± 0·49	7·2 ± 1·22
	2 weeks	1/13	19·5 ± 0·7	4·42 ± 0·63	8·1 ± 1·04
	3 weeks	4/13	20·1 ± 0·8	5·39 ± 0·68	9·8 ± 1·17
Anæmic mouse liver (13)	Pre-treatment	—	16·2 ± 1·0	2·69 ± 0·37	5·6 ± 0·80
	1 week	2/13	16·0 ± 1·1	2·36 ± 0·23	4·4 ± 0·58
	2 weeks	9/13	15·8 ± 1·6	1·65 ± 0·23	2·8 ± 0·18
	3 weeks	11/13	16·8	1·42	2·3

These results are consistent with the theory that a hæmatopoietic factor is present in beef liver in higher concentration than in normal mice liver and is absent from liver of mice which had subsisted on beef muscle. The existence in liver of an anti-anæmic factor(s) other than vitamin B_{12}, folic acid and folinic acid has repeatedly been claimed[3].

JUDITH ILAN
K. GUGGENHEIM

Laboratory of Nutrition,
Department of Biochemistry,
Hebrew University–Hadassah
Medical School,
Jerusalem.

---

[1] Adler, S., *Bull. Res. Counc. Israel*, 7, E, 9 (1958).

[2] Ilan, J., Kende, M., and Guggenheim, K., *Blood* (in the press).

[3] Wintrobe, M. M., "Clinical Hematology", fourth ed., 446 (Lea and Febiger, Philadelphia, 1951).

Effect of Anti-Diuretic Hormone and Calcium on the Equivalent Pore Radius of Kidney Slices from *Necturus*

THE passive permeability of kidney slices may be expressed in terms of the equivalent pore radius. The present work is concerned with measurement of this parameter for kidney slices from the amphibian, *Necturus maculosus*, both under normal conditions, and as affected by the action of anti-diuretic hormone and calcium. Measurements have been made by the method of D. A. Goldstein and A. K. Solomon (private communication), which depends on the determination of the external concentration of permeant solute required to prevent water movement into or out of the cell at the instant of immersion in the medium. When the initial rate of change in volume of the cell is zero, the cell is in transient osmotic equilibrium with its environment. As Staverman[1] has pointed out, the concentrations required to produce transient osmotic equilibrium are higher for permeant solutes than for impermeant ones. Goldstein and Solomon have shown how these zero-time isotonic concentrations may be related to the equivalent pore radius.

Slices (0·2 mm. thick, 100–200 mgm. wet weight) from the kidneys of *Necturus* were weighed and immersed in a number of test solutions. Changes in the weight of the slice, which served as an index of cell volume change, were measured for 30 min. At 3–4-min. intervals, each slice was taken out of the solution, blotted, weighed and returned to the solution. Since the rate of change of weight was essentially constant during the first 5–10 min., an average during that period was determined and recorded as the per cent weight change per minute. All the bathing solutions contained sodium bicarbonate, 21 m*M*; dipotassium hydrogen phosphate, 0·6 m*M*; sodium dihydrogen phosphate, 2·4 m*M*; potassium chloride, 13 m*M*; magnesium sulphate, 1·2 m*M*; sodium sulphate, 0·6 m*M*; calcium chloride, 1 m*M* and glucose 5·5 m*M*, making a total of 78 mOsm./l. In addition, one of the following non-lipid-soluble non-electrolytes was added: raffinose, sucrose, mannitol, erythritol, glycerol or urea. The final total concentration ranged from 125 to 300 mOsm./l. *p*H was kept at 7·3 ± 0·1 by bubbling with 95 per cent oxygen and 5 per cent carbon dioxide. The experiments were performed at 18–20° C.

The zero-time rate of change of slice weight, $(dw/dt)_0$, is obtained by extrapolation. It is shown in Fig. 1 as a function of the concentration of probing molecule in the medium. Each point is the average of results obtained from 8–12 slices from 4–6 kidneys. It may be seen that $(dw/dt)_0$ for sucrose is zero at a concentration of 83 m*M*, as is also the case for raffinose and mannitol at the same concentration.

Table 1. C_{iso} AND σ FOR NON-LIPID-SOLUBLE NON-ELECTROLYTES IN KIDNEY SLICES

	No 'Pitressin'		'Pitressin'		Molecular radius* Å.
	C_{iso} (m*M*)	σ	C_{iso} (m*M*)	σ	
Urea	160 ± 10†	0·52	160	0·52	2·3
Glycerol	108 ± 4	0·77	128	0·65	2·9
Erythritol	93 ± 3	0·89	108	0·77	3·2
Mannitol	83 ± 4	1·0			4·0
Sucrose	83 ± 2	1·0	83	1·0	4·5
Raffinose	83 ± 3	1·0			6·0

* Molecular radii were determined on Stuart and Briegleb models, except raffinose, taken from viscosity measurements (ref. 8).

† Errors are standard errors of the mean.

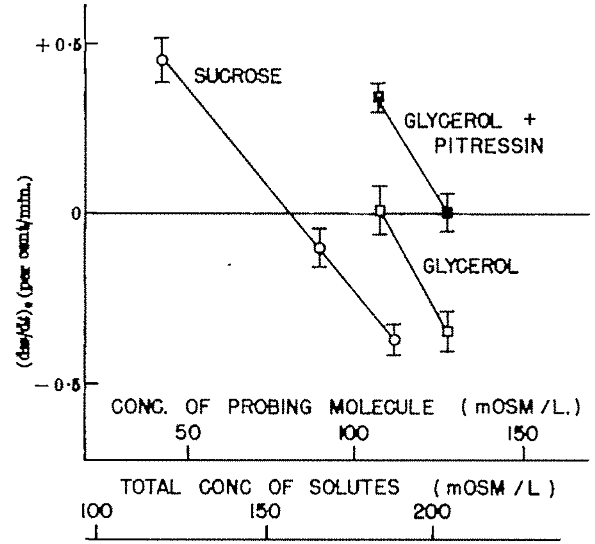


Fig. 1. Initial change in weight plotted as a function of the concentration of solute in the bathing solution. C_{iso} for sucrose may be seen to be 83 mOsm./l. compared with 108 for glycerol

Since we found the volume of distribution of mannitol to be the same as that of inulin in these kidney slices, it appears that all three solutes are confined to the extracellular phase during the course of our experiments. Consequently, the 83 m*M* concentration has been taken as the base line for comparison with experiments utilizing permeant solute. The zero time isotonic solution concentrations, C_{iso}, are given in Table 1. The determination of C_{iso} is equivalent to the determination of Staverman's reflexion coefficient, σ, also shown in Table 1. σ is given by the ratio (osmotic pressure due to permeant solute)/(osmotic pressure that would arise if solute were impermeant).

Goldstein and Solomon (private communication) have constructed a family of theoretical curves which relate (1 − σ) to the equivalent pore radius in the membrane and to the radius of the probing molecule. They applied these curves to their measurements of σ and obtained a figure of 4·2 Å., for the equivalent pore radius in human red cells, in agreement with the value of 3·5 Å. obtained by an independent method[5]; this agreement lends support to the use of σ to determine equivalent pore radii for such small pores. The curves given by Goldstein and Solomon (private communication) may also be applied to the data in Table 1. As shown in Fig. 2, an equivalent pore radius of 5·6 Å. fits our results. Although the slices are composed predominantly of proximal tubule cells, they contain also other cell types. Thus the figure of 5·6 Å. represents an average over all the types of cells that are encountered within the slice.

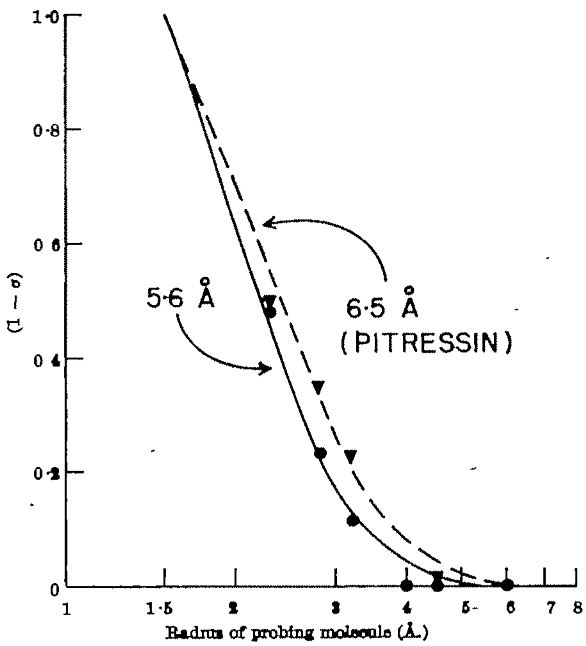


Fig. 2. (1 − σ), which is $[1 - \pi_{obs}/\pi_{theor.}]$ plotted as a function of the radius of the probing molecules. The circles represent our experimental values in normal animals and the triangles the results after injection of 'Pitressin'

The effect of anti-diuretic hormone ('Pitressin', Parke Davis and Co.) was examined in a group of experiments in which 10 pressor units of 'Pitressin' per animal were injected intraperitoneally $2\frac{1}{4}$–$3\frac{1}{4}$ hr. before the kidneys were taken out. As shown in Table 1, no change in C_{iso} for sucrose was observed; however, C_{iso} for erythritol and glycerol decreased significantly ($P = 0·01$). When these results are plotted in Fig. 2, it is seen that the equivalent pore radius is increased to 6·5 Å. Results compatible with this observation have previously been described by Ussing for toad skin[3], and by Sawyer and Hays *et al.*[5] for amphibian bladder.

Table 2. INHIBITION OF 'PITRESSIN' ACTION BY CALCIUM IN *Necturus* KIDNEY SLICES

Calcium (m*M*)	Initial rate of weight change in isotonic glycerol* (per cent/min.) 1	5	10
No 'Pitressin'	0·01 ± 0·07	0·00 ± 0·04	0·01 ± 0·06
'Pitressin'	0·34 ± 0·04	0·17 ± 0·04	−0·03 ± 0·06
'Pitressin' induced effect	0·33 ± 0·08	0·17 ± 0·06	−0·04 ± 0·08
P of induced effect	< 0·01	0·02	> 0·6

* The solutions were maintained isotonic by substitution of calcium chloride for sodium bicarbonate. The glycerol concentration was 108 mOsm./l. The osmolarities of the solutions were checked by freezing-point depression.

The absence of calcium is known to cause cell swelling, as shown by Fukuda[6] in *Anthocidaris* eggs, and by Bozler[7] in muscle. Consequently, it seemed desirable to examine the influence of calcium on our preparation. An increase of calcium from the normal value of 1 m*M* up to 10 m*M* had no detectable effect on $(dw/dt)_0$ when the cells were immersed in sucrose solutions. On the other hand, removal of calcium from the medium produced a sharp increase in weight, the tissue becoming permeable to sucrose (molecular radius 4·5 Å.), though remaining impermeable to raffinose (molecular radius 6·0 Å.). It may be inferred that the calcium content of the membrane exercises a delicate control over the equivalent pore radius. Consequently, a set of experiments was carried out to see whether excess calcium might inhibit the action of anti-diuretic hormone. The results shown in Table 2 indicate that this is indeed the case. When the slices are immersed in isotonic glycerol, 5 m*M* calcium reduces the effect of 'Pitressin' to half and 10 m*M* calcium suppresses it. A similar effect has been observed when the slices are immersed in isotonic erythritol, 10 m*M* calcium completely inhibiting the 'Pitressin' effect. These results suggest that the action of anti-diuretic hormone on membrane permeability may be due to an interaction with membrane calcium.

This work was supported in part by grants from the Life Insurance Medical Research Fund and the National Science Foundation.

Note added in proof. Since this communication was submitted, we have seen a paper by P. J. Bentley (*J. Endocrin.*, 18, 327; 1959), who observed a similar interaction between calcium and 'Pitressin' on toad bladder.

G. WHITTEMBURY*
N. SUGINO†
A. K. SOLOMON

Harvard Medical School, Boston, Mass.

---

* Helen Hay Whitney Foundation Fellow. On leave of absence from Facultad de Medicina, Lima, Peru.

† On leave of absence from Nihon University Medical School, Tokyo, Japan.

[1] Staverman, A. J., *Rec. Trav. Chim.*, 74, 344 (1951).

[2] Paganelli, C. V., and Solomon, A. K., *J. Gen. Physiol.*, 41, 259 (1957).

[3] Ussing, H. H., "Colston Papers", 7, 33 (Butterworths Scientific Publications, London, 1954).

[4] Sawyer, W. H., *Endocrinol.*, 66, 112 (1960).

[5] Hays, R. M., Lamdin, E., Maffly, R. H., and Leaf, A., *Fed. Proc.*, 18, 66 (1959).

[6] Fukuda, T., *J. Cell. and Comp. Physiol.*, 7, 301 (1936).

[7] Bozler, E., *Amer. J. Physiol.*, 197, 505 (1959).

[8] Schultz, S. G., and Solomon, A. K., Fourth Ann. Meeting of the Biophysical Society, Abstract *F4* (1960).

HÆMATOLOGY

MNSs Gene Frequencies in English Blood Donors

ESTIMATES of the MNSs gene frequencies in the English population have been based hitherto on the results of tests with anti-M, -N and -S only[1,2]. Recently, a supply of the very rare anti-s was made available through the kindness of Dr. J. O'Riordan of Dublin[3], and a random series of 1,000 Sutton blood donors was tested with all four antisera. The samples were also tested with anti-Mia, -Vw and -Mg. All were negative with the last two antisera, but one donor was found to be *Ms*/*Ns*, Mi(a +) Vw−, and a study of her family showed *Mi*a to be travelling with *Ns*. The results of the major grouping tests are given in Table 1.

Table 1. SAMPLES FROM 1,000 UNSELECTED SUTTON BLOOD DONORS TESTED WITH ANTI-M, -N, -S and -s

Reactions with anti -M	-N	-S	-s	Number
+	−	+	−	57
+	−	+	+	140
+	−	−	+	101
+	+	+	−	39
+	+	+	+	224
+	+	−	+	226
−	+	+	−	3
−	+	+	+	54
−	+	−	+	156
			Total	1,000

Table 2. PERCENTAGE FREQUENCIES OF THE MNSs GENES IN ENGLISH PEOPLE

	Sutton series, 1959 Calculations based on the use of Anti-M,-N,-S-s	Anti-M,-N,-S	Race and Sanger (ref. 1) 1950	Ikin *et al.* (ref. 2) 1952
MS	23·11 ± 1·022	23·58 ± 1·116	24·72	24·02
Ms	30·90 ± 1·102	30·67 ± 1·185	28·31	29·71
NS	7·09 ± 0·678	6·89 ± 0·807	8·02	5·64
Ns	38·90 ± 1·155	38·86 ± 1·233	38·95	40·63
No. tested	1,000		1,419	1,166

Gene frequencies have been calculated by the method of maximum likelihood estimation, and are presented in Table 2. They have also been calculated from the same data, assuming the use of anti-M, -N and -S only; these results are included in Table 2 for comparison along with those of Race and Sanger[1], and of Ikin *et al.*[2], whose tests were in fact made with the three sera only. The calculated gene frequencies, when recombined, give expected figures for the 9 phenotype classes which fit very closely with those observed ($\chi^2 = 3{\cdot}64945$ for 4 d.f.)

I am indebted to Dr. J. H. Edwards of the Medical Research Council Population Genetics Research Unit, Oxford, for the statistical treatment. He has estimated from these results that tests on 800 samples with all four antisera may be expected, on average, to yield as much information as tests on 1,000 samples with the three antisera more readily available.

T. E. CLEGHORN

South London Transfusion Centre,
38 Stanley Road, Sutton, Surrey.

---

[1] Race, R. R., and Sanger, R., "Blood Groups in Man", 51 (1950); 62 (1954); 74 (1958) (Oxford University Press).

[2] Ikin, E. W., *et al.*, cited by Mourant, A. E., in "The Distribution of the Human Blood Groups", 358 (Oxford University Press, 1954).

[3] O'Riordan, J., and Cann, J., *Vox Sang.* (N.S.), 4, 242 (1959).

Chemical Constitution of the Red Blood Cell Membrane

SOME authors[1–6] claim that the red blood cell membrane is a continuous lipoid. Others[7–10] do not accept this. They assert that the membrane consists of a protein skeleton with lipoid molecules in the hollows of the protein skeleton.

The work reported here aims at settling this with the help of the Sanger dinitrofluorobenzoic acid method for amino end-group determination[11].

Red cells freed from native protein and its fraction were used. Fractionation was as follows: to 10 ml. red cell suspension 20 ml. physiological salt solution and 10 ml. ether were added. This was shaken for 5 min. and then centrifuged. Three phases resulted: the central layer (the stroma) was solid; the upper ether phase contained lipoid; the lower solution contained hæmoglobin. The extraction was repeated five times. We combined the fraction obtained in the course of the extractions. The stroma and the watery solution from ether were dried and the ether solution evaporated. Thus we obtained ether-soluble lipoid- and hæmoglobin-free stroma, ether hæmolysate and such lipoid fraction as contained any ether-soluble fat-like matter.

Since the alcoholic solution of dinitrofluorobenzoic acid causes hæmolysis on native red cells, the method had to be modified. The reactions were performed with native red cells and aqueous solution, with physiological salt of dinitrofluorobenzoic acid at *p*H 8·0 (0·15 *M* HCO_3–CO_3), at 37° C. by slight stirring for 60 min. Hydrolysis of the products was effected with 6 *N* hydrochloric acid at 105° C. (6 hr.). Analysis of purified dinitrophenyl derivatives was performed with paper chromatography[12].

The chromatogram of native red cell and of its three fractions is illustrated in Fig. 1.

Each substance was identified by its mobility and by the application of model compounds.

On the surface of the native red cell[9] two amino-acids, arginine and serine amino end-groups, are to be found. Serine can be derived both from stromatin-proteins and from cephalin; consequently its presence is not conclusive. The arginine, however, is exclusively of protein origin, therefore the stroma-proteins are not likely to be encircled by coherent lipoid membrane. This fact is confirmed by Block and Bollding[13], who

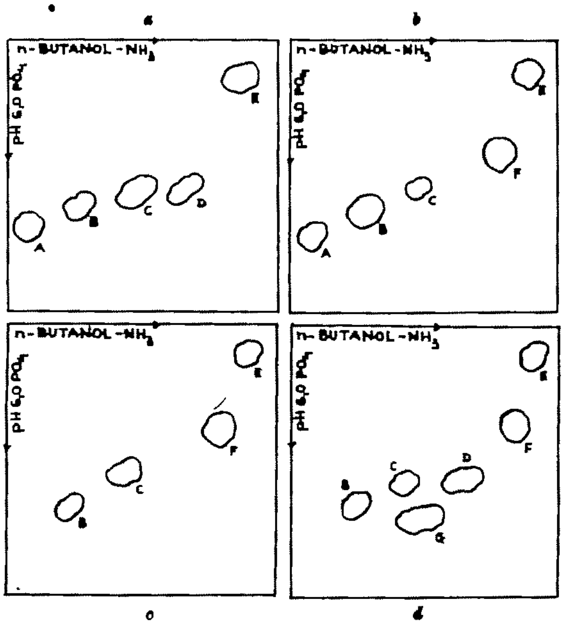


Fig. 1. *a*, Native red cells. *A*, DNP-arginine; *B*, DNP-serine; *C*, unknown amine; *D*, unknown amine; *E*, DNP-NH$_2$. *b*, Lipid-free stroma; *F*, DNP-colamin. *c*, Lipid extraction. *d*, Hæmolysate; *G*, DNP-valine

find that the arginine content of stroma-protein is very high. After the removal of a greater part of lipoids by ether from the stroma obtained further end-groups originating from amino-acid could not be observed. The fact that serine is to be found in the stroma, too, confirms its protein or cephalin origin, which in greater part is attached to protein, although it probably occurs in the form of lipoprotein. The latter is confirmed also by the fact that colamin can be found in the stroma in great quantities, which can be isolated in the form of dinitrophenyl-colamin. In the lipoid fraction removed from the red cell by ether, serine and an unknown amino compound were found (Fig. 1c).

The possibility arose that the dinitrofluorobenzoic acid did not react on the surface of the red cell only but also in its interior. Our experiments have shown that this is not the case, because in the hæmolysate of typical hæmoglobin origin[11] 2 mol. valine end-group appeared; in the case of the native red cell this product could not be found.

T. FEHÉR

I. Medical Department,
University of Medicine, Budapest, 8.

BÉLA MATKOVICS

Department of Organic Chemistry,
University of Szeged.

[1] Fricke, H., Parker, E., and Ponder, E., *J. Cell. and Comp. Physiol.*, 13, 69 (1939).

[2] Parpart, A. K., and Dziemian, A. J., *Cold Spring Harbor Symp. Quant. Biol.*, 8, 17 (1940).

[3] Ballentine, R., and Parpart, A. K., *J. Cell. and Comp. Physiol.*, 16, 49 (1940).

[4] Winkler, K. A., and Bungenberg de Jong, H. G., *Arch. Neerl. Physiol.*, 25, 431 (1941).

[5] Jung, F., *Klin. Woch.*, 917 (1942).

[6] Lindemann, B., *Arch. Exp. Path. Pharm.*, 209, 44 (1950).

[7] Wolpers, C., *Naturwiss.*, 29, 416 (1941).

[8] Ponder, E., "Hemolysis and Related Phenomena" (New York, 1945).

[9] Perosa, L., and Raccuglia, G., *Experientia*, 8, 182 (1952).

[10] Jonas, H., *Biochim. Biophys. Acta*, 13, 241 (1954).

[11] Sanger, F., Biochem. Soc. Symp., 3, 29 (1950).

[12] Koch, G., and Weidel, W., *Hoppe-Seylers Z.*, 303, 213 (1956).

[13] Block, R. J., and Bolling, D., "The Amino Acid Composition of Proteins and Foods" (Thomas, Springfield, 1951).

PATHOLOGY

High-Energy Bound Phosphate and Diabetes Mellitus

THE problem of whether oxidative phosphorylation is impaired in diabetes mellitus or not remains obscure. Cutolo and Siliprandi[1] and Sacks[2] demonstrated a decrease in high-energy bound phosphate content in alloxan-diabetic rat liver. Vester and Stadie[3] found diminished oxidative phosphorylation in depancreatized cat liver mitochondria but not in alloxan-diabetic rat liver mitochondria. Parks *et al.*[4] also failed to find an abnormality in alloxan-diabetic rat liver mitochondria. Goranson and Erulkar[5] found uncoupling of oxidative phosphorylation in the heart muscle of alloxan-diabetic rats, but Peterson and his collaborators[6] reported that the high-energy bound phosphate content of skeletal muscle was in the normal range.

In order to see whether the formation of high-energy bound phosphate is disturbed in diabetic patients, we determined the blood high-energy bound phosphate in 65 diabetic patients and 63 non-diabetic control subjects. The blood high-energy bound phosphate content in the overnight fasting state was determined as 10 min. hydrolysed phosphorus by the method described elsewhere[7]. The values obtained by the method showed a fair agreement with those obtained by the method of Wolff and Paysant[8]. The diabetic patients studied were non-ketotic. In patients treated with insulin, blood specimens were obtained after the omission of regular insulin for 24 hr.

The mean 10-min. phosphorus in blood level was $3 \cdot 4 \pm 0 \cdot 09$ mgm./100 ml. for the diabetic group and $3 \cdot 5 \pm 0 \cdot 11$ mgm./100 ml. for the control group and there was no significant difference statistically ($P > 0 \cdot 10$). The mean 10 min. phosphorus content of blood cells was $7 \cdot 7 \pm 0 \cdot 17\gamma \times 10^{-9}$ per red cell for the diabetic group and $7 \cdot 8 \pm 0 \cdot 07\gamma \times 10^{-9}$ per red cell for the non-diabetic group. Therefore, the fasting blood high-energy bound phosphate content of diabetic patients was not different from that of non-diabetic control subjects.

Our previous work showed, however, that the injection of adrenaline (0·5 mgm.)[7] or cortisone (25 mgm.)[9] depressed the level of blood 10 min. phosphorus to a greater extent in diabetic patients than in non-diabetic subjects. The increase in blood 10 min. phosphorus produced by the subcutaneous injection of insulin (5 units)[9], by the oral administration of 25 gm. of butter[10] or by the oral administration of 1 gm. of carbutamide[11] was significantly less in diabetic patients than in non-diabetics. No significant difference between diabetic patients and non-diabetic subjects was found in the changes of blood 10 min. phosphorus-level after the oral ingestion of 50 gm. of glucose[12], after the intramuscular injection of glucuronic acid (1,000 mgm.)[13] or after the oral administration of phenethylbiguanide (100 mgm.)[11]. Similar results were obtained in the study on alloxan-diabetic rabbit liver 7 min. phosphorus, that is, there was no significant difference in the liver 7 min. phosphorus in the post-absorptive state between diabetic rabbits and normal rabbits, but the change after adrenaline administration (0·01 mgm./kgm.) was significantly greater and the change after insulin (1·5 units/kgm.) was significantly less in the diabetic rabbit groups than in the normal group[14].

We feel that diabetic patients have a slight disturbance in high-energy bound phosphate formation which becomes manifest after the administration of adrenaline, cortisone, insulin, etc.

Yoshio Goto
Isao Ito
Akihiko Kuwano
Yukio Ujiie

From the Medical Department of
Prof. S. Yamagata,
Tohoku University Medical Faculty,
Sendai, Japan.

---

[1] Cutolo, R., and Siliprandi, N., *Experientia*, 8, 24 (1952).

[2] Sacks, J., *Amer. J. Physiol.*, 172, 93 (1953).

[3] Vester, J. W., and Stadie, W. C., *J. Biol. Chem.*, 227, 669 (1957).

[4] Parks, jun., R. E., Adler, J., and Copenhaver, jun., J. H., *J. Biol. Chem.*, 214, 693 (1955).

[5] Goranson, E. S., and Erulkar, S. D., *Arch. Biochem.*, 24, 40 (1949).

[6] Peterson, R. D., Beatty, C. H., Bocek, R. M., and West, E. S., *Amer. J. Physiol.*, 179, 499 (1954).

[7] Goto, Y., and Ito, I., *Tohoku J. Exp. Med.*, 67, 65 (1957).

[8] Wolff, R., and Paysant, P., *Bull. Soc. chim. biol.*, 33, 1877 (1951).

[9] Ito, I., *Tohoku Igaku Z.*, 56, 592 (1957).

[10] Goto, Y., and Numazawa, Y., *Tohoku J. Exp. Med.*, 68, 57 (1958).

[11] Goto, Y., Ujiie, Y., Takanami, A., Kuwano, A., and Uchiyama, T., *Tohoku J. Exp. Med.*, 69, 131 (1959).

[12] Goto, Y., Ito, I., and Ujiie, Y., *Tohoku J. Exp. Med.*, 68, 51 (1958).

[13] Goto, Y., Ujiie, Y., Takanami, A., Kuwano, A., and Uchiyama, T., *Tohoku J. Exp. Med.*, 69, 137 (1959).

[14] Ujiie, Y., *Tohoku Igaku Z.*, 59, 606 (1959).

Recovery of Leukæmogenic Agent from Non-Leukæmic Tissues of Thymectomized Mice

It has been shown by Gross and others[1] that filtrates of leukæmic tissues are leukæmogenic following injection into new-born mice of a low-leukæmic strain, and that total thymectomy prevents the development of lymphocytic leukæmia in inoculated mice[2]. On the other hand, normal thymuses grafted to inoculated thymectomized hosts as late as 6 months after thymectomy develop lymphocytic neoplasms[3]. It follows, therefore, that a leukæmogenic agent might be recoverable from the tissues of inoculated mice up to 6 months or more after thymectomy.

Six-months old *C3Hf*/*Gs* mice, which had received an intraperitoneal injection of passage *A* filtrate (a potent leukæmogenic filtrate) at or soon after birth and had been thymectomized at 3–4 weeks of age, were killed, and extracts were prepared from their spleens or brains. Microscopic examination of these organs did not reveal any leukæmic cells or any other abnormality. Some of the spleen cells were transplanted to normal adult *C3Hf*/*Gs* mice, but these remained free from leukæmia during a total period of observation of 8–9 months. The spleen and brain extracts were inoculated intraperitoneally into new-born *C3Hf*/*Gs* mice, which then received no further treatment. As can be seen in Table 1, 60–80 per cent of the mice in the experimental group developed leukæmia as early as 3 months after birth. No leukæmia developed in 13 control mice inoculated with brain and spleen extracts prepared from untreated 6-month-old *C3Hf*/*Gs* mice.

Extracts from non-leukæmic tissues of inoculated thymectomized hosts were passaged through successive generations of thymectomized mice and finally into non-thymectomized mice. Leukæmias are already appearing in the group with intact thymuses, suggesting that: (1) multiplication of the leukæmic agent has taken place each time during transfer through thymectomized hosts; (2) the thymus is not a necessary site for replication of the agent since in the last two generations of thymectomized hosts the material was injected after thymectomy. These results will be published in full detail when the results are complete.

I wish to thank Profs. A. Haddow and P. C. Koller for their interest. The investigations have been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the Medical Research Council, the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

J. F. A. P. Miller

Chester Beatty Research Institute,
Institute of Cancer Research,
Royal Cancer Hospital,
Fulham Road,
London, S.W.3.

---

[1] Gross, L., *Cancer Res.*, 18, 371 (1958). Miller, J. F. A. P., *Brit. J. Cancer*, 14, 83 (1960).

[2] Gross, L., *Proc. Soc. Exp. Biol. and Med.*, 100, 325 (1959). Levinthal, J. D., Buffett, R. F., and Furth, J., *Proc. Soc. Exp. Biol. and Med.*, 100, 610 (1959). Miller, J. F. A. P., *Nature*, 183, 1069 (1959).

[3] Miller, J. F. A. P., *Nature*, 184, 1809 (1959); *Brit. J. Cancer*, 14, 93 (1960).

Table 1. THE DEVELOPMENT OF LYMPHOCYTIC LEUKÆMIA IN MICE INOCULATED WITH EXTRACTS OF NON-LEUKÆMIC TISSUES OF THYMECTOMIZED PASSAGE *A*-INOCULATED MICE

Donor material		Recipient		Mice with lymphocytic leukæmia		
		Number	Age at injection	Number	Age in months	Per cent
Passage *A*-inoculated thymectomized 6-months-old *C3Hf*/*Gs* mice	Brain extract	16	1 day	10	3–6 (av. 4·1)	63
	Spleen extract	14	1 day	11	3–5 (av. 3·8)	80
	Spleen cells	8	2–3 months	0	—	0
Untreated 6-month-old *C3Hf*/*Gs* mice	Brain extract	6	1 day	0	—	0
	Spleen extract	7	1 day	0	—	0

Total period of observation 8–12 months.

Effect of a Primary Tuberculous Infection on the Resistance of Male and Female Mice to Ectromelia

A TUBERCULOUS infection or vaccination with *BCG* has been shown to raise the resistance of mice and guinea pigs not only to a challenge with mycobacteria but also to secondary infections caused by other species of bacteria. This latter, non-specific type of immunity has been demonstrated against infection with *Brucella abortus*[1], *Bacillus anthracis* and *Brucella suis*[2], *Staphylococcus aureus*[3], *Pasteurella pestis*[4] and *Salmonella enteritidis*[5]. The present work was undertaken to see whether a primary tuberculous infection also increased the resistance of mice to virus infections, using in the first instance ectromelia (mouse pox) as the test virus.

Male and female mice, strain *VS*, aged 7–9 weeks (weight 18–20 gm.) were each divided into two groups.

Table 1

Experiment No.	Tuberculous mice				Normal mice			
	Male		Female		Male		Female	
	Survivors* No. per group	Percentage of survivors	Survivors* No. per group	Percentage of survivors	Survivors* No. per group	Percentage of survivors	Survivors* No. per group	Percentage of survivors
1	8/20	40	11/19(1)†	58	4/30	13	5/10	50
2	11/30	37	12/28(2)†	43	5/30	17	15/29(1)†	52
3	13/56(4)†	23	9/56(4)†	16	2/59(1)†	3	17/55(5)†	31
Total	32/106	30	32/103	31	11/119	9	37/94	39

Mice inoculated intraperitoneally with ectromelia (experiments 1 and 2, 10 *LD*50; experiment 3, 30 *LD*50) 3 weeks after infection with *Myco. tuberculosis*.

* Seventeen days after infection with ectromelia.

† Bracketed figures indicate number of mice which died without typical ectromelia or with severe tuberculosis and were excluded from group.

Probability that difference between survivor ratios for tuberculous and normal males occurred by chance $< 0·001$ ($\chi^2 = 14·6$).

Probability that difference between survivor ratios for normal males and normal females occurred by chance $< 0·001$ ($\chi^2 = 25·6$).

Probability that difference between survivor ratios for tuberculous males and normal females occurred by chance $> 0·2$ ($\chi^2 = 1·47$).

One group of male and one of female mice were inoculated intravenously with 0·0065 mgm. *Mycobacterium tuberculosis* (virulent human strain, *H37Rv*) in order to produce a chronic stable type of pulmonary tuberculosis[4]. One group of each sex was left uninfected. Three weeks later, when the infected mice showed small tuberculous lesions in the lungs, all groups were inoculated intraperitoneally with a suspension of ectromelia. In the first two experiments the virus suspension contained approximately 10 *LD*50 per inoculated dose and in the third experiment 30 *LD*50 (determined with weanling mice aged 3–4 weeks). Subsequent deaths were recorded daily and the cause of death confirmed at autopsy. The few mice which died without typical lesions of ectromelia or with lesions of tuberculosis sufficiently severe to account for death were excluded from an experiment. The results of three such experiments are shown in Table 1. In all the experiments the resistance to ectromelia of the normal male mice, as indicated by the proportion of survivors, was consistently less than that of the male mice with tuberculosis. The resistance to ectromelia of normal female mice, initially higher than that of normal male mice, was not significantly influenced by a primary tuberculous infection and was approximately equal to that of the male mice with tuberculosis. The lower resistance of the normal males compared with the females may not apply to mice of all strains and ages. We have some evidence that the resistance of normal weanling mice (aged 3–4 weeks) of strain *VS* is about the same in males and females.

Under the conditions of these experiments, tuberculosis increases the resistance of adult male mice to the lethal effects of ectromelia, a typical pox virus. Although tuberculosis can increase the resistance of animals to secondary infections caused by other species of bacteria, this is the first time it has been observed with a secondary virus infection. Nevertheless it is not known whether this increased resistance to a virus infection results from the same non-specific immune processes which operate against the bacterial injections.

A. W. Gledhill
R. J. W. Rees

National Institute for Medical Research,
Mill Hill, London, N.W.7.

---

[1] Bakterkunst, A., and Sulitzeanu, D., *Nature*, 182, 883 (1958).

[2] Dubos, R. J., and Schaedler, R. W., *J. Exp. Med.*, 106, 703 (1957).

[3] Girard, G., and Grumbach, F., *C.R. Soc. Biol.*, 152, 280 (1958).

[4] Hart, P. D'Arcy, and Rees, R. J. W., *Lancet*, ii, 391 (1950).

[5] Henderson, D. W., Lancaster, M. C., Packman, L., and Peacock, S., *Brit. J. Exp. Path.*, 37, 597 (1956).

[6] Howard, J. G., Biozzi, G., Halpern, B. N., Stiffel, C., and Mouton, G., *Brit. J. Exp. Path.*, 40, 281 (1959).

RADIOBIOLOGY

Comparison of Iodine-124 and Iodine-131 in Inhibition of Goitrogenesis in the Rat

Phillips[1] has suggested that iodine-124 might prove more effective than iodine-131 in the treatment of cancer of the thyroid, largely because the greater energy of its β-rays should increase the amount of radiation administered from areas of functioning tumour to adjacent foci that do not take up iodine. We were therefore interested to compare experimentally the damaging effect on the thyroid of the two isotopes. The method used was that of Doniach and Logothetopoulos[2], who showed that radiation damage to the thyroid of rats may be revealed by their loss of ability to produce goitres in response to a 10-day course of propylthiouracil when challenged 3–4 months after a single dose of iodine-131. Marked inhibition of goitrogenesis resulted from an intraperitoneal injection of 30 μc. of iodine-131. This dose gives a mean of about 12,000 rads to the rat thyroid with the very large range of about 2,000–24,000 rads, due to uneven uptake and distribution of iodine in the thyroid and loss of β-radiation from the gland periphery. It was found that the dose of external X-irradiation to the rat's thyroid necessary to inhibit the goitrogenic response to a degree equivalent to 30 μc. of iodine-131 was only 1,000 rads[3]. It is likely that part of the greater effectiveness of external X-irradiation over iodine-131 in terms of dosage is a reflexion of the uneven uptake of iodine and consequent comparative escape from iodine-131 radiation of less-actively functioning areas of thyroid. We thought that the radiation dose of iodine-124 necessary to inhibit goitrogenesis would be less than that of iodine-131 because its more penetrating radiation might even out the dosage throughout the thyroid gland, following Phillips's[1] argument with regard to thyroid cancer.

The iodine was prepared on the Medical Research Council cyclotron at Hammersmith Hospital by bombarding antimony with α-particles of about 18 MeV. A chemical separation of the iodine produced a specimen of high specific activity (1 mc./μgm.); the iodine-124 was, however, contaminated with other radioisotopes of iodine inevitably formed in the alpha bombardment of natural antimony. These are iodine-123 (half-life 13 hr.), iodine-126 (13 days) and iodine-125 (60 days). The extent of the contamination was estimated by following a sample of the mixture in a re-entrant ionization chamber. This chamber had been calibrated with several known isotopes, and its response was found to be linear with specific γ-ray emission if radiations below about 100 keV. are ignored. At the time of administration it is estimated that the response of the chamber to the different isotopes was in the proportions iodine-123 : iodine-124 : iodine-126 = 1·0 : 2·0 : 0·17. The proportions in terms of microcuries can be found by dividing these figures by the appropriate specific γ-ray emissions. There is some uncertainty about the specific γ-ray emission of iodine-124 (refs. 4–7); the figures for the administered quantities quoted in the table assume a value of 6·5 r./mc. hr. at 1 cm., the contribution from the 30-keV. X-rays being ignored. The estimated quantity of iodine-124 administered is inversely proportional to the figure assumed. The amount of iodine-125 present was not directly determined, but experience with previous samples indicates that it was present to the extent of only a few microcuries per 100 microcuries of iodine-124.

Table 1

Group (number of rats per group in brackets)	Thyroid weight in mgm. ± *S.D.* of mean	Percentage inhibition of goitrogenesis
Controls (11)	23·6 ± 0·8	—
Methylthiouracil (11)	48·9 ± 3·1	0
10·1 μc. iodine-131 followed by methylthiouracil (12)	44·7 ± 1·3	20
29·5 μc. iodine-131 followed by methylthiouracil (12)	34·8 ± 1·1	60
21 μc. iodine-124 followed by methylthiouracil (11)	45·3 ± 2·9	20
37 μc. iodine-124 followed by methylthiouracil (12)	40·0 ± 1·5	40
53 μc. iodine-124 followed by methylthiouracil (11)	35·0 ± 2·2	60
126 μc. iodine-124 followed by methylthiouracil (11)	27·7 ± 1·7	88
222 μc. iodine-124 followed by methylthiouracil (12)	24·7 ± 0·8	100

Thyroid weights of rats after 16 days on 0·1 per cent methylthiouracil in the drinking water, started 104 days after intraperitoneal injection of various doses of iodine-124 or iodine-131. Percentage inhibition of goitrogenesis is calculated on the assumption of 25 mgm. for weight of the untreated thyroid and 50 mgm. for the weight of methylthiouracil goitre in the absence of radiation inhibition.

105 male pen-inbred rats of the hooded Lister strain were divided into 9 groups, 11 or 12 per group. At the age of 8–9 months the rats in 7 groups were injected intraperitoneally with carrier-free iodine-131 or iodine-124 in 1 ml. water in the dose-range shown in Table 1. 104 days later the treated animals and 1 non-radiated group were put on methylthiouracil in the drinking water, 1 gm. per l., and killed after sixteen days of this goitrogenic regime together with the remaining group of non-irradiated, non-thiouracil-treated controls. There were two deaths among the 105 rats during the experiment. The average thyroid weight of the controls was 23·6 mgm., and that of the thiouracil but non-radioactive iodine-treated was 48·9 mgm. Thus the goitrogenic regime had doubled the thyroid weight. It is seen in Table 1 that 29·5 μc. iodine-131 significantly inhibited the goitrogenic response, the thyroid weight being 34·8 mgm. However, 10·1 μc. iodine-131 showed little effect, the thyroid weight being 44·7 mgm. The dose of iodine-124 equivalent to 29·5 μc. iodine-131 in inhibition of goitrogenesis was 53 μc. thyroid weight 35·0 mgm. The degrees of inhibition of goitrogenesis produced by the various doses of radioactive iodine may be expressed as percentages, as shown in Table 1 where the control thyroid weight is regarded as 25·0 mgm., and the goitrogen treated as 50 mgm. 29·5 μc. iodine-131 and 53 μc. iodine-124 each showed a 60 per cent inhibition.

To interpret this equivalence in terms of radiation dose is not easy. The dimensions of the rat thyroid are comparable with the ranges of β-particles, and calculations of radiation dose are therefore very dependent on the precise geometry of the gland and the exact ranges of the particles. If the biological half-life of iodine in the gland is taken as 100 hr., and the gland is assumed to consist of two cylinders 5 mm. long and 2 mm. in diameter, an approximate calculation shows that about 2·5 μc. of iodine-124 will give the same average radiation dose to the gland as 1 μc. of iodine-131. Our experimental result of 1·8–1 suggests that rather less than this amount of iodine-124 is required in order to produce equivalent damage. The comparison is approximate, particularly because of the uncertainty in the value of the specific γ-ray emission of iodine-124. It is, however, considered very fully in recent work by Christine M. Matthews and J. F. Fowler[8].

Our thanks are due to the cyclotron staff here for preparation of the iodine-124.

I. DONIACH
Department of Pathology,
Postgraduate Medical School of London.
P. E. FRANCOIS*
Medical Research Council
Radiotherapeutic Research Unit,
Hammersmith Hospital.

* Now with the Central Electricity Generating Board.

[1] Phillips, A. F., *Brit. J. Radiol.*, 30, 247 (1957).
[2] Doniach, I., and Logothetopoulos, J. H., *Brit. J. Cancer*, 9, 117 (1955).
[3] Abbatt, J. D., Doniach, I., Howard-Flanders, P., and Logothetopoulos, J. H., *Brit. J. Radiol.*, 30, 86 (1957).
[4] Dyson, N. A., and Francois, P. E., *Phys. Med. Biol.*, 3, 111 (1958).
[5] Mitchell, A. C. G., Juliano, J. O., Creager, C. B., and Kocher, C. W., *Phys. Rev.*, 113, 628 (1959).
[6] Girgis, R. K., and Van Lieshout, R., *Physica*, 25, 133 (1959).
[7] Haybittle, J. L., *Phys. Med. Biol.*, 4, 280 (1960).
[8] Matthews, C. M. E., and Fowler, J. F., *Nature*, 186, 983 (1960).

Behaviour of Radioactive Griseofulvin in Skin

THE present clinical and laboratory success of griseofulvin in the treatment of superficial fungal infection has prompted investigation into the sites of concentration of this material in an effort to clarify its effects. Preliminary work with spectrophotometry suggested that griseofulvin accumulated, at least for short periods, in the skin. Since this tissue is also the site of the primary infection, I confined my studies to the localization of the agent in that organ, using radioactive griseofulvin the presence of which could be identified by radioassay and autoradiography.

Two investigations were made using griseofulvin–chlorine-36 of specific activity 6·7 μc. per gm. In the first part 2 normal rats were fed by tube 100 mgm./kgm. of radioactive griseofulvin on three successive days. The rats were killed 4 and 7 hr. respectively after the last doses, and radioassay and spectrophotometric analyses were carried out on skin samples. Other skin specimens were used for autoradiography with 10- and 15-μ sections exposed to Kodak *A.R.* 10 and *A.R.* 50 autoradiographic film after eosin staining. Parallel control experiments were employed with one rat receiving no therapy and three rats to which had been given DL-cystine–sulphur-35 (specific activity

31 µc./m.mole) in respective doses of 100, 10 and 1 µc. per 100 gm. weight on three successive days before killing.

In the second experiment a 10 per cent preparation of the radioactive griseofulvin was applied to an area of the skin surface of 2 normal patients and to the tinea lesions of 8 infected human patients. Geiger counting was done after application and 8 hr. later immediately prior to skin biopsy following cleansing of the area with spirit. Biopsies were examined by autoradiography.

In the first experiment with normal rats autoradiographs showed that in the griseofulvin-treated animals sites of radioactivity were limited almost entirely to the hair follicles; some accumulation was seen in the stratum corneum adjacent to the follicular openings. Of the hair follicles, only those in the anagen phase of the growth-cycle contained radioactive grains, and of these, only 1 in 10. Grains accumulated in the suprabulbar region initially, and with the growth of hair keratin, were gradually carried toward the surface, which they reached in three days. Three separate bands could be seen, interrupted by zones without activity, apparently representing the three separate doses of radioactive material given. No grains were observed in the bulb of the hair. The greater suprabulbar accumulation of radioactivity was seen in the rat killed 7 hr. after the last dose of griseofulvin.

In the rats to which DL-cystine–sulphur-35 had been given almost all the hair follicles except those in the telogen phase were found to contain radioactivity. Grain concentration was dense, in contrast to that seen in the griseofulvin-treated rats. Radioactive material had accumulated in the suprabulbar portion of the follicle, the keratogenous zone, and throughout the length of the hair shaft, suggesting that the radioactive cystine had been fully incorporated into the keratin. The stratum corneum also contained a diffuse and moderate concentration of radioactivity.

Assays based on content of radioactive chloride and radioactive griseofulvin (Table 1) agree closely, indicating that the griseofulvin–chlorine-36 molecule remained relatively intact during its 3-day sojourn in the skin examined here. One of the sets of figures obtained from spectrophotometric analysis corroborates this. Both results also suggest an increase in concentration of griseofulvin in the skin 4–8 hr. after dosage. Comparison of these figures with those obtained by calculation of the theoretical skin content if distribution were equal throughout all tissues suggests that the concentration of griseofulvin actually in skin is approximately 10 times that expected.

Table 1

	Treatment administered						
	Griseofulvin–^{36}Cl		DL-Cystine–^{35}S			Nil	
	1 (killed 68 hr.)	2 (killed 71 hr.)	3	4	5	6	7
Total dose of radioactivity (µc./100 gm. rat)	0·2	0·2	300	30	3	0	0
Radioactivity of skin (% of dose)	0·004	0·02	0·4	0·2	0·23	0	0
Griseofulvin assay							
Spectrophotometry (% of dose)	0·023	0·027					
Radioassay* (% of dose)	0·004	0·021					
Expected content based on even tissue distribution (% of dose)		0·0027					

* Assuming all chlorine-36 remains in griseofulvin.

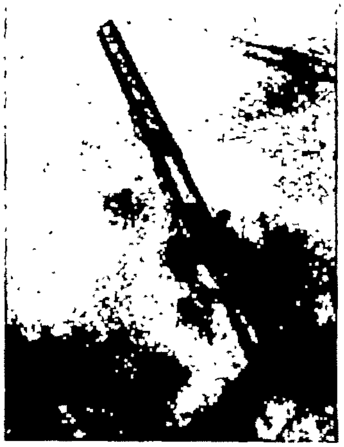


Fig. 1. Autoradiograph showing the accumulation of griseofulvin–chlorine-36 around an infected hair. The bulk of radioactivity is in the keratogenous zone with grains located in the hair shaft of this and the adjacent hair. (× 250)

Autoradiographs obtained in the second experiment demonstrated a denser collection of radioactivity in infected stratum corneum as well as in involved hair follicles. Normal skin showed a pattern of accumulation similar to that seen in uninfected rat skin, and similarly scant. In skin from lesions, however, grains were detected in almost all infected hair follicles, in the suprabulbar and keratogenous zones. Clumps of grains were also seen in infected stratum corneum, extending as far as the stratum granulosum. In a few cases in which parallel periodic acid–Schiff stains were used, the collections coincided with the areas of direct fungal infection. As may be seen (Table 2) direct counts over the lesions showed a higher concentration of radioactivity in these areas than in normal skin (10–20 per cent as contrasted with 2 per cent).

Table 2

Test area of skin	No. of cases	Radioactivity (expressed as per cent of initial value)
Normal	2	1
Infected	8	9–18 (average 12)

The similarity in the distribution of griseofulvin–chlorine-36 and DL-cystine–sulphur-35 in the hair follicles of the rat suggests that the former is taken up during the production of keratin. That it is not intimately involved in the manufacture of keratin is indicated by the limitation of its distribution to the actively growing phase, its interrupted, band-like localization in the hair keratin, and finally, by its failure to appear in quantity in the soft keratin of the stratum corneum. In all these points it differs from radioactive cystine. Studies with radioactive glucose and anions[1] have shown that these are localized in the hair bulb in contrast to those materials directly concerned with keratin. Based on this experience our findings would indicate that the griseofulvin–chlorine-36 molecule remained relatively intact, since our distribution of radioactivity resembled that observed for cations and amino-acids involved in keratin production. This conclusion is supported by the results in the spectrophotometric and radioassays, which also indicate a preferential localization of griseofulvin in keratin sites.

Since the radioactive material did not persist in one site but was carried distally with the keratin, there does not appear to be any intracellular fixation, but rather an incorporation in the interstices of the keratin 'lattice'[2] described by Rudall. This evidence supports the findings of Gentles[3] in which he demonstrated a large water-extractable moiety in skin containing griseofulvin. My failure to demonstrate radioactivity in any quiescent areas of skin suggests the possible inability of griseofulvin to affect fungus situated in necrotic tissue. In work on human skin, griseofulvin was found to concentrate preferentially in infected areas and particularly around sites of fungal accumulation. This might indicate that the associated partial degeneration of infected keratin favours the entrance of griseofulvin into the keratin interstices where its fixation permits a fungistatic action.

I wish to thank the Glaxo Laboratories, Ltd., Greenford, Middx., which supplied the radioactive griseofulvin and carried out the assay of that material.

A. Scott

St. Bartholomew's Hospital,
London, E.C.1.

[1] Bern, H. A., *et al.*, *Acta Anat.*, 31, 35 (1957).

[2] Rudall, K. M., "Adv. in Prot. Chem.", 7, 253 (1952).

[3] Gentles, J. C., Barnes, M. J., and Fantes, K. H., *Nature*, 183, 256 (1959).

BIOLOGY

Development of Mouse Eggs beneath the Kidney Capsule

During experiments to produce extra-uterine pregnancies in mice, eggs were transplanted beneath the kidney capsule. Only one egg was transplanted under any one kidney capsule in each experiment. The eggs used were 1-, 2- and 4-cell stages, morulæ and blastocysts.

The transplants were made within a pure line, and within a heterogeneous population. Males and pregnant and non-pregnant females were used as hosts. Results are shown in Table 1.

Table 1

Stage of egg	No. of experiments	No. of positive results	No. of embryos x	No. of *T.G.C.* and *E.M.* y
1 cell	10	8	0	8
2 cell	8	6	0	6
4 cell	8	6	0	6
Morulæ	10	7	0	7
Blastocysts	50	41	16	25

Embryos x = No. of experiments showing embryonic shield derivatives.
T.G.C. and *E.M.* y = No. of experiments showing embryonic membranes and trophoblastic giant cells.

All 36 pre-uterine eggs extracted from the oviduct failed to to produce embryonic-shield derivatives. Fawcett[1], in a similar experiment, transplanted 4–8-cell stage eggs only, and also stated that "differentiation of recognizable tissues or organs of the embryo proper did not occur". In contrast to this result, 16 of the 50 eggs (blastocysts) obtained from the uterus and transferred beneath the kidney capsule gave rise to embryonic shield derivatives. In a number of cases perfectly normal embryos developed (Figs. 1 and 2).

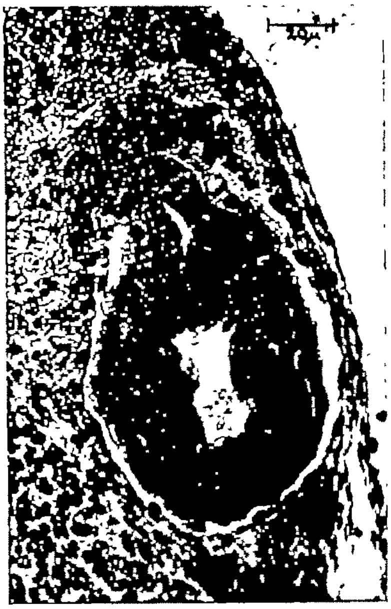


Fig. 1. Sagittal section of embryo embedded in kidney cortex of adult male mouse. Autopsy four days after transplantation of one blastocyst

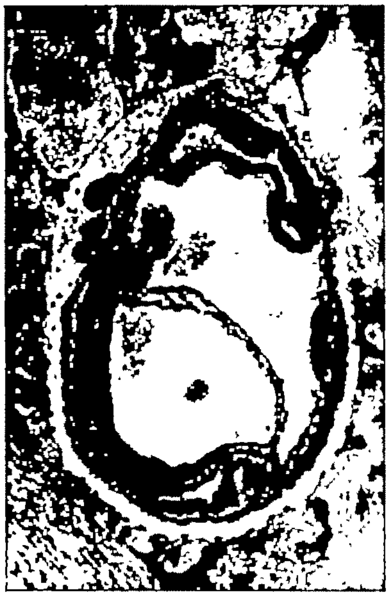


Fig. 2. Section of embryo at head-fold stage with all the embryonic membranes. Autopsy nine days after transplantation of one blastocyst

Nicholas[2], using the rat as experimental animal, transplanted eggs of various stages to the same site and found that only disorganized embryonic tissues developed, and that there was no invasion of the host kidney. In my experiments the embryonic tissues were always surrounded by a matrix of highly invasive trophoblastic giant cells, which caused considerable destruction of the kidney. Lacunæ of extravasated maternal blood lie in the interstices of this matrix of giant cells.

With the progress of invasion of the kidney, the embryonic tissue sinks deeper below the original level of the cortical surface. Compared with intra-uterine gestation, embryos beneath the kidney-capsule are usually retarded in development. Genotype or sex of the host had no effect on the growth of embryonic tissues, except that in transplants to pregnant females the mass of embryonic tissue tended to be larger, but not more differentiated.

I wish to acknowledge with thanks the help given to me by Dr. M. Fischberg. This work was carried out during the tenure of a Research Studentship of the Department of Scientific and Industrial Research.

D. R. S. KIRBY

Embryological Laboratory,
Department of Zoology and
Comparative Anatomy,
Oxford.

[1] Fawcett, D. W., *Anat. Rec.*, 108, 71 (1950).

[2] Nicholas, J. S., *J. Exp. Zool.*, 90, 41 (1942).

Cyclical Changes in the Distribution of the Testis Lipids in the Common Frog, *Rana temporaria*

THAT the cytoplasm of the interstitial cells contains fatty substances has been known since as early as 1850 when Leydig reported them in the interstitium of bat, pig, cat and mole[1]. Since then, Leydig cell lipids have been reported in every group from the Agnatha to the Mammalia[2]. Although an enormous amount of work has been carried out on the seminiferous tubules, the majority of workers have used traditional wax-embedding techniques which result in the dissolution of lipids. Thus many aspects of the testis cycle escaped notice until comparatively recent times[3]. It is now known that at the conclusion of spermatogenesis in wild birds, the seminiferous tubules undergo a metamorphosis involving the sudden genesis of large quantities of cholesterol-positive lipids. At about the same time a new generation of Leydig cells arises in the exhausted interstitium[4]. This tubule lipid appears to contain progestogens[5]. Such a complete post-nuptial tubule metamorphosis does not occur in seasonal mammals[6], but it is a regular part of the cycle of certain teleost fishes[7] and has been reported in at least one reptile[8]. It is not known whether Amphibia display comparable events in the seminiferous and endocrine elements of the testis. Few, however, have been studied to this end.

In order to investigate this phenomenon adult male grass frogs (*Rana temporaria*) were collected during every month for one year and the testicular material subjected to a series of histological and histochemical techniques[9].

R. temporaria breeds, in Great Britain, during late February and early March, and specimens killed during this period can be classified into two main groups based on the sudanophil condition of the interstitium and the spermatogenetic condition of the tubules: (1) Those specimens in which sperm shedding has not yet occurred possess tubules filled with bunched and free spermatozoa, scarcely any intra-tubular lipid material and no cholesterol. The interstitium, on the other hand, contains Leydig cells the cytoplasm of which displays numerous lipoidal droplets that give a positive cholesterol reaction when subjected to the Schultz test[10]. Numerous fuchsinophil granules are also present in these cells. (2) Specimens that have discharged their spermatozoa and the tubules of which now possess only spermatogonia and Sertoli cells contain some intra-tubular lipids in the form of a few small Schultz-negative droplets which appear to be in the Sertoli cytoplasm. The interstitial cells are now densely lipoidal and strongly cholesterol-positive (Fig. 1). Fuchsinophil granules have also increased in number. In addition to these two main categories, some autopsied specimens show an intermediate stage in which only some of the testis tubules have discharged their spermatozoa while others still retain theirs. In such gonads the interstitium adjacent to the 'spent' tubules is much more densely filled with cholesterol-rich lipid material than tissue surrounding sperm-containing elements.

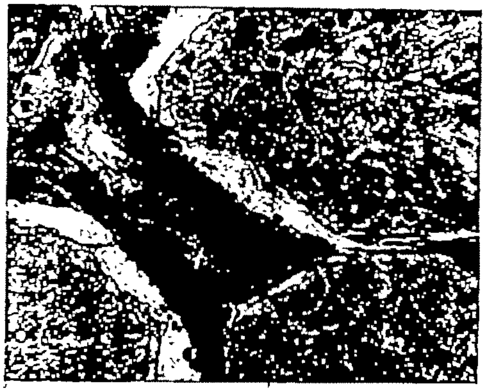


Fig. 1. Frog testis in early March. The 'spent' tubules have not yet become lipoidal but the interstitial Leydig cells are filled with dense cholesterol-positive lipids. (Formol–calcium fixation, sudan-black colouring at 8μ. × c. 250)

As the breeding season progresses, more and more frogs discharge their ripened germinal products and undergo the above-described sequence of events, so that by late March and early April the majority of specimens have passed into their post-nuptial phase and possess testes with Leydig cells in maximum lipid condition and with nuclei measuring $10\mu \times 6\mu$. From then until June prespermatogenesis occurs, during which multiplication of spermatogonia takes place, but these do not develop further than into primary spermatocytes, which thereupon soon degenerate[11,12]. Major changes in the lipid distribution also occur during this period. Leydig cells gradually lose their cytoplasmic cholesterol-rich lipids and fuchsinophil granules, and, accompanying this, there is a shrinkage of the nucleus to an average size of $6\mu \times 4\mu$. In the adjacent seminiferous elements,

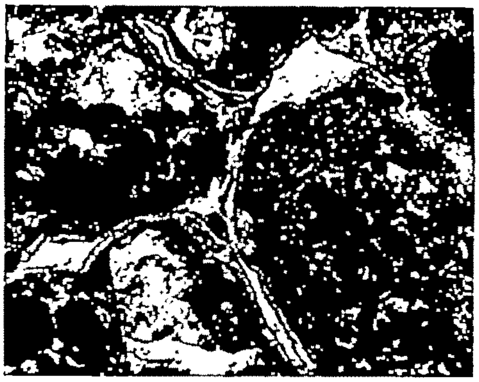


Fig. 2. Frog testis in June. Tubules are now densely lipoidal and cholesterol-positive. Interstitial lipids have disappeared. (Technique and magnification as in Fig. 1)

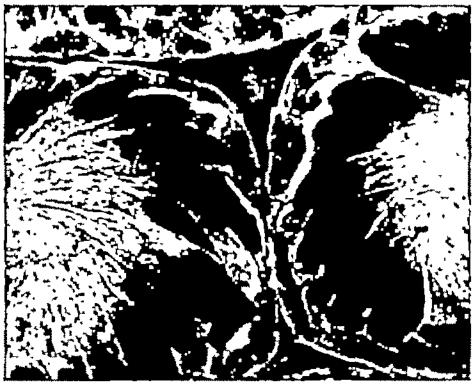


Fig. 3. Frog testis in December. Bunched spermatozoa in tubules. Interstitial Leydig cells have only a few small lipid droplets in their cytoplasm. (Technique and magnification as in Fig. 1)

on the other hand, there is a rapid build-up of intra-tubular lipid. By late June they have increased in size and contain densely lipoidal cytoplasm which now gives a strong cholesterol reaction to histochemical tests. When this Sertoli steatogenesis has reached its maximum level, Leydig cells have lost nearly all lipoidal inclusions (Fig. 2) and become indistinguishable from ordinary connective tissue cells, a condition previously noted by Aron[12]. A few interstitial cell mitoses are seen during this period.

Throughout July and August the tubule lipids disappear and spermatogenesis restarts. This proceeds rapidly and frogs killed in September have gonads in which the seminiferous tubules are once again filled with bunched spermatozoa and contain only small traces of the once profuse intra-tubular lipid material. In the interstitium, Leydig cells are once again starting to develop. This is the so-called static phase[13] during which hibernation occurs. Tubules are at their maximum development and will remain unchanged throughout the winter until sperm discharge in the following breeding season. Although sometimes described as a period of complete testicular inactivity[11], interstitial development does continue. This is revealed by the gradual accumulation of fuchsinophil granules in the Leydig cells, which become more and more numerous during the months of hibernation. The nucleus also increases in size until it once again measures 9μ × 6μ. A few small lipid droplets appear in December (Fig. 3) and by January the majority of Leydig cells contain numerous small lipid droplets in their cytoplasm. Cholesterol is also present from December onwards. In February there is a rapid build-up of interstitial lipid and the animal is once again ready to breed.

These observations reveal that the seminiferous tubules of *R. temporaria* undergo a sequence of cyclical events comparable with those occurring in other sub-mammalian vertebrates. This involves a post-nuptial accumulation of cholesterol-positive lipid within the tubules, and its disappearance when spermatogenesis restarts. This may be of endocrine significance since analysis of similar material in birds has shown it to contain progestogens[5]. The presence of tubule lipid coincides with the period of prespermatogenesis. The interstitial cycle, too, is basically similar to that of birds in that it involves a seasonal accumulation and discharge of cholesterol-positive lipids. But whereas in birds and fishes the Leydig cells gradually discharge the sudanophil contents before mating, the interstitium of the frog contains its maximum lipid content immediately after mating and then becomes slowly exhausted. A similar cycle occurs in seasonal mammals[8]. These events led Champy[11] to suggest that the interstitium of *Rana* was not involved in the development of the secondary sexual characters. However, the sudden increase in lipid and cholesterol in the Leydig cells after sperm shedding does not necessarily imply that the cholesterol is being utilized. On the contrary, it seems not impossible that this phenomenon may indicate that sex hormone secretion, having ceased after copulation, cholesterol is no longer being used in its manufacture, and accumulates. This explanation is supported by the work of Marshall and Wilkinson[14]. These authors found that Orkney voles (*Microtus orcadensis*) seasonally expend their Leydig lipids in apparently the same manner as birds, but that when solitary male voles were placed in complete darkness the cholesterol-positive lipids were no longer used but were stored in the interstitium.

The possible endocrine significance of these events is being investigated by means of chromatography and bio-assay techniques and will be reported elsewhere.

B. Lofts

Department of Zoology and Comparative Anatomy,
St. Bartholomew's Hospital Medical College,
University of London, E.C.1.

C. Boswell

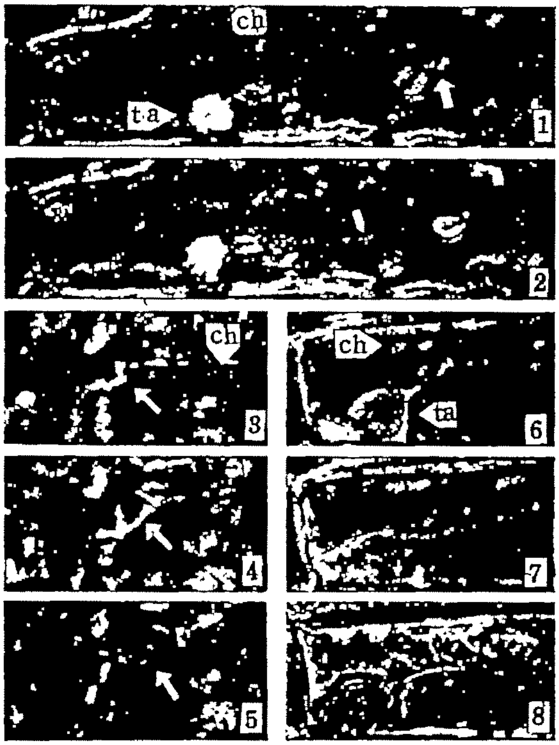
Biology Department,
Giggleswick School, Yorkshire.

[1] Leydig, F., *Z. wiss. Zool.*, **2**, 1 (1850).
[2] Marshall, A. J., and Lofts, B., *Nature*, 177, 704 (1956).
[3] Marshall, A. J., *Quart. J. Micro. Sci.*, **90**, 265 (1949).
[4] Marshall, A. J., *Mem. Soc. Endocrinol.*, **4**, 75 (1955).
[5] Lofts, B., and Marshall, A. J., *J. Endocrinol.*, **9**, 16 (1959).
[6] Lofts, B., *Quart. J. Micro. Sci.*, 101, 199 (1960).
[7] Lofts, B., and Marshall, A. J., *Quart. J. Micro. Sci.*, **98**, 79 (1957).
[8] Marshall, A. J., and Woolf, F. M., *Quart. J. Micro. Sci.*, **98**, 89 (1957).
[9] Marshall, A. J., *Wilson Bull.*, **63**, 238 (1951).
[10] Schultz, A., *Centralb. Allg. Path. Path. Anat.*, **35**, 314 (1924).
[11] Champy, C., *Arch. Zool. exp. gén.*, **52**, 13 (1913).
[12] Aron, M., *Arch. Biol., Paris*, **36**, 1 (1926).
[13] Gallien, L., *Bull. Biol.*, 74, 1 (1940).
[14] Marshall, A. J., and Wilkinson, O., *Proc. Zool. Soc. Lond.*, **126**, 391 (1956).

Behaviour of a Thread-like Apparatus in the Petiole of *Mimosa pudica*

Although I have published several communications[1–4] concerning the cytology of the thread-like apparatus in *Mimosa pudica*, these observations were carried out with vital staining and/or with fixation. For a full understanding of the subject, it is necessary to observe the non-treated material in the living state. In this communication, the behaviour of the thread-like apparatus with a phase-contrast microscope is reported.

The sections of the fresh material were prepared in the following manner. Petiole sections were cut 30–50μ in thickness by a hand microtome and by razor, and then sections were immersed in medium solution. All sections were freshly prepared at the beginning of each observation. Observations were made with phase-contrast microscopy in conjunction with dark-medium contrast 100 × objective with a 'Periplan' 10 × ocular. Photomicrographs were



Figs. 1–7. Photomicrographs of the thread-like apparatus of lacunal parenchymatous cells of *Mimosa* petiole, taken with the phase microscope. 1, arrow indicates rosary-like portion; 2, small arrow indicates tiny granule in vicinity of thread; 3–5, vermiculation of a part of thread indicated by arrows; 6, 7, connexion of tannin vacuole and thread-like apparatus. 1–7 are mounted in tap water. 8, caffeine reaction in the same cell of Fig. 7 with bright field microscope (× about 800). *ch*, chloroplast; *ta*, tannin vacuole

taken with a 35-mm. camera attachment (Figs. 1–7). The material in the present work consisted chiefly of those plants which had already received a stimulus. All experiments were carried out at room temperature (25–30° C.) in the summer of 1959.

In the case of the present observations, we must discriminate carefully between the thread-like apparatus and plasma streaming. Furthermore, it is of fundamental importance to distinguish the thread-like apparatus from the other cellular elements. I have attempted the caffeine treatment on the intact cell on the basis of past experience. The reaction of precipitation in the presence of caffeine occurred as one of the specifications of the thread-like apparatus, as was shown previously[1]. The reason for this is simply that caffeine solution was used as a medium after the successful observation of the behaviour of the thread-like apparatus.

The sections were mounted in tap water, without any subsequent treatment, a method deemed most harmless to the protoplasm. In one of the lacunal parenchymatous cells, several minutes after preparation, a movement of the thread-like apparatus began to appear (Figs. 1 and 2). The thread-like apparatus assumed many shapes. A part of the thread is shown as a rosary-like figure or small mass indicated by arrow in Fig. 1, and other parts of the thread are developed to such an extent as to form a long slender structure. Each portion of the thread moves continuously. On careful examination the threads, though not clear in these photographs, are seen to be accompanied by tiny granules. These tiny granules are difficult to photograph in living cells, due to their small size and rapid motion along the thread-like apparatus. But as shown in Fig. 2, successful photographs exhibit a small number of these granules near the thread. The small arrow indicates a tiny granule.

For the purpose of gaining a more complete knowledge of the behaviour of the thread-like apparatus, I made detailed observations on the threads and other cellular elements. The material was soaked in tap-water as mentioned in the foregoing experiment. As shown in the series of photomicrographs (Figs. 3, 4 and 5), the vermiculation of a part of the thread-like apparatus is observable. This vermiculation occurred continuously.

Next, I sought a connexion between the thread-like apparatus and tannin vacuole. The series of photomicrographs show that the thread extends from the tannin vacuole as a horn or a tail (Figs. 6, 7 and 8). In this case, the terminal of the thread was associated with the chloroplasts which were accompanied by tiny granules. Furthermore, caffeine treatment with bright field microscopy was also undertaken (Fig. 8). Accordingly, from the above observation, it seems that the thread-like apparatus is a modified vacuome system of the tannin vacuole.

Recently, Sorokin[6] observed the long filamentous structure in living epidermal cells of the Cichorieae. These filaments branch out, and even anastomose, forming loops and networks under anaerobic conditions. They are regarded as modified plastids. The investigation and the critical comparison of the cellular elements and thread-like apparatus in *Mimosa* must be the subject of future work. The details will be reported in the near future.

Hideo Toriyama

Biological Section,
Tokyo Woman's Christian College,
Tokyo.

Feb. 27.

[1] Toriyama, H., *Cytologia*, 20, 237 (1955).
[2] Toriyama, H., *Cytologia*, 22, 60 (1957).
[3] Toriyama, H., *Bot. Mag.* (Tokyo), 71, 309 (1958).
[4] Toriyama, H., *Nature*, 184, 737 (1959).
[5] Toriyama, H., *Cytologia* (in the press).
[6] Sorokin, H. P., *Exp. Cell Res.*, 9, 510 (1955).

Differentiation in *Peronospora tabacina* Adam.

Some results that we have obtained indicate that at least three ecotypes of *Peronospora tabacina* occur in Australia and that the differences between them may prove of importance in breeding for resistance to the pathogen.

Zink[1] reported the occurrence of two races of *P. effusa* (Grev. ex Desm.) Ces. on spinach, and Grabe and Dunleavy[2] described eight races of *P. manshurica* (Naum.) Syd. ex Gaum. on soybeans. Differences between the host-ranges of *P. tabacina* of tobacco in Australia and the United States were reported by Hill[3], who later[4] suggested the possibility of different strains of the pathogen. Within Australia the relative isolation geographically of the major tobacco-growing areas could provide conditions for the development of distinct strains of *P. tabacina*.

On two occasions comparable seedling populations of tobacco breeding lines with some resistance to attack by *P. tabacina* were spray-inoculated with standardized spore suspensions of multispore isolates of *P. tabacina* from North Queensland and Canberra under similar glasshouse conditions. The Canberra isolate was originally introduced from Victoria in

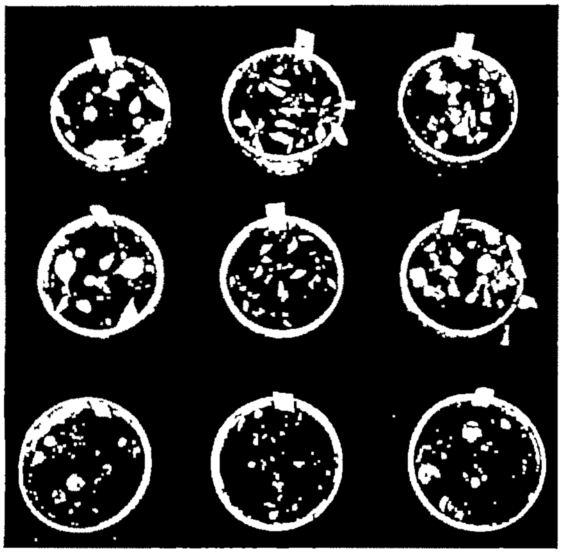


Fig. 1. Disease reaction of three *Nicotiana* spp. to isolates of *P. tabacina* from: front row, Canberra; middle row, North Queensland; back row, Western Australia. The species are: left, *tabacum* L. (var. Virginia Gold); middle, *trigonophylla* Dunal, right, *umbratica*, N. T. Burbidge. Photo 12 days after inoculation

1954. Seedlings showing sporulating lesions within the first 14 days after inoculation were classed as susceptible. The numbers of resistant and susceptible plants in these tests are shown in Table 1. A higher proportion of the plants was susceptible to the Canberra isolates than to the North Queensland isolates, and this was true for all 7 lines which included resistance derived from 3 species.

Groups of four-week-old glasshouse seedlings of 13 spp. of *Nicotiana* which had been obtained as seeds from 33 different localities were inoculated with the two isolates of *P. tabacina* described above and a third isolate from Western Australia. At 7 days after inoculation the amount of sporulation on seedlings grown from the same seed lot was similar for all three collections of the pathogen. In seedlings from 19 seed localities a similar response to infection was maintained as the disease developed with time. In the remaining 14 lots (including *N. tabacum* var. Virginia Gold) the subsequent incidence of disease in the four tests, as recorded after 12 and 20 days and summarized in Table 2, reflected differences due to source of inoculum (Fig. 1).

Table 1. NUMBERS OF TOBACCO SEEDLINGS RESISTANT AND SUSCEPTIBLE TO ISOLATES OF *P. tabacina* FROM NORTH QUEENSLAND (N.Q.) AND CANBERRA (C.)

Breeding line	Source of resistance	Source of inoculum			
		N.Q.		C.	
		R	*S*	*R*	*S*
Test 1					
1	*N. debneyi*	72	0	58	14
2	*N. knightiana*	72	0	55	15
3	unknown	648	0	547	107
4	*N. goodspeedii*	15	1	0	16
5	*N. goodspeedii*	9	3	0	12
Test 2					
6	*N. goodspeedii*	100	116	0	216
7	*N. debneyi*	88	128	0	216

Table 2. DISEASE SEVERITY IN 14 LINES OF *Nicotiana* spp.

Number of seedling lines	Incidence of disease in decreasing order of severity			
2	W.A.	C.	or	N.Q.
5	C.	N.Q.	or	W.A.
6	C.	N.Q.		W.A.
1	C.	W.A.		N.Q.

W.A., Western Australia; C., Canberra; N.Q., North Queensland.

Sporulation intensity of the three isolates on *N. tabacum* var. Virginia Gold was determined using the leaf disk technique of Cruickshank and Müller[5]. In two separate tests six disk replications, taken from leaves of plants inoculated with each isolate, were incubated at 20° C. For comparative purposes the Canberra isolate was given a sporulation intensity index value of 100, the corresponding values for the North Queensland and Western Australian isolates being 44·1 and 54·9 respectively. Thus the number of conidia produced by the Canberra isolate was approximately twice that produced under similar conditions by each of the other two isolates.

These results indicate that isolates of *P. tabacina* differ in their pathogenicity range, host reaction and reproductive capacity. The first of these differences, although not so clearly defined at present as those reported for other *Peronospora* spp.[1,2] represents qualitative differences which may be of considerable importance in the development of blue-mould (*P. tabacina*) resistant tobacco varieties. The second and third differences are quantitative only but may be of significance in terms of epidemiology. Environmental conditions favouring spread of the disease occur only periodically, therefore a reduced capacity for reproduction could result in a much slower build-up of the pathogen and a significant reduction in loss due to the disease.

D. C. WARK
A. V. HILL
M. MANDRYK
I. A. M. CRUICKSHANK

Division of Plant Industry,
Commonwealth Scientific and Industrial
Research Organization,
Canberra.

[1] Zink, F. W., *Plant Disease Reporter*, **42**, 818 (1958).
[2] Grabe, D. F., and Dunleavy, J., *Phytopath.*, **49**, 791 (1959).
[3] Hill, A. V., *J. Austral. Inst. Agric. Sci.*, 1, 81 (1935).
[4] Hill, A. V., C.S.I.R.O. (Aust.) Div. of Plant Industry, Tech. Paper 9 (1957).
[5] Cruickshank, I. A. M., and Müller, K. O., *Nature*, **180**, 44 (1957).

CYTOLOGY

Uptake of Heparin by Cells

IN a previous communication[1] we showed that the epithelial cells and lymphocytes of the thymus gland are capable of being converted into mast cells under conditions of tissue proliferation. With the view of confirming the correctness of this finding, we added partially decomposed heparin in cultures of thymus, spleen and lymph-node tissues and found that the heparinoid substance was taken up considerably by the thymus and by the other two tissues to a lesser extent. The heparinoid matter is then synthesized into complete metachromatic substance in the cells[2]. Tissues obtained from new-born to 1-month-old rats were used in those experiments. We have now attempted to ascertain whether there exists such a difference between the various tissues also in respect of heparin which has not been decomposed and to observe the behaviour of the different tissues in respect to their readiness to take up heparin in the successive phases of ontogenesis.

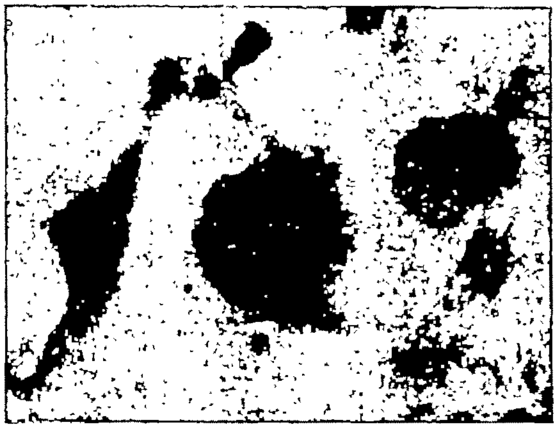


Fig. 1. Cells containing heparin in the culture of thymic tissue taken from 16–17-day-old rat embryo. Toluidine blue. (c. × 400)

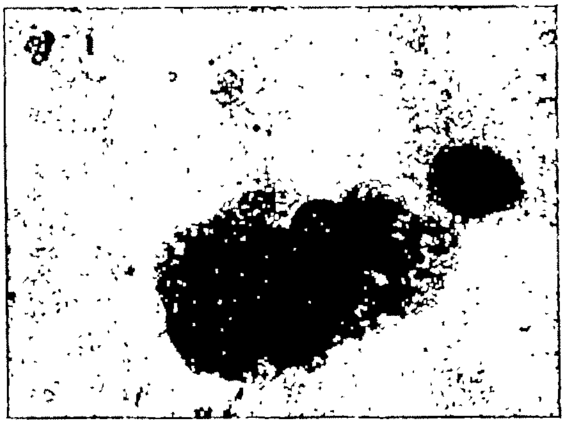


Fig. 2. Cell containing heparin in the thymus of rat weighing 200 gm. Intracellular heparin appears in the shape of coarse lumps. Toluidine blue. (× c. 400)

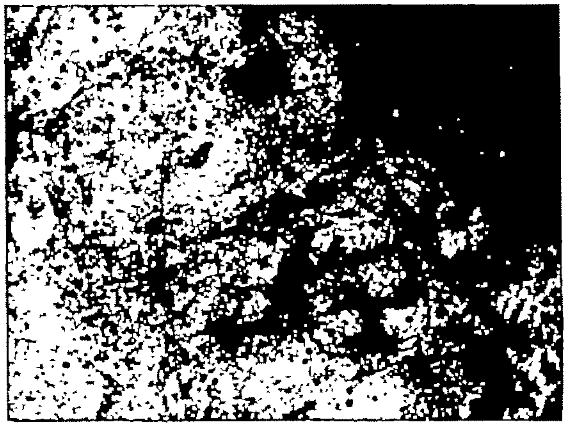


Fig. 3. Formation and disintegration of regular mast cells in the migration zone of the thymus obtained from pregnant rat. Toluidine blue. (× 700)

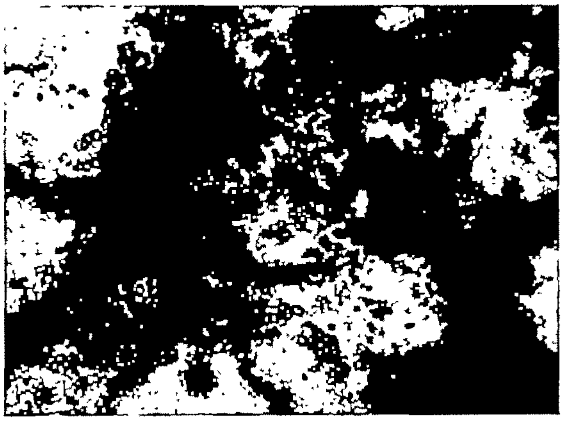


Fig. 4. Enlarged detail of Fig. 3. Toluidine blue. (× 700)

Tissues taken from the spleen, liver, lymph nodes, heart, kidney and thymus of 16-day-old intra-uterine and new-born rats weighing 50 gm., 100 gm., 150 gm. and 200 gm. respectively, and also pregnant and tumorous rats were explanted to Maximow's double cover-slip cultures and grown on a medium consisting of hen plasma coagulated with chick embryo extract. A mixture of horse serum, Tyrode solution and chick embryo extract (3 : 6 : 1) served as bathing fluid. The cultures were first washed 48 hr. after the explantation and again after another 24 hr. The fluid used for this second washing also contained 1 mgm. heparin per 1 ml. of the fluid (heparin pulvis Richter 80 I.U./mgm.). The cultures were fixed in Carnoy's fixing fluid and stained with toluidine blue 48 hr. after the heparin treatment. A total of 800 cultures was divided into two groups.

Experimental results are given in Table 1. The number of cells containing heparin (determined by subjective estimates) is indicated by the number of crosses.

It is evident that all embryonic tissues examined are capable of taking up heparin; kidney and heart of new-born rats are no longer able to do so, and the liver loses this capacity in animals weighing 100 gm. Thymus, spleen and lymph nodes seem to be able to take up heparin throughout the series, and this ability is especially pronounced in the case of the thymus. It can be concluded that all tissues of an embryo, the organs of which contain a great amount of mucopolysaccharides, are capable of taking up heparin, and that—with advancing age—this function is limited to the lymphatic organs, and to the thymus in the first place.

The form in which heparin appears varies according to the age of the animal from which the tissues are taken. Dispersion of heparin granules is very high in the cells of young tissues, and granulation becomes coarser and coarser with advancing age. We regard

Table 1. UPTAKE OF HEPARIN AT DIFFERENT STAGES OF THE RAT'S ONTOGENESIS

Tissue	Embryo	New-born	50 gm.	100 gm.	150 gm.	200 gm.	Pregnant	Tumorous
Spleen	+	+	++	+	+ ?	+ ?	+ ?	–
Liver	+	+	+	–	–	–	–	–
Lymph node	–	+	++	++	+	+	++	+ ?
Myocardium	+	–	–	–	–	–	–	–
Kidney	+	–	–	–	–	–	–	–
Thymus	++	++	+++	+++	+++	++	+++	+ ?

this phenomenon as being more or less in harmony with intracellular colloid-chemical alterations associated with senescence[3-5].

Especial interest is attached to tissues collected from tumorous and pregnant animals. One encounters in them not merely mast-cell-like cells containing heparin but also regular mast cells which disintegrate into granules—a process similar to the disintegration of mast cells contained in the connective tissue. It may be assumed that processes of tissue proliferation involve a factor in the organism which releases cellular disintegration so that, in contradiction to current belief, the break-down of mast cells is not caused by mechanical factors alone.

G. Csaba
Esther Kapa

Institute of Histology and Embryology,
Budapest Medical University.

[1] Csaba, G., Törő, L., Acs, T., and Kiss, F. L., *Acta Morph. Hung.*, 9, 187 (1960).

[2] Csaba, G., Törő, L., and Kapa, E., *Acta Morph. Hung.*, 9, 197 (1960).

[3] Heilbrunn, L. V., "The Dynamics of Living Protoplasm" (Academic Press, New York, 1956).

[4] Heilbrunn, L. V., *Fed. Proc.*, 15, 948 (1956).

[5] Heilbrunn, L. V., *J. Gerontol.*, 13, 1 (1958).

Cytochemical Evidence of the Origin of Lipid Bodies (so-called Golgi Bodies) from Mitochondria

Since Hirsch's[1] theory of the Golgi presubstance, according to which there exist homogeneous granular mass as a precursor of the 'Golgi' system, there has been very little attempt to investigate the origin of these inclusions in the cell. Nath and Chopra[2] reported the origin of 'Golgi dictyosomes' from mitochondria in the spermatocytes of the slug, *Anadenus altivagus*. However, such a conclusion was arrived at on the basis of morphological study inasmuch as the 'Golgi dictyosomes' disappear at the metaphase and anaphase stages of meiosis I and II, probably merging into the mitochondria; they again appear in the respective telophase stages by the alignment of lipid granules, which seemed to take their origin from the mitochondria. These observations were later confirmed by Nath and Gupta[3] in the living spermatocytes of *Anadenus* and *Euaustenia* under phase-contrast microscopy.

My present cytochemical investigations on the developing oocytes of a large number of species of fish, namely, *Ophiocephalus punctatus*[4], *Barbus ticto*[5], *Mystus tengara*, *Cirrhina reba*, *Labeo dyocheilus*, *Chrysophrys berda*, *Muraenesox talbonides*, *Pseudorhombus elevatus*, *Boleophthalmus dussumierii*[6], clearly demonstrate the origin of lipid granules, corresponding to 'Golgi' granules of earlier workers, from the mitochondria. The earliest oogonia completely lack the 'Golgi' material, and consist of only a juxtanuclear mass of fine mitochondrial granules. However, in the developing oogonia of freshwater fishes, namely, *Ophiocephalus*, *Barbus*, *Mystus*, *Cirrhina* and *Labeo*, the mitochondrial granules align themselves into filaments, while in those of the marine fishes, namely, *Chrysophrys*, *Muraenesox*, *Pseudo-rhombus*, and *Boleophthalmus*, the granular juxta-nuclear mass becomes very dense. In the former case a large number of bigger and denser lipid granules appear as tiny blebs on the surface, and in intimate association with the mitochondrial filaments; but in the latter they develop among the juxta-nuclear mass. However, these inclusions acquire a separate entity in the growing oocytes; they either grow directly into large spheres or attach themselves to tiny vacuoles in the cytoplasm so as to produce rings and crescents.

These 'Golgi' inclusions are very rich in lipid material as revealed by their strong coloration in sudan black *B*. Baker's[7] acid-hæmatin technique with pyridine extraction control reveals the phospholipid nature of the lipid material. However, it changes later into triglycerides as shown by Cain's nile blue technique. The pure lipid nature of these inclusions is demonstrated by the lipid extraction techniques, and is further confirmed by the absence of carbohydrates and proteins, as revealed by periodic acid–Schiff reagent, and Mazia's mercuric bromphenol blue tests, respectively.

Thus it may be concluded from the above results that the mitochondria which always have some phospholipid material in definite configuration with proteins are constantly pinching off phospholipid material in the form of 'Golgi' granules on their surface. The extrusion of lipid material by the mitochondria has also been found by Lever[9] by electron microscopy. Therefore, it seems very probable that the mitochondria also produce 'Golgi' material in the cell, besides their vital oxidative activities.

It may also be stated that the 'Golgi' material always appears in the form of granules in the early stages which may later grow directly into big spheres, or they may come in contact with vacuoles and spread around them to form rings and crescents showing the characteristic duplex structure corresponding to the externum and internum of Hirsch. However, in some cells where 'Golgi' granules lie close together, osmium and silver impregnation tends to make a 'net-work'-like pattern, which is soon resolved in the growing oocytes by their dispersal. These conclusions support Baker's[10] new terminology 'lipochondria' for 'Golgi' inclusions, which would not only signify their granular form and lipid nature but would also indicate their mitochondrial origin.

I wish to thank Prof. Vishwa Nath and Dr. H. S. Roberts for helpful suggestions.

H. C. Chopra*

Zoology Department,
Duke University,
Durham,
North Carolina.

* Hargitt Fellow.

[1] Hirsch, G. C., *Protoplasma* Monographs (Berlin, 1939).

[2] Nath, V., and Chopra, H. C., *Res. Bull. Panj. Univ.* (India), 74, 91 (1955).

[3] Nath, V., and Gupta, B. L., *Quart. J. Micro. Sci.*, 97, 369 (1956).

[4] Chopra, H. C., *Quart. J. Micro. Sci.*, 99, 149 (1958).

[5] Chopra, H. C., *Res. Bull. Panj. Univ.* (India), 152, 211 (1958).

[6] Chopra, H. C., *La Cellule*, 60, 301 (1960).

[7] Baker, J. R., *Quart. J. Micro. Sci.*, 87, 441 (1946).

[8] Chopra, H. C., *Nature*, 184, 656 (1959).

[9] Lever, J. D., *Amer. J. Anat.*, 97, 409 (1955).

[10] Baker, J. R., *J. Roy. Micro. Soc.*, 74, 217 (1954).

VIROLOGY

Activation of One Plant Virus by Another

Tobacco necrosis is a disease that can be caused by several serologically unrelated viruses[1], all of which are soil-borne and cause necrotic local lesions in leaves of tobacco (*Nicotiana tabacum* L.) and French bean (*Phaseolus vulgaris* L.) plants. The virus Bawden and Pirie[2,3] called the 'Rothamsted culture' differed in several respects from other members of the group; the ratio of infectivity to specific antigen content varied greatly in different preparations, it lost infectivity *in vitro* more rapidly than the others, and infective preparations always contained particles of two different sizes, about 17 mμ and about 30 mμ in diameter. Crystalline preparations (identified as nucleoproteins), consisting almost entirely of the smaller particles, had little or no infectivity, whereas other partly purified preparations that contained many more of the larger particles were infective. From this, Bawden and Pirie concluded that probably only the larger particles were infective and that the smaller ones, which were usually the major constituent of their preparations, were an additional product of the multiplication of the larger ones[4].

We have now found that the large and small particles in the Rothamsted tobacco necrosis are serologically unrelated, and that whereas the large particles can apparently multiply by themselves, the small ones multiply only in the presence of the large. Particles having different sedimentation-rates were separated from partly purified virus preparations, made as described by Bawden and Pirie[5], by centrifuging in sucrose density gradients[6]. After sedimenting for 2 hr. at 17,000 r.p.m. (about 25,000*g* at the top of the gradient column), two and sometimes three light-scattering zones were formed. The top zone contained particles 17 mμ in diameter, the second one particles 30 mμ in diameter, and the third zone, when present, contained aggregates each apparently consisting of a group of 12 of the 17 mμ particles. The approximate sedimentation constants, estimated from the depths of the zones as described elsewhere[7], were 45*S*, 116*S*, and 216*S*, respectively, assuming the value for tobacco mosaic virus to be 187*S*. These three components presumably correspond to those reported as having sedimentation constants of 51, 116 and 240*S* (ref. 2).

When material from each of these zones was inoculated separately to French bean or tobacco plants, only that from the middle zone produced lesions, and these were more uniform in size than those produced from inocula made by extracting sap from diseased plants. In one experiment, when these leaves inoculated from the middle zone were later macerated and the virus from them extracted and purified, the ratio of 30 mμ to 17 mμ particles was 21 : 1. Similar leaves, inoculated with a mixture of equal volumes of top zone and middle zone material, gave a ratio of 1 : 1. Leaves inoculated with either top or bottom zone material alone failed to develop lesions, and extracts from such leaves showed no virus-like particles when examined with the electron microscope. When tested in double-diffusion precipitin tests in agar gel against an antiserum containing antibodies to both large and small particles, the extracts from plants inoculated with middle zone material gave one line, those from plants inoculated with mixtures of top and middle zone gave two lines, and those from plants inoculated separately with top or bottom zone only gave no lines.

Table 1 shows the effects of using as inocula particles from the middle and top zones. Mixing the two decreases the size of the lesions below that produced by the middle zone alone.

Table 1. INFECTIVITY OF SMALL AND LARGE PARTICLES SEPARATELY AND WHEN MIXED IN DIFFERENT PROPORTIONS

Inocula	Numbers of lesions on seven half-leaves of French beans	
	Large lesions	Small lesions
Large particles, 4 mgm./l.	322	0
Large particles, 4 mgm./ml. + small, 5 mgm./l.	12	314
Large particles, 4 mgm./ml. + small, 20 mgm./l.	4	295
Large particles, 4 mgm./ml. + small, 80 mgm./l.	1	184
Small particles, 80 mgm./l.	0	0

A small proportion of small particles did not alter the total number of lesions, but only a few were now large. Further successive increases in the proportion of small particles in the inoculum did decrease the total number of lesions, and almost all were small.

These results indicate that the small particles interfere with, and when abundant may even suppress, the multiplication of the large particles, and that they multiply detectably only when inoculated together with the large ones. It seems likely that a pure preparation of large particles would infect and multiply without producing any of the small particles, but it is impossible to establish this because the middle zone cannot be removed from the centrifuge tube without some contamination from top or bottom zones. However, our results clearly suggest that the number of small particles produced in the inoculated leaves depends upon the proportion of small particles in the inoculum.

The production of non-infective particles along with infective ones has been described before with other viruses, but in all such examples known to us the non-infective particles are serologically related to the infective ones so that they can be regarded as products of the synthesis of one virus. The association of two sizes of particles in the Rothamsted tobacco necrosis culture appears to be unique, for the two kinds of particles are serologically unrelated and thus seem to be separate viruses, one of which is apparently completely dependent upon the other for its multiplication.

B. KASSANIS
H. L. NIXON

Rothamsted Experimental Station,
Harpenden,
Herts.

[1] Bawden, F. C., *Brit. J. Exp. Path.*, 22, 59 (1941).
[2] Bawden, F. C., and Pirie, N. W., *Brit. J. Exp. Path.*, 23, 314 (1942).
[3] Bawden, F. C., and Pirie, N. W., *Brit. J. Exp. Path.*, 26, 277 (1945).
[4] Bawden, F. C., and Pirie, N. W., *J. Gen. Microbiol.*, 4, 464 (1950).
[5] Bawden, F. C., and Pirie, N. W., *J. Gen. Microbiol.*, 16, 696 (1957).
[6] Brakke, M. K., *Arch. Biochem. Biophys.*, 45, 275 (1953).
[7] Harrison, B. D., and Nixon, H. L., *J. Gen. Microbiol.*, 21, 569 (1959).

Infective Ribonucleic Acid from the Viruses of Talfan and Teschen Diseases

INFECTIVE ribonucleic acids have been obtained from several animal viruses by the cold phenol method described by Gierer and Schramm[1]. In general, however, most of the experiments have been done with crude suspensions, and it has not always been clear whether the infective ribonucleic acid was derived from the virus itself or from a viral precursor or other related material. The work of Huppert and Sanders[2] with mouse encephalomyocarditis virus has shown clearly that the infective ribonucleic acid which can be obtained from mouse carcinoma cells infected with this virus has its origin in a viral precursor and not in the virus itself. In fact, infective ribonucleic acid cannot be extracted from this virus by the cold phenol method. On the other hand, it is likely that the infective material which can be obtained from suspensions of tissues infected with the viruses of poliomyelitis[3], mouse encephalomyelitis[4], Mengo encephalitis[5], Murray Valley encephalitis[6] and foot-and-mouth disease[7,8] by this method is being derived from the viruses themselves. This difference in behaviour emphasizes the differences in the chemical structures of the viruses. Furthermore, the work of Wecker[9] has shown that purified Western equine encephalomyelitis virus, which does not yield any infective ribonucleic acid on treatment with cold phenol, can be made to do so if the extraction is carried out at 40–50° C.

Similar experiments have now been done with the viruses of Talfan and Teschen diseases. Talfan disease is a recently described[10] polioencephalomyelitis affecting young pigs in Britain and shows close similarities to Teschen disease, an infection of pigs well known in Europe. The cross-neutralization tests described by Chapronière, Done and Andrewes[11] suggested that the two diseases are caused by identical or similar viruses. The preliminary results described here show that the infective material which can be obtained from suspensions of each virus by treatment with cold phenol is a ribonucleic acid which is being extracted either from the virus itself or from a material which sediments along with the virus in the ultracentrifuge.

Tissue culture fluids were harvested from pig kidney cell monolayers 24–30 hr. after infection. After this period of incubation, all the cells were off the glass and the virus titre was at a maximum. The virus suspensions were concentrated by dialysis against polyethylene glycol[12] at 2° C. These concentrates were then centrifuged at 30,000 r.p.m. for 1 hr. in the *L* 30·2 head of the 'Spinco' ultracentrifuge. The top 7 ml. (supernatant fraction) of each tube was then removed and the pellet suspended in the lower 2 ml. diluted with a further 7 ml. of tissue culture medium (deposit fraction). The virus content of the initial concentrate and of each fraction was determined by observing the number of plaques formed on pig kidney cell monolayers. Tenfold dilutions were used, and the monolayers stained with neutral red after 96 hr. incubation. Phenol extracts were prepared from each fraction and 0·4 ml. aliquots inoculated on to pig kidney cell monolayers in 4-oz. bottles. Four bottles per tenfold dilution were used and the monolayers were examined daily for cytopathic effects. The results (Table 1) show that infective ribonucleic acid could not be detected in the phenol extracts of the supernatant fractions but only in the deposit fractions. This is similar to the results we have obtained previously with foot-and-mouth disease virus[7], but is in direct contrast to those obtained with mouse encephalomyocarditis virus[4]. In the latter case, infective ribonucleic acid could be obtained from the supernatant fraction only, although this contained less than 0·1 per cent of the initial virus.

The cytopathic effects produced by the phenol extracts could be prevented by incubating them with 10 μgm. ribonuclease/ml. for 15 min. at 20° C. prior to inoculation on to the monolayers. As the titre of the parent viruses was not affected by adding 10 times this amount of the enzyme to each virus dilution, it seems probable that the infective agent in the phenol extracts is a ribonucleic acid.

Table 1. YIELD OF INFECTIVE RIBONUCLEIC ACID FROM ULTRACENTRIFUGE FRACTIONS OF TESCHEN AND TALFAN VIRUSES

Virus	Fraction	Virus titre (p.f.u./ml.)	Ribonucleic acid titre (log *ID*50/ml.*)
Talfan	Initial	$3 \cdot 6 \times 10^8$	2·2
	Supernatant	$1 \cdot 0 \times 10^5$	None detected
	Deposit	$2 \cdot 5 \times 10^8$	2·2
Teschen	Initial	$2 \cdot 4 \times 10^8$	2·0
	Supernatant	$1 \cdot 3 \times 10^4$	None detected
	Deposit	$1 \cdot 5 \times 10^8$	2·2

* 0·4 ml. inocula used.

The fluids harvested from those monolayers which showed cytopathic effects following infection with the ribonucleic acid had properties similar to those of the intact viruses. They were neutralized by antisera prepared by inoculation of the viruses into rabbits. Thus 100 *ID*50 of the parent virus or the ribonucleic acid harvest was neutralized by an equal volume of 1/1,000 homologous rabbit antiserum, as measured in pig kidney cell suspensions by the metabolic inhibition test (Martin, W. B., and Chapman, W. G., unpublished work). The possibility that the neutralization was an anti-tissue effect of the sera was rejected, as the same sera had no effect on the titration end-point of foot-and-mouth disease virus (strain 997, Waldmann type *O*) in the same cell system.

We wish to thank Mrs. J. O. Farley for the rabbit antisera and Dr. W. B. Martin and Mr. W. G. Chapman for furnishing us with details of the metabolic inhibition test prior to publication.

F. BROWN
DOREEN L. STEWART

Research Institute
(Animal Virus Diseases),
Pirbright, Surrey.
May 3.

[1] Gierer, A., and Schramm, G., *Nature*, 177, 702 (1956).
[2] Huppert, J., and Sanders, F. K., *Nature*, 182, 515 (1958).
[3] Koch, G., Koenig, S., and Alexander, H. E., *Virology*, 10, 329 (1960).
[4] Franklin, R. M., Wecker, E., and Henry, C., *Virology*, 7, 220 (1959).
[5] Colter, J. S., Bird, H. H., Moyer, A. W., and Brown, R. A., *Virology*, 4, 522 (1957).
[6] Ada, G. L., and Anderson, S. G., *Nature*, 183, 799 (1959).
[7] Brown, F., and Stewart, D. L., *Virology*, 7, 408 (1959).
[8] Mussgay, M., and Strohmaier, K., *Zbl. Bakt.*, I, Orig., 173, 163 (1958).
[9] Wecker, E., *Virology*, 7, 241 (1959).
[10] Harding, J. D. J., Done, J. T., and Kershaw, G. F., *Vet. Rec.*, 69, 824 (1957).
[11] Chapronière, D. M., Done, J. T., and Andrewes, C. H., *Brit. J. Exp. Path.*, 39, 74 (1958).
[12] Kohn, J., *Nature*, 183, 1055 (1959).

Polyoma Virus Mutant with a Reduction in Tumour Formation

INFECTION with polyoma virus *in vivo* can result in a cytopathic effect, hyperplasia, and the formation of benign or of malignant tumours[1]. The use of single plaque isolations has indicated that these different types of response can be produced by the same virus[2]. During the course of investigations on the induction of different responses to virus infection *in vitro*, a plaque-type mutant of polyoma, with a smaller-sized plaque than the wild type, was found in the virus produced by a line of mouse cells with a stable cell-virus association[3]. This line of cells was established by the culture of survivors after cytopathic effect in primary mouse embryo monolayers that had been infected with wild type polyoma. The cell line has now been releasing virus in culture for more than

1 year, and the plaques made by the virus are still of the mutant type. The mutant has been designated as *sp* (= small plaque). Cross-neutralization of plaques has so far shown no antigenic difference between *sp* and the wild type.

sp virus harvested 8 months after the establishment of the cell line was tested for tumour induction *in vivo*. In contrast to a 100 per cent incidence of animals with tumours after inoculation of wild type polyoma into hamsters, even with an input of 1·0–3·0 × 10^5 plaque-forming units of *sp* per animal, only subcutaneous sarcomas were found in 3 out of 31 hamsters (Table 1). One litter of *AKR* mice was inoculated when 2 days old with *sp*, and during an observation period of 6 months, parotid tumours only were observed in 1 out of 5 animals, in contrast to a 100 per cent tumour induction after inoculation of wild type virus.

Table 1. TUMOUR INDUCTION IN HAMSTERS AFTER INOCULATION WITH WILD TYPE POLYOMA VIRUS AND THE MUTANT *sp*

Virus	No. of litters	Age at inoculation (days)	Input virus per animal (plaque-forming units)	Observation period (months)	No. with tumour / No. of animals
Wild type	6	3 to 6	1 0 × 10^5	2 5	30/30
sp	3	2 to 4	1 0 to 3 0 × 10^5	2 5	1/16
	3	3 to 6	1·4 to 2 0 × 10^5	3 to 4	2/15

Animals inoculated subcutaneously with 0 1 ml. of virus suspension.

These results show that it is possible to obtain, with a tumour virus, a mutant that is 'attenuated' regarding its tumour-producing capacity, while retaining its cytopathic effect. The existence of complete attenuation for tumour-producing capacity, and of the reverse type of mutant, that is, tumour production without cytopathic effect, is now being looked for. It is of interest that in common with the *d*[4] and *MS*[5] mutations of polyomyelitis that can be associated with reduced neuropathogenicity, the reduced tumour induction by this polyoma mutant is also associated with a plaque type mutation.

LEO SACHS
DAN MEDINA

Department of Experimental Biology,
Weizmann Institute of Science,
Rehovoth, Israel.

[1] Stanton, M. F., Stewart, S. E., Eddy, B. E., and Blackwell, R. H., *J. Nat. Cancer Inst.*, 23, 1441 (1959).

[2] Winocour, E., and Sachs, L., *Virology*, 8, 397 (1959); and unpublished work

[3] Medina, D., and Sachs, L., *Virology*, 10, 387 (1959).

[4] Vogt, M., Dulbecco, R., and Wenner, H. A., *Virology*, 4, 141 (1957).

[5] Yukrahige, K., and Melnick, J. L., *J. Exp. Med.*, 109, 9 (1959).

Virus and Antibodies in the Lymph and Blood of Sheep infected experimentally with the Virus of Tick-borne Encephalitis

IT is known that foreign substances which penetrate the organism are resorbed by the lymphatic system. This also applies to bacteria and viruses

In previous experiments[1] it was found that when tick-borne encephalitis virus was administered subcutaneously to mice, it was resorbed via the regional lymph vessels into the blood stream, from which it afterwards penetrated further lymph vessels and other organs. This was demonstrated by detecting the virus in the lymph nodes and blood.

Since I was interested in the question of the part played by the lymphatic and blood vascular systems in direct resorption of the virus from infected tissue; in their time relationships and in the antibody response in the lymphatic system, it was necessary to increase the accuracy of the preceding experiments by examining more adequate systems, namely, lymph and blood.

The experiments were carried out in sheep with an artificial lymph-blood circulation[2]. Lymph was collected from the cannulated thoracic duct and blood was obtained from a contralateral vein (one of the branches of the right jugular vein). The virus was detected in mice by intracerebral infection. Neutralizing antibodies were determined by an intraperitoneal test in mice.

The experiments clearly demonstrated that the lymphatic system is the main route by which the virus penetrates the blood stream from the subcutaneous tissue. No direct resorption of the virus from the subcutaneous tissue into the blood stream was found. If this occurs at all, it is evidently on such a small scale that it cannot be detected by the method used. The rate of resorption by the lymphatic system depends on the amount of virus. When administered subcutaneously into the metatarsus of the hind limb in amounts of 0 043 ml. 20 per cent suspension/1 kgm. body-weight (about three to four thousand million intracerebral mouse *LD*50), the virus was detected 60 min. later in lymph collected from the thoracic duct. No penetration of the virus into the blood stream from any part of the lymphatic system other than the thoracic duct was observed. Following re-infection seven and twelve days after primary inoculation, the virus was not detected in the lymph or the blood, even at very early intervals after reinfection[3].

Neutralizing antibodies were detected in the lymph sooner and in higher titres than in the blood plasma. Antibodies were also determined in the lymph of a sheep in which the thoracic duct was exteriorized and its connexion with the blood stream was interrupted, so that the virus, which was administered into a peripheral lymph vessel, passed through the regional lymph vessels only. This means that antibodies were determined in the lymph after antigenic stimulation to which, in effect, only the regional lymph vessels were exposed. The first antibodies were always found when the virus rapidly decreased in the lymph and in the blood. The higher antibody titre in the lymph was maintained up to the seventh day after infection. From then onwards it was higher in the blood plasma. Re-infection on the seventh and twelfth day after primary inoculation resulted in a further antibody increase in the lymph and the blood plasma, which was greater in the latter[4].

These experiments show that the lymphatic system plays an important part in resorption and transport of the tick-borne encephalitis virus and in the formation of antibodies against it.

DOUBRAVKA MÁLKOVÁ

Military Institute of Hygiene,
Epidemiology and Microbiology,
Prague.

[1] Málková, D., and Franková, V., *Acta Virologica*, 3, 210 (1959).

[2] Málek, P., and Kolc, J., *Časopis lékařů českých*, 34, 1069 (1958).

[3] Málková, D., *Acta Virologica* (in the press).

[4] Málková, D., *Acta Virologica* (in the press).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

BRANCH PRINCIPAL (with a good degree and suitable experience in universities or technical colleges) OF THE ENUGU BRANCH of the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (August 26).

LECTURERS (with an honours degree, or equivalent, in engineering or applied science, and industrial, research or teaching experience) IN MECHANICAL ENGINEERING—The Registrar, Royal Technical College, Salford, Lancs (August 31).

RESEARCH FELLOW (microbiologist with postgraduate research experience, and preferably experience in microbial genetics) IN MICROBIOLOGY, to join a research team of chemists and microbiologists concerned with fundamental studies on biosynthesis—The Registrar, University College, Singleton Park, Swansea (August 31).

PHYSIOLOGISTS (ASSISTANT LECTURERS, LECTURERS, or SENIOR LECTURERS) (with a degree in physiology, of honours standard, and for one of the appointments preference will be given to a candidate with postgraduate training and research experience in the field of human physiology) IN THE NEW DEPARTMENT OF ERGONOMICS AND CYBERNETICS, for research and postgraduate teaching in ergonomics—The Academic Registrar, Loughborough College of Technology, Loughborough, Leicestershire, quoting Ref. 17/AF (September 1).

RESEARCH ASSISTANT (preferably with research experience) IN THE DEPARTMENT OF BOTANY, for work in translocation in plants—The Secretary, The University, Aberdeen (September 3).

SENIOR LECTURER or LECTURER (with special qualifications either in plant pathology or virology) IN BOTANY—Joint Clerk to the University Court, Queen's College (University of St. Andrews), Dundee (September 8).

ASSISTANT DIRECTOR OF RESEARCH IN DYNAMICAL OCEANOGRAPHY in the Department of Applied Mathematics and Theoretical Physics—Dr. F. G. Friedlander, Secretary of the Appointments Committee of the Faculty of Mathematics, the Arts School, the University, Bene't Street, Cambridge (September 9).

ASSISTANT LECTURER (graduate, with special interests in either igneous petrology or sedimentary petrology and palaeozoic stratigraphy) IN GEOLOGY—The Registrar, The University, Leicester (September 10).

LECTURER (with a good honours degree in electrical engineering or physics, preferably of a British university, together with some industrial experience, and preferably some teaching experience and a special knowledge of microwave engineering) IN ELECTRICAL ENGINEERING—The Secretary, University College, Gower Street, London, W.C.1 (September 10).

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree or five subjects at G.C.E. "O" level and at least two at "A" level) IN THE DEPARTMENT OF POTATO GENETICS, to assist in routine tests and pathological investigations—The Secretary, John Innes Institute, Bayfordbury, Hertford, Herts (September 12).

SENIOR LECTURER IN HORTICULTURE at the University of Sydney, Australia, to undertake teaching and research in fruit and vegetable production—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 13).

EXPERIMENTAL OFFICER (MICROBIOLOGIST) (with experience in the isolation and maintenance of pure bacterial cultures, and preferably experience in the biochemical techniques) at the National Chemical Laboratory, D.S.I.R., Teddington, Middlesex, to join a team studying the influence of micro-organisms on corrosion of metals, particularly in soil—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.275/0A (September 19).

BOTANIST or BIOCHEMIST (with an interest in field work), to grow and test plants for suitability as sources of protein—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (September 20).

LECTURER IN ANATOMY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 30).

SENIOR LECTURER IN PHYSICS, and LECTURERS (2) IN PHYSICS at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 30).

PHYSICIST or CHEMIST, Scientific Officer grade (male, with a first- or second-class honours degree, and preferably experience of polymers or biological systems or ionizing radiation), at the Royal Military College of Science, Shrivenham, for a two- or three-year programme of fundamental research (of an academic character and intended for publication) on effects of high energy radiation of polymers in solutions, and the effect of additives as a means of radiation protection or enhancement. This work would be correlated with corresponding effects in biological systems—Technical and Scientific Register (K), Ministry of Labour, 26 King Street, London, S.W.1, quoting A.326/0A (October 6).

AGRICULTURAL OFFICER (EDUCATION) (male, with a degree in agriculture or natural science, at least two years suitable postgraduate experience or training, and preferably some teaching experience) in Nyasaland, to teach agricultural subjects to African students at the Colby School of Agriculture near Lilongwe—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/4/023/T.

ASSISTANT LECTURER (Grade B) IN MATHEMATICS—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3.

ASSISTANT (with a degree in botany or agriculture, and preferably experience of plant pathology) TO THE MYCOLOGIST—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

BIOLOGIST (with a good degree in physiology or zoology and considerable research experience preferably with spermatozoa), to join a small research team investigating cervical mucus, with particular reference to problems of fertility—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 60/13.

CHEMISTS, MATHEMATICIANS (including STATISTICIANS), METALLURGISTS, MECHANICAL AND ELECTRICAL ENGINEERS, and PHYSICISTS (including BIOPHYSICISTS) (men and women, with a first- or second-class honours degree or equivalent) at Research and Development Establishments of the War Office at various locations, including Sevenoaks, Kent; Byfleet, Chertsey and Tolworth, Surrey; Shoeburyness, Essex; Christchurch and Farnborough, Hants; Salisbury, Wilts; and in Cornwall—Technical and Scientific Register (K), Ministry of Labour, 26 King Street, London, S.W.1, quoting A.300/0A.

DEMONSTRATOR IN AGRICULTURAL ZOOLOGY at the School of Agriculture, Sutton Bonington—The Registrar, The University, Nottingham.

ELECTRONICS TECHNICIAN (male or female), for research work—Dr. E. Bulbring, Department of Pharmacology, The University, South Parks Road, Oxford.

EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (preferably with a degree in dairying, or the N.D.D., together with good experience of laboratory work) IN THE BACTERIOLOGY DEPARTMENT, to work on hygienic aspects of milk production and processing—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 60/8.

EXPERIMENTALIST (with G.C.E. at "A" level, H.N.C. in applied physics or equivalent qualifications and preferably an interest in electronics) IN THE METALLURGY DIVISION, A.E.R.E., to assist with experimental measurements for the study of solids by diffracting beams of neutrons from nuclear reactors—The Personnel Manager (1747/34), United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

GEOLOGISTS (not over 35, with a first- or good second-class honours degree in geology) with the Government of Northern Nigeria, for regional geological mapping and the examination of mineral deposits—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/3/01.

HONOURS GRADUATE (preferably in physics), for work on electrical and mechanical properties of ceramics at ordinary and elevated temperatures—The Director of Research, British Ceramic Research Association, Queens Road, Penkhull, Stoke-on-Trent.

LABORATORY TECHNICIAN (with some training in bacteriological technique and preferably with Inter I.M.L.T.)—The Secretary, Royal Veterinary College, Royal College Street, London, N.W.1.

MALE SPECIALIST VIROLOGIST (with qualifications registrable in the United Kingdom, and a minimum of seven years postgraduate experience, at least five of which must have been spent in the practice of virology) in Hong Kong, to take charge of the Vaccine Institute and the manufacture of human and animal vaccines—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD117/51/062.

PHYSICAL CHEMIST (with at least five years research experience) IN THE RESEARCH LABORATORIES, initially to lead a team studying the bulk properties of high polymers—The Director, Arthur D. Little Research Institute, Inveresk, Midlothian, Scotland.

PHYSICAL CHEMIST (with doctorate, preferably with experience in low temperature calorimetry), for academic research in the thermodynamic properties of compounds of biochemical interest—Institute of Scientific Research, New Mexico Highlands University, Las Vegas, New Mexico, U.S.A.

PLANT PHYSIOLOGIST (with a good honours degree in botany or chemistry with specialization in plant physiology and not less than two years suitable postgraduate experience or training) in Tanganyika, for research work on coffee, with particular reference to over bearing and plant nutrition, and to collaborate with other specialists—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/026/T.

POST-DOCTORAL FELLOWS IN THE DEPARTMENT OF CHEMISTRY, for research work in the fields of electron spin resonance spectroscopy of free radicals at liquid helium temperature, and mass spectroscopy including photo-ionization studies—Prof. C. A. McDowell, Department of Chemistry, University of British Columbia, Vancouver 8, B.C., Canada.

POST-DOCTORAL RESEARCH FELLOW IN THE DEPARTMENT OF ORGANIC CHEMISTRY, for work on biosynthesis in fungi and bacteria—The Registrar, The University, Liverpool, quoting Ref. CV/N.

RESEARCH ASSISTANT (PHYSICIST) (with a knowledge of electronics and a degree in physics), for work with the X-ray scanning micro-analyser (electron probe) in the field of ore microscopy—Dr. A. P. Millman, Mining Geology Department, Royal School of Mines, Prince Consort Road, London, S.W.7.

SCIENTIFIC ASSISTANT (ABSTRACTOR) (with a degree in agriculture or natural science and a knowledge of languages)—The Director Commonwealth Bureau of Pastures and Field Crops, Hurley, Berkshire.

SENIOR LECTURER IN SERVOMECHANISMS AND CONTROL ENGINEERING, a SENIOR LECTURER IN STRUCTURAL ENGINEERING, a SENIOR LECTURER IN ENGINEERING DRAWING, a LECTURER IN THE STRENGTH OF MATERIALS AND ELASTICITY, a LECTURER and an ASSISTANT LECTURER IN APPLIED MECHANICS, a LECTURER IN ENGINEERING DRAWING, a LECTURER IN THERMODYNAMICS, a LECTURER IN PRODUCTION ENGINEERING, and a LECTURER IN CHEMICAL ENGINEERING, IN THE DEPARTMENT OF MECHANICAL, CIVIL AND CHEMICAL ENGINEERING—The Secretary, Royal College of Science and Technology, George Street, Glasgow, C.1.

SENIOR LECTURER (with good teaching experience, together with research or industrial experience) IN INORGANIC or IN PHYSICAL CHEMISTRY—The Principal, Huddersfield College of Technology, Huddersfield.

SENIOR SCIENTIFIC GLASSBLOWER (well qualified, with considerable experience in high vacuum techniques, metal/glass seals, quartz work, etc.) IN THE DEPARTMENT OF CHEMISTRY—The Secretary, Department of Chemistry, University of British Columbia, Vancouver, B.C., Canada.

SENIOR TECHNICIAN II, to take charge of the Biochemistry Department in the Group Laboratory, Connaught Hospital, Walthamstow—The Secretary, Forest Group H.M.C., Langthorne Road, London, E.11.

SPECIALIST OFFICER (PLANT PATHOLOGIST) (with a university degree in natural science (botany) with first- or second-class honours, and two years postgraduate experience in plant pathology) IN THE DEPARTMENT OF AGRICULTURAL RESEARCH, Ibadan, Nigeria, to undertake research into virus diseases of food crops—The Appointments Secretary, Federal Public Service Commission, Nigeria House, 9 Northumberland Avenue, London, W.C.2, quoting B.7/2.

TECHNICIAN (with some knowledge of, and interest in, insects or spiders)—Prof. G. C. Varley, Hope Department, University Museum, Oxford.

VISITING ASSISTANT PROFESSOR-RESEARCH ASSOCIATE, to give some lectures in general chemistry and in an advanced course in inorganic chemistry, help with the supervision of laboratory work, and engage in research in inorganic chemical synthesis or reactions—Louis J. Bircher, Box 1550, Vanderbilt University, Nashville 5, Tennessee, U.S.A.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research: Road Research Laboratory. Road Note No. 25: Sources of White and Coloured Aggregates in Great Britain (1959). Pp. 15. (London: H.M. Stationery Office, 1960.) 1*s*. 3*d*. net. [136

Commonwealth Mycological Institute, Kew. Mycological Papers. No. 76: Dematiaceous Hyphomycetes: 1. By M. B. Ellis. Pp. 36. No. 77: A Supplement to a Host List of Plant Diseases in Malaya. By A. Johnston. Pp. 30. 7*s*. 6*d*. net. (Kew: Commonwealth Mycological Institute, 1960.) [136

British Broadcasting Corporation. Television Field Trials of 405-line and 625-Line Systems in the UHF and VHF Bands, 1957–1958. Part 1: Results of Field Trials of 405-Line Television in Bands I and V. Part 2: Results of Field Trials of 405-Line Television in Band I and 625-Line Television in Band V. Pp. 152. (London: British Broadcasting Corporation, 1960.) 20*s*. [136

Flora of Tropical East Africa. Edited by C. E. Hubbard and E. Milne-Redhead. Rosaceae. By R. A. Graham. Pp. 61. (London: Crown Agents for Oversea Governments and Administrations, 1960.) 5*s*. [136

Lawes Agricultural Trust. Report of the Rothamsted Experimental Station for 1959. Pp. 288. (Harpenden: Rothamsted Experimental Station, 1960.) 10*s*. [136

British Society for the Promotion of Vegetable Research. National Vegetable Research Station Tenth Annual Report 1959 (Oct. 1958–Sept. 1959). Pp. viii+63. (Wellesbourne, Warwick: National Vegetable Research Station, 1960.) [136

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 85: The Propagation of Trees. Pp. 12. (Belfast: Ministry of Agriculture, 1960.) [136

Scientific Proceedings of the Royal Dublin Society. Series A. Vol. 1, No. 2: Light Collection on Liquid Scintillator Cells. By D. O. Cummins, C. F. G. Delaney and I. R. McAulay. Pp. 21–26. 1*s*. Vol. 1, No. 3: The Stratigraphy and Structure of the Lower Palaeozoic Rocks of North-West Galway. By Dr. W. S. McKerrow and Dr. C. J. Campbell. Pp. 27–52+plates 1–6. 8*s*. Series B. Vol. 1, No. 1: An Investigation of Winter Dormancy in *Heterodera rostochiensis*. By P. C. Cunningham. Pp. 1–4. 1*s*. Vol. 1, No. 2: Problems of Grass Conservation in Ireland. By J. R. O'Callaghan. Pp. 5–20. 4*s*. (Dublin: The Royal Dublin Society, 1960.) [136

John Innes Horticultural Institution. Fiftieth Annual Report, 1959. Pp. 50. (Bayfordbury, Hertford: John Innes Horticultural Institution, 1960.) 3*s*. [136

The Carnegie United Kingdom Trust. 46th Annual Report, 1959. Pp. viii+68. (Dunfermline, Fife: Carnegie United Kingdom Trust, 1960.) [136

Department of Agriculture and Fisheries for Scotland. Spaced-Plant Trials at East Craigs. 6: Varieties of Perennial Ryegrass, *Lolium perenne* L. 1956–58. Pp. 7+2 figures. (Edinburgh: Department of Agriculture and Fisheries for Scotland, 1960.) [136

Department of Scientific and Industrial Research: Building Research Station. Factory Building Studies No. 5: Sites and Foundations. Pp. iv+20. (London: H.M. Stationery Office, 1960.) 3*s*. net. [136

Department of Scientific and Industrial Research: National Engineering Laboratory. Mechanical Engineering Research 1959: Report of the National Engineering Laboratory Steering Committee, with the Report of the Director of the National Engineering Laboratory. Pp. iii+64+4 plates. (London: H.M. Stationery Office, 1960.) 4*s*. 6*d*. net. [146

British Film Institute. National Film Archive Catalogue, Part 2: Silent Non-Fiction Films, 1895–1934. Pp. x+195+12 plates. 15*s*. The National Film Archive. Pp. 16. 2*s*. 6*d*. (London: British Film Institute, 1960.) [146

Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act, 1954, for 1959. Durham Division. By W. Widdas. Pp. iv+39+5 plates. 3*s*. 6*d*. net. East Midland Division. By H. S. Stephenson. Pp. iv+41+5 plates. 3*s*. 6*d*. net. (London: H.M. Stationery Office, 1960.) [146

Royal Greenwich Observatory Bulletins. No. 19: Time Service 1959, July–September. Pp. 259–276. (London: H.M. Stationery Office, 1960.) 3*s*. 6*d*. net. [146

Department of Scientific and Industrial Research: Building Research Station. Tropical Building Studies No. 1: Densities in Housing Areas. By P. H. M. Stevens. Pp. 55. (London: H.M. Stationery Office, 1960.) 10*s*. net. [146

Educational Productions Limited. Filmstrip No. C6348: The Hedgerow. 36 frames. 27*s*. 6*d*. Notes for use with Filmstrip No. C6348. Pp. 12. Filmstrip No. C6349: Beautiful Butterflies. 31 frames. 27*s*. 6*d*. Notes for use with Filmstrip No. C6349. Pp. 16. Filmstrip No. C6403: Flowers of Marsh and Pool. 31 frames. 27*s*. 6*d*. Notes for use with Filmstrip No. C6403. Pp. 13. Filmstrip No. C6430: The Woodlands. 35 frames. 27*s*. 6*d*. Notes for use with Filmstrip No. C.6430. Pp. 13. (East Ardsley, Wakefield. Educational Productions, Ltd., 1959 and 1960.) [156

Other Countries

Proceedings of the California Academy of Science. Fourth Series. Vol. 29, No. 16: The Morphology of *Phyllaplysia zostericola*, New Species. By James E. McCauley. Pp. 549–576. Vol. 29, No. 17: Rhoicinine Spiders (Pisauridae) of Western South America. By Harriet Exline. Pp. 577–620 (5 plates). (San Francisco: California Academy of Sciences, 1960.) [315

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 41 (April 1960): Overweights Benefit from Weight Reduction. Why Older People are Hospitalized. The American Family Today. Loss of Life in Violent Storms and Floods. Pp. 12. (New York: Metropolitan Life Insurance Company, 1960.) [315

Geological Survey of Tanganyika. Bulletin No. 30: Microfloral Investigation of the Lower Coal Measures (K2); Ketewaka-Mchuchuma Coalfield, Tanganyika. By George F. Hart. Pp. iii+18+3 plates. Shs. 5. Memoir No. 1: Summary of the Geology of Tanganyika. Part 2: Geological Map. Pp. 6+map. Shs. 5. (Dar-es-Salaam: Government Printer, 1960.) [315

Mauritius Sugar Industry Research Institute, Annual Report, 1959. Pp. 102+xxv. (Réduit, Mauritius: Mauritius Sugar Industry Research Institute, 1960.) [315

United States Department of Agriculture: Agricultural Research Service. Technical Bulletin No. 1222. Collecting Insects by Airplane, with special reference to Dispersal of the Potato Leafhopper. By Perry A. Glick. Pp. ii+16. (Washington, D.C.: Government Printing Office, 1960.) 10 cents. [315

Smithsonian Miscellaneous Collections. Vol. 139, No. 9: A Long-Range Forecast of United States Precipitation. By C. G. Abbot. Pp. 78. (Publication 4390.) (Washington, D.C.: Smithsonian Institution, 1960.) [315

Universidade de Sao Paulo. Contribuicoes Avulsas do Instituto Oceanografico. No. 2. Os Equinodermas do Litoral de Sao Paulo, II. Por Luiz Roberto Tommasi. Pp. 27+6 plates. No. 3: Sôbre duas Arenicolas da Costa Brasileira (Annelida, Polychaeta). Por E. Nonato. Pp. 6+1 plate. Catalogue of Marine Larvae. By M. Vannucci. Pp. 44+74 figures. (Sao Paulo: Universidade de Sao Paulo, Instituto Oceanografico, 1958 and 1959.) [315

Annals of the New York Academy of Sciences. Vol. 84, Article 4: The Organization of Psychiatric Care and Psychiatric Research in the Union of Soviet Socialist Republics. By Nathan S. Kline. Pp. 147–224. Vol. 84, Article 5: A New Method for Cytological Diagnosis of Pulmonary Cancer. By Ludwig von Bertalanffy and Felix F. Bertalanffy. Pp. 225–238. Vol. 84, Article 6: The Kinetics of Reactions at Changing Temperature. By C. Olin Ball. Pp. 239–250. Vol. 85, Article 2: Freezing and Drying of Biological Materials. By Harold T. Meryman and 12 other authors. Pp. 501–734. (New York: New York Academy of Sciences, 1960.) [315

Smithsonian Contributions to Astrophysics. Vol. 5, No. 1: The Meteoric Head Echo. By Allan F. Cook and Gerald S. Hawkins. Pp. ii+1–7. 20 cents. Vol. 5, No. 2: The Upper Atmosphere and Satellite Drag. By R. J. Stirton. Pp. ii+9–15. 20 cents. Vol. 5, No. 3: On the Structure of the Sunspot Zone. By Barbara Bell. Pp. ii+17–28. 20 cents. (Washington, D.C.: Government Printing Office, 1960.) [315

World Health Organization. Technical Report Series. No. 194: Local Health Service—Third Report of the Expert Committee on Public Health Administration. Pp. 40. (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) 2 Swiss francs; 3*s*. 6*d*.; 0.60 dollars. [315

U.S. Department of Health, Education, and Welfare. Public Health Service Publication No. 735: Highlights of Progress in Mental Health Research 1959: Items of Interest on Program Developments and Research Studies conducted and supported by the National Institute of Mental Health. Pp. v+51. (Washington, D.C.: Government Printing Office, 1960.) 25 cents. [315

U.S. Department of the Interior: Fish and Wildlife Service. Fishery Bulletin No. 169: Definition of Haddock Stocks of the Northwestern Atlantic. By John R. Clark and V. D. Vladykov. Pp. iv+253–295. 20 cents. Fishery Bulletin 170: Annotated Bibliography on Biology of American Menhaden. By John W. Reintjes, James Y. Christmas, Jr., and Richard A. Collins. Pp. iv+297–322. 25 cents. (Washington, D.C.: Government Printing Office, 1960.) [315

Transactions of the American Philosophical Society. New Series. Vol. 50, Part 4: The Ainu of Northern Japan: a Study in Conquest and Acculturation. By Takakura Shinichiro. Translated and annotated by John A. Harrison. Pp. 88. (Philadelphia: American Philosophical Society, 1960.) 2 dollars. [315

Canada Department of Agriculture. Annual Report of the Forest Insect and Disease Survey, 1959. Pp. 121. (Ottawa: Queen's Printer, 1960. Obtainable from Information Division, Canada Department of Agriculture, Ottawa.) [36

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

UNIVERSITY EDUCATION IN BRITAIN

In the stimulating discussion of the diffusion of knowledge, to which he devoted his Foundation Oration at Goldsmiths' College, University of London, last March, Dr. Michael Grant pleaded for recognition of the task of exposition as worthy in itself and demanding high qualities of skill in interpretation and even scholarship; he also urged that a university should study deliberately how to produce the habit of mind which would make its students want, both before and after graduation, to take an open-minded interest in at least something worth while outside their own careers. The schools can do little to help, but the universities could give their students the habit of mind which would enable them to enjoy and benefit from reading about subjects other than their own, written in comprehensive terms.

Much the same point of view was taken by Prof. J. A. B. Gray in an inaugural lecture at University College, London, on February 23, on the place of physiology in university education*. He enumerated four main aims of formal courses: the provision of professional training; teaching people to understand the language used by experts and to be able to assess the value of their opinions; training the undergraduate to interpret evidence and to make sound judgments; and to develop a sense of values. He placed them in that order of increasing difficulty of achievement and increasing importance. Men with a sound professional training can increase material standards of living, but Prof. Gray believes that if our society is to make progress, the universities must provide men and women who are not overawed by the opinions of experts, who can assess the real worth of propaganda, pressure groups and advertising, and who have a sense of values, and his lecture discussed the possibility of physiology providing a basis for such an education in the universities as they are to-day.

Prof. Gray did not, of course, attempt to deal comprehensively with modern physiology, but limited himself to the discussion of certain problems connected with the physiology of receptors and sensory mechanisms. Pointing out that the most challenging of all problems connected with sensory mechanisms is to be found in the problem of human knowledge itself, and that our mental image of the world is determined by the ability of our receptors to detect the very narrow band of electromagnetic waves that we call light, he suggested that the development of receptors having very high sensitivities to events in the environment, and so small that animals can employ large numbers of them, should be regarded as one of the most significant factors in the adaptation of life to its environment and in the evolution of man himself. The width of the contacts which a physiologist working in this field should have with other branches of knowledge illustrates the contribution which physiology could make to his four aims of university education.

One of the problems with which the modern world is faced is the great increase in the use of specialized knowledge, and at the same time a decrease in the breadth of what is known by any one person. Many people, whether they are in a profession, in government service, in industry, or in academic life, are constantly needing advice from experts, and frequently have to judge between the opposing opinions of experts in entirely different fields. The point of decision may be in the general administrative field but it is frequently on what is a professional or scientific matter, and Prof. Gray observes that it is a great help to know what the other person is talking about and what sort of questions ought to be asked. Physiology, he thinks, has much to offer in this way because of its central position among university subjects, and he also believes that it could be made a gateway to science for those reading for an arts degree and who wish to take up a career in administration, because physiology sets out to answer certain of the human problems that they are likely to have met in their studies of human thought. Apart from this, physiology, as already noted, will bring the student into contact with ideas derived from most branches of science.

Prof. Gray readily admits that to have any hope of success such a course of physiology would have to differ considerably from those run to-day. He also claims that physiology can train a man to interpret evidence and make sound judgments from it and that accordingly it can provide a sound education for those who are looking for a non-specialist career in administration or industry. Finally, he suggests that physiology is able to bring the student face to face with questions of value and responsibility. Its subject-matter is the mechanisms of life, and this in itself tends to stimulate the intelligent student into asking himself or discussing with others questions about the meaning of life and about the nature of mind and consciousness.

As regards the nature of the courses to serve these several purposes Prof. Gray holds that the need of each of the different classes of students should be considered on its own merits and that courses should be constantly developing and changing to meet the challenge of new demands. Indeed, in his view, physiology itself will only flourish if it is in a position to draw help and inspiration both from other branches of knowledge and from the applications which it serves. It is an advantage to have specialist departments in certain specialist institutions, but as with many other subjects, the roots of physiology will lie in departments which are not only located in multi-faculty institutions but also are actively working in more than one faculty.

---

* The Place of Physiology in University Education. By Prof. J. A. B. Gray. (Inaugural-lecture delivered at University College, London, 23 February, 1960.) Pp. 16. (London: H. K. Lewis and Co., Ltd., 1960.) 2s. 6d. net.

There is thus some critical thinking already going on in the universities of Britain about the nature and re-shaping of university education; the plea which the Duke of Edinburgh advanced, in opening the Conference of the United Nations Educational, Scientific and Cultural Organization in London on humanism and technology, for a proper balance between science and humanism should fall on fertile ground. No one, he said, trained for a scientific post could hope to make his full contribution unless he has a broadly cultivated mind, and it is very doubtful, he suggested, whether a traditional scholar could really claim to make any contribution to philosophy in the technological age if he is utterly ignorant of scientific facts. Sir Julian Huxley added that, in the long run, it is perhaps of most importance to educate people as human beings and there is need for a background of approach to our thought which sees man as trustee for the whole of this planet and all those on it.

Clearly we are here touching the fundamental question of the real purpose of a university education, and in the debate in the House of Lords on May 11 on university and other higher education in Britain this was urged by several speakers as one of the most important questions requiring study, if not by a Royal Commission, then by something in the nature of a Crowther Committee or the University Grants Committee itself. Indeed, Lord Beveridge, in urging that the purpose of a university to-day is to make youth fit and eager to render professional service to their fellow citizens, not simply to sharpen wits but to build character, seemed to put into different words much that Prof. Gray said in his inaugural lecture. It is undoubtedly a fundamental question, and the answer we give to it may well determine that to be given to the various questions arising as to how and where university expansion should take place—the character as well as the size of university institutions, the scale on which they are to be equipped with halls of residence and libraries, the balance between research and teaching, and the ratio of staff to students as well as the content of courses and the standards of admission. Unless clear and considered answers are given to such questions, university expansion is unlikely to proceed at the necessary speed without seriously endangering standards.

The debate in the House of Lords showed that these problems are recognized rather than that acceptable answers to them have been found. Lord Simon of Wythenshawe proposed specifically to refer some of them to a special committee of inquiry or even to a Royal Commission to consider the needs of the next twenty years, and meanwhile to instruct the University Grants Committee to proceed with its present plans. Lord Beveridge similarly pleaded for a special, impartial study of such questions as the number of university students at which we should aim, the size of particular universities, the emphasis on research, the method of selecting students, the relation of university education to other advanced education for adults in Britain, and the study of university methods outside Britain and the changes of social conditions and their effect on university life. There seemed to be some general agreement in the debate that expansion in the main must fall upon the more modern and younger universities or by the creation of new institutions, though it was also recognized that some regard must be paid to the expansion of technological education; indeed, it was a feature of the debate that the contribution to higher education made outside the universities was so strongly stressed.

Lord Dalton strongly urged that university matters should be kept outside the Ministry of Education; Lord Adrian advocated making the Minister of Education responsible for all education, university and technological, as well as technical and primary and secondary, though he did not want to see the Ministry take over the functions of the University Grants Committee, and in this he had strong support from Lord Pakenham. Indeed, he suggested that we must be rather careful that in planning extensions in technological education as well as in other fields of higher education we do not set up an organization which would threaten the independence of the universities, and he himself supported the idea of an independent inquiry quite apart from the problems of university expansion.

No one was more emphatic than Lord Bridges that the main point calling for inquiry to-day is what we should expect to get from the universities in quality rather than in quantity. With such an inquiry into what the nation and the professions could expect and look for from those who have finished a university education could go a parallel inquiry into the rate of expansion in the universities and the way that expansion is carried out, including the processes by which new universities are established, their location and the idea of a regional university. Lord Esher, who was highly critical of the present university graduate, urged the importance of giving change and variety to the pattern of university life, and Lord James of Rusholme, too, believes that many of the present university courses designed to produce scholars in a narrow field rather than for the education of those with no genuine pretensions to scholarship may not be the most suitable we could devise. There is something to be said, he believes, for continuing work in general education, and it is right that we should demand not only technical skill and new knowledge but also those judgments of value which can illumine the life of the whole community. Viscount Caldecote made a similar point in suggesting that our selective system is so efficient that it is widening a dangerous gulf between those who go to a university and those who do not. He, too, emphasized the increasing importance of a broad education as science takes a larger place in our lives, if science is to be our servant and not our master; and he is specially concerned at the effects of premature specialization and of paying excessive attention to the passing of examinations to the detriment of broad education. He believes that the most important question that requires examination at the moment is the effect of university policy on education in the schools.

There was other authoritative support for a fresh look at the relation between education in the universities and in the schools, and at the distribution of effort between research and teaching in different universities, for example, from Lady Wootton of Abinger; but it was noticeable that neither of the Government spokesmen, the Earl of Dundee, early in the debate, or Lord Hailsham, in concluding, touched on this question of the purpose of education. Lord Hailsham, indeed, admitted that democracy and parliamentary government and the preservation of freedom require an adequate supply of graduates if they are to function to-day—this is a matter not merely of quantity but equally of quality. Nor did Lord Hailsham limit his view of graduates to those coming from the universities alone.

Lord Hailsham's speech was of interest chiefly for what he said about the basis on which the Government has laid its plans for university expansion in Britain. It is estimated that, apart from the nine colleges of advanced technology with some 9,000 full-time students, existing universities and university colleges had roughly 101,000 full-time students in October 1959 and will have by 1965–67 some 135,000; apart from any places that may then be available in the proposed new universities at York, Norwich or elsewhere. First, Lord Hailsham emphasized that, at least up to 1970, the difficulties will lie in finding places for the talent that will be available for the schools. In the light of this knowledge, the universities have discussed with the University Grants Committee how far and fast they can expand, and the possibility of further expansion from 135,000 to 170,000 places is now being explored. It is believed that this can be achieved without detriment to academic traditions and standards by expansion at the existing universities, with a contribution from new universities. Thirdly, the Government has examined separately the problem of meeting the need for scientists and technologists, and by 1970 the universities should be producing rather more than half the 20,000 required; some 10,000 would come from the colleges of technology. The probable demand for school teachers during the next fifteen years has also been studied, and it has been decided to provide a further 25,500 places in teacher-training colleges.

Lord Hailsham reiterated the Government's desire to maintain the academic independence of the universities themselves in spite of their increasing dependence on Government finance, and its firm support of the University Grants Committee as the means for preserving such autonomy. He did not exclude the possibility of an independent appraisal of the whole situation, and more especially of questions of curriculum in both schools and universities, though in any such inquiry he would like to see due account taken of the views of the Advisory Council on Scientific Policy. Especially he stressed the desirability of satisfying ourselves that the present arrangements for co-ordination between the universities and other places of higher education are adequate, and that we have an organization between the University Grants Committee and the Ministry of Education capable of dealing with questions that might arise as to the allocation of resources between the universities and the colleges of technology. Lord Hailsham promised that the Government would consider very carefully the points of view that had been put forward in the debate, and would seek the best possible means of giving effect to them.

As Lord Simon recognized, more could not be expected; but it is clear that the discussion on the purpose of a university education, its content, and where it should be given and to what proportion of the population, is only beginning. Until those questions, however, are answered, no firm decisions can be taken as to the proportion of our resources to be expended on higher education, let alone its distribution.

FUTURE OF BRITISH AGRICULTURE

Principles for British Agricultural Policy

A Study sponsored by the Nuffield Foundation. Edited by H. T. Williams. Pp. xiii+317. (London: Oxford University Press, 1960. Published for the Nuffield Foundation.) 18*s*. net.

AGRICULTURE differs so completely from other industries that none of the ordinary rules seem to apply. It is carried on by individuals and not by limited liability companies, its units are small compared with those of commercial enterprises, its risks cannot in general be estimated and covered by insurance, and its financial rewards are on a much lower level than those of most other business activities. But it plays so vital a part in the life of the nation that it has to be kept efficient in good times and bad. In 1945 the Nuffield Foundation set up a small committee to formulate the principles on which a stable agriculture could be based capable of producing in time of peace enough food to avoid heavy imports, and in time of war expanding sufficiently to save the nation from starvation. The committee included among others Sir Frank Engledow, Sir Geoffrey Crowther, the President, Vice-President and Secretary of the National Farmers' Union. The first draft of its report was ready in 1951, and preparations for the second, the present volume, began in 1956: the effect of the long delay shows itself in some unevenness in the dates of the statistics but it does not appear to have adversely affected the text.

The book opens with an account of the vicissitudes of British farming from 1840, when the abolition of import duties on corn led to unrestricted competition from the newly developing countries which finally reduced British agriculture almost to bankruptcy in the 1890's. Some recovery followed, but by 1931 the experiences of the First World War and the 1920's had shown that a different type of treatment was necessary if the industry was to survive in any efficient way. The first efforts had little success; by 1939, when the Second World War began, only about 30 per cent of the nation's food (measured in calories) was being produced at home. Vigorous government intervention stimulated greater output during the war but at enormous public expense: the maximum increase was about 50 per cent in net output, but 70 per cent in calories, and it took four years to accomplish.

After the War it was realized that the provision of food for the nation was too important a matter to be left entirely to the play of international markets, and in 1947 an Act was passed with the object of giving agriculture a stable economic basis and directly encouraging efficiency in production. The method adopted was to help farmers in carrying out improvements in methods and to assure for all listed commodities a market at guaranteed prices arrived at by negotiations between the National Farmers' Union and the Ministry of Food and Agriculture. This involves a good deal of public expenditure, amounting now to about £250 million per annum, but it is achieving results, and the present output is some 30 per cent higher than the war-time peak, 68 per cent higher than pre-war, and still rising. The Committee thinks a further rise of 60 per cent is possible; the methods proposed include an extension of ley farming, drainage, and larger use of fertilizers and lime.

The justification for so much public assistance is discussed from the social, economic and strategic points of view. The social case is not very strong: there is no evidence that home-grown food is more nutritious than imported, though in so far as it is fresher it may be more tasty. Country life is healthier than town life and the surroundings are pleasanter, but the differences are lessening as urban health improves and the beauty of the countryside is increasingly despoiled. More might have been made of the call of the land that keeps many in the country who know they could earn far more in the towns, and the fact that 80 per cent of our farmers are farmers' sons and that 40 per cent of their sons are going in for agriculture. The economic consideration is that higher food production at home protects the balance of payments; indeed the ingenious suggestion is put forward that our growing industries will require such large imports of raw materials that there may be insufficient money left to pay for large imports of food. But the strongest considerations in favour of continued government support are strategic. Agriculture should be so efficiently equipped and directed that it could in one season switch over from peace-time to war-time farming, and, for guidance to this end, that investigations should be started to discover the minimum diet under siege conditions. Storage of a year's supply of food, of tractor fuel, and of farm appliances is suggested.

The book covers much new ground, raises many points for useful discussion, and will be helpful to all concerned with agricultural administration. It will be particularly interesting to the large number of people who are beginning to wonder whither British agriculture is tending.

E. JOHN RUSSELL

IN PURSUIT OF WORLD HEALTH

World Health

By Fraser Brockington. (Pelican Book No. A425.) Pp. 405. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1958.) 5s.

TO write a book on world health which is directed to "all who are interested in the health of the world" would seem a boundless undertaking. Prof. Brockington takes a wide view of his assignment—those with a special interest in the more technical problems of the organization of health measures throughout the world might deem too wide. But if one accepts, in line with the author's argument, that a necessary ingredient of health policy is the understanding and co-operation of the people affected, that the promotion of better health depends on rousing the interest and enthusiasm of politicians, specialists and the public in general, then he has written the right kind of book. He ranges widely, he illustrates richly, he provokes and stimulates by the skilful use of example and statistics, he communicates enthusiasm.

Health is essentially a social concept and the pursuit of public health involves one, as Prof. Brockington interprets it, "not only in technology, but also in philosophical, anthropological, organizational, social and economic considerations". After a brief discussion of the meaning of health and disease and a sketch of the picture of disease throughout the world, he discusses the social framework and its relation to health and disease. In only some hundred pages he carries one through a consideration of geography, of beliefs and customs, of family life, of population, of occupation, of town life, of hospitals, of food, of industrialization. Points are made rather than theories developed—he relies on the piquant example and the vivid detail. Tuesdays and Fridays, one learns, are special days for treatment in Peru as they are magically favoured. 'Spitting forbidden' is not a universally acceptable maxim: the restriction against spitting tobacco juice on the walls had to be withdrawn before the maternity home gained favour in one African township. But should there be disappointment with the brevity of the treatment, he provides for this section a particularly lengthy and wide-ranging list of references. (The whole bibliography is indeed an excellent and most useful compilation.)

The sections on public health practice throughout the world and on international public health give a rapid survey of the organization of public health in different areas and at different times and lead up to a review of the first ten years of the World Health Organization. While recognizing the difficulty of finding any set of common principles for the practice of public health, Prof. Brockington proffers five for consideration: "the inseparability of preventive and curative medicine", "the primacy of preventive medicine", "unity of control", "co-ordination" and "local government and participation by the people". These would seem to add up to the philosophy which runs through the book and to the view of public health which Prof. Brockington seeks to propound. He looks back with approval on Chadwick, who whipped nineteenth-century England along the right road, and cites, as an example of an effective modern policy, Yugoslavia which "wiped the slate of past endeavours clean" and under the wise guidance of Prof. Stampar recognized the importance of the local health unit and based its health services on the health centre and the institute of hygiene.

In the final section, on the measurement of health, Prof. Brockington deals with health statistics and the problems of collecting and recording data. It is enlivened by shrewd comment and timely cautions; but, being both too brief to serve as an adequate introduction to the subject and too sketchy to be useful as a text-book, one wonders whether the more technical material might have been included more usefully as an appendix. It has its place in a comprehensive book on world health, but it is in a different key from the discussion of wider, more general issues, and follows awkwardly on a plea for better international understanding through the common pursuit of health. Certainly for the non-medical reader it is not as a text-book but as, in the best sense, propaganda, that this is such a very stimulating and interesting book. CHRISTINE COCKBURN

CLASSIFICATION OF THE CESTODES OF VERTEBRATES

Systema Helminthum

By Prof. Satyu Yamaguti. Vol. 2: The Cestodes of Vertebrates. Pp. vii+860. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 90 dollars; £34.

THE second volume of Satyu Yamaguti's "Systema Helminthum", which deals with the cestodes, conforms in plan with the preceding volume dealing with the digenetic trematodes. Essentially, the book is a compilation of diagnoses of 55 families, 43 sub-families and 466 genera of cestodes, arranged in five parts according to the classes of vertebrate hosts. Specific names are also listed for the genera, and there is a brief "Systematic Survey" bringing together all the taxonomic units used down to genera, which is followed by 2,427 references to the original literature, 584 illustrations grouped in 70 plates, and an index taking up rather more than 90 pages of two columns each. Some of the criticisms applied to the previous volume[1] apply also to this one. The arrangement of the diagnoses under the headings of hosts—fishes, amphibians, reptiles, birds and mammals—will be convenient to some users of the book, but others will be dismayed to find the data for genera and species dispersed for any family which has representatives in two or three classes of hosts.

An orthodox scheme of classification is adopted. Cestodes are arranged in two unequal subclasses, the Cestodaria (3 orders, 4 families, 9 sub-families and 31 genera) and the Eucestoda (10 orders, 51 families, 34 sub-families and 435 genera). The orders of non-segmented cestodes (Cestodaria) are named Amphilinidea (2 families), Gyrocotylidea (1 family) and Caryophyllidea (1 family). The orders of strobilate cestodes (Eucestoda) are named Pseudophyllidea (9 families), Aporidea (1 family), Cyclophyllidea (15 families), Diphyllidea (1 family), Lecanicephalidea (5 families), Nippotaeniidea (1 family), Proteocephalidea (1 family), Spathebothriidea (3 families), Tetraphyllidea (4 families) and Trypanorhyncha (11 families). There is also a list of 12 genera incertae sedis, 8 occurring in fishes, 2 in birds and 2 in mammals.

This inequality of the orders of cestodes in respect of families extends also to families in respect of sub-families and genera. 43 out of 55 families do not require sub-families and these contain 152 out of a total of 466 genera. 15 of the 43 families contain one genus, 9 contain two genera and 7 contain 3 genera, while the remaining 12 families contain altogether 98 genera, 4–18 per family. 4 of the 12 sub-divided families have two sub-families (14 genera), 3 have three (112 genera), 3 have four (96 genera), 1 has five (58 genera) and 1 has nine sub-families (22 genera): thus, 12 families contain all the sub-families involved in the classification of the Cestoda and a total of 302 genera. Notably, the Hymenolepididae contains 83 genera, the Dilepididae 73 genera and the Anoplocephalidae 58 genera. These families belong to the Cyclophyllidea. Next in this descending order come the Proteocephalidae and the Caryophyllaeidae with 23 genera each, and the Phyllobothriidae with 20 genera.

Cestodes are also unequally distributed in the classes of host; 37 families are represented in fishes, 4 in amphibians, 6 in reptiles, 16 in birds and 10 in mammals. However, only 42 families of cestodes are represented solely in one class of host, 33 families in fishes, 1 family in amphibians, 6 families in birds and 2 families in mammals. No family is represented in reptiles alone. Thus, 13 families of cestodes occur in two or more classes of hosts, and there are 31 overlaps between the classes, 4 involving fishes, 3 amphibians, 6 reptiles, 10 birds and 8 mammals. Families represented in two classes of host number 1 in fishes and reptiles, 1 in fishes and birds, 1 in amphibians and reptiles, and 5 in birds and mammals. Families represented in three classes of hosts number 1 in fishes, amphibians and reptiles, 1 in fishes, amphibians and birds, and 3 in reptiles, birds and mammals. In contrast with the findings for the digenetic trematodes, not one family of cestodes is represented in all classes of vertebrate hosts, or even in four out of five of them.

In his introduction, Yamaguti mentions previous work dealing with particular groups of cestodes or with cestodes of particular geographical regions. He also pays a tribute to the book "The Zoology of Tapeworms", by Wardle and McLeod (1952), the only other book dealing with cestodes on a world-wide scale. It will be useful therefore to note, so far as space permits, how the taxonomic arrangements made by Yamaguti compare with those made by Wardle and McLeod. Notably, the Caryophyllidea is restored to the Cestodaria and the Biporophyllidea is abandoned, because based on a form which is indubitably a detached proglottis of some strobilate cestode. In both schemes the Eucestoda contains 10 orders, but there are major changes which seem reasonable. Yamaguti does not uphold the Disculicipitidea, referring its type family to the Lecanicephalidea, from which the Echinobothriidae is removed to stand as the solitary family of the Diphyllidea, which did not occur in Wardle and McLeod's scheme. The Pseudophyllidea has 7 families common to both schemes, but the name Diphyllobothriidae replaces the name Dibothriocephalidae, and two new families are added, the Cephalochlamydidae (2 genera) and the Parabothriocephalidae (3 genera). The order Aporidea, with its single family the Nematoparataeniidae, is retained. 13 families of the Cyclophyllidea are common to both schemes, but Yamaguti does not uphold the Biuterinidae; instead, he places the three genera (*Biuterina*, *Deltokeras* and *Cyclorchida*) for which Meggitt established the family in the Dilepididae, the first two genera in the Paruterinae and the third genus in the Dilepidinae. *Neyraia* (Syn. *Biuterinoides*) is also placed in the Dilepididae (Paruterinae). Included also in the Cyclophyllidea is the family which I will call the Progynotaeniidae Fuhrmann, 1936, emend. Burt, 1939, formerly standing in the Acoleidae, and the new family Triplotaeniidae made for *Triplotaenia*, which Wardle and McLeod placed in the Anoplocephalidae.

In the order Lecanicephalidea Yamaguti retains the Lecanicephalidae, after abstracting *Tetragonocephalum* and making it the type genus of a new family, the Tetragonocephalidae. He also makes *Parataenia* a synonym of *Polypocephalus* and rejects the family Cephalobothriidae, in which Wardle and McLeod placed the latter genus, placing *Cephalobothrium*, *Hexacanalis*, *Tylocephalum* and *Calycobothrium* in the Lecanicephalidae, and making *Adelobothrium* the type genus of a new family, the Adelobothriidae. As already stated, the Disculicipitidae is also added to the Lecanicephalidea, and another added family is the Balanobothriidae, erected by Pintner for *Balanobothrium*, which Wardle and McLeod placed in the Tetraphyllidea! Yamaguti has retained the Nippotaeniidea (1 family) and also the Proteocephalidea, which also has only one family but, thanks largely to the work of Mola and of Woodland, 7 sub-families, to which the Prosobothriinae is now added to contain *Prosobothrium* (Syn. *Lintoniella*). Wardle and McLeod placed "*Lintoniella*" in the Proteocephalidea (Proteocephalidae) but *Prosobothrium* in the Lecanicephalidea (as a genus inquirendum)! The order Spathebothriidea is retained as founded by Wardle and McLeod, and the two large families of the order Tetraphyllidea with comparatively few changes, although *Tetracampos* is removed, regarded as a synonym of *Polyonchobothrium* and placed in the Pseudophyllidea. *Myzophorus* is also removed and placed in the Proteocephalidea. Two new families are added to the Tetraphyllidea for genera not mentioned by Wardle and McLeod, namely the Triloculariidae and the Maccallumeiollidae. Finally, Yamaguti upholds the ten families of the complex order Trypanorhyncha, which is divided into the sub-orders Cystidea (8 families) and Acystidea (3 families); included in the Cystidea is the family Hornelliellidae erected by Yamaguti in 1954.

It would be beyond the scope of this review to enter into further details. Let it suffice to say that Yamaguti's sterling attempt to correct many errors of judgment which appear in "The Zoology of Tapeworms" will be received gratefully by many parasitologists. They may not agree with his scheme in its entirety, but will have to admit that it is a step in the right direction. The illustrations are better than those of trematodes in the previous volume, although some of them are too small to be serviceable. That part of the "Systema Helminthum" which deals with the flat-worms (Platyhelminthes) is now complete. Unfortunately, it is not a text-book and therefore morphological details are diagnostic and incomplete. But the task of arranging about 3,290 species of cestodes (discounting about 560 names which include synonyms, varieties, renamed species, etc.) and 4,934 species of digenetic trematodes (discounting about 333 names of synonyms, etc.) in a taxonomic scheme has been achieved. Families in the Cestoda and the Digenea number respectively 55 and 102, sub-families 43 and 355, and genera 466 and 1,024, respectively. Both groups are predominantly parasitic in fishes and the Digenea show the greater degree of spreading into other classes of vertebrate hosts. For the assembly of this enormous amount of scientific data Yamaguti has richly earned the gratitude of an army of research workers in the field of parasitology.

BEN DAWES

THE PRESENT POSITION IN LEATHER SCIENCE

The Chemistry and Technology of Leather
Edited by Fred O'Flaherty, William T. Roddy and Robert M. Lollar. Vol. 2: Types of Tannages. (American Chemical Society Monograph Series, No. 134.) Pp. xiv+554. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 132s. net.

LEATHER science is not amenable to easy presentation in text-book or treatise form. Many of the problems of practical importance to the industry are of such complexity that only empirical results exist, which different investigators have attempted to link together by plausible hypotheses. It is not possible to decide between rival hypotheses using the available data, so that differing views have in some instances continued to exist side by side over long periods, with fluctuating popularity. In contrast, topics where scientific progress has been greatest—the composition and structure of collagen; the structure of vegetable tannin materials—can only with difficulty be related to practical problems facing the industry to-day.

This uneven development of the subject is reflected perhaps more sharply in the second than in the first of the four volumes on "The Chemistry and Technology of Leather", entitled "Types of Tannages", which F. O'Flaherty, W. T. Roddy and R. M. Lollar are editing for the American Chemical Society Monograph Series. Vegetable tanning and chrome tanning are each considered in three chapters, one concerned with the chemistry of the tanning agents, a second with the mechanism of tannage and the third with the industrial process. While T. White ably summarizes critically the extensive structural research on vegetable tannins, a comparable critical account is not achieved by T. C. Thorstensen in his chapter on the chemistry of chromium salts. The chapter by E. B. Thorstensen on the practice of chrome tanning is also inadequate, which is especially unfortunate in view of the present importance of chrome tanning processes in the industry.

The treatment of other tannages varies according to the interests of the author. A. Kuntzel, in his account of oil tanning (chamois leather), draws on literature from all over the world. In contrast, G. A. Butz, in considering combination tannages, concentrates on the production of U.S. Army 'Retan' leathers. He includes a number of detailed manufacturing processes, whereas some other authors exclude these. Each of these two chapters is valuable in itself, but they do not stand easily side by side in a single book.

The rapid development of zirconium tannage has already somewhat outdated I. C. Somerville's clearly written account. Other chapters are concerned with aldehydes, alum and iron tanning, the use of silica, polyphosphates, replacement synthetic tans, resin tannage and sulphonyl chloride.

Three general chapters are included in the volume. Y. Nayudamma gives a useful summary of shrinkage temperature measurements and their significance, while L. Seligsberger and C. W. Mann draw on their experience at the U.S. Quartermaster Research and Engineering Center, Natick, Mass., to discuss stability of tannage. This chapter is especially valuable as the subject has been neglected by other books on leather.

---

[1] Dawes, B., *Nature*, 183, 957 (1959).

R. M. Lollar's opening chapter on the criteria which define tannage, illustrates the difficulties of drawing general conclusions, and of summarizing so varied a subject.

Much of the book is of too technical a character to interest chemists other than those concerned with the production and use of leather. For leather chemists, it provides useful summaries of certain fields, but in others, requires cautious study, and in a third, smaller, group of subjects, it gives only an inadequate account. Students will not easily use it, except for reference, and even there its usefulness is limited by the need to read critically. In this respect, the second volume falls short of the first, where several chapters, while providing adequate reviews, were also excellently adapted to student use.

A. G. WARD

THE NEWER METALS

Tantalum and Niobium

By Dr. G. L. Miller. (Metallurgy of the Rarer Metals, No. 6.) Pp. xxii+767. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1959.) 120*s*.; 21 dollars.

Analytical Chemistry of Titanium Metals and Compounds

By Maurice Codell. (Chemical Analysis: a Series of Monographs on Analytical Chemistry and Its Applications, Vol. 9.) Pp. xiii+378. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 90*s*.

The Chemical Behavior of Zirconium

By Warren B. Blumenthal. Pp. vi+398. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1959.) 82*s*. 6*d*.

COMPARATIVELY recent improvements in the techniques of extraction metallurgy have given, in effect, new metals for old. The higher degrees of purity now attainable, and in particular the much greater control over oxygen, nitrogen and hydrogen contents, have with several metals caused brittleness to be replaced by an attractive ductility. This, and the constant search for metals capable of withstanding ever more stringent conditions of service, accounts for the considerable amount of research and development work now in progress on metals such as niobium, tantalum, titanium, and zirconium, with which the three books under review are concerned.

In his book "Tantalum and Niobium", Dr. G. L. Miller has followed the general pattern of his earlier volume, "Zirconium", in the same series. Most of the available data on niobium and tantalum are presented in a systematic manner and generally in considerable detail. About a third of the book is devoted to the extraction and consolidation of the metals, another fifth to the known binary equilibrium diagrams, and a seventh to behaviour of the metals under corrosive conditions. The role of niobium and tantalum in steels and in heat-resisting alloys is dealt with less fully, and reference is made to a monograph on the subject.

Many line diagrams and half-tone plates are used to illustrate the text and apart from a few printing errors the book is well produced.

During the past five years there has been a considerable increase in the effort devoted to the refractory metals and their alloys, and it seems likely that this book has been produced just before the results of many of the newer investigations are published; a second edition may be required at a relatively early date. In the meantime, the volume will be a useful reference book for those concerned with the production of niobium and tantalum, and with research into their properties.

Realization of the importance of minor impurities, and the development of titanium from a scientific oddity to a metal of technological importance has brought with it many analytical problems. In his book on "Analytical Chemistry of Titanium Metals and Compounds" Maurice Codell has provided a comprehensive account of modern methods. About 100 pages are devoted to the chemistry of titanium and general analytical procedures, including spectrographic, vacuum fusion, polarographic and spectrophometric techniques, 200 pages to the analysis of titanium and its alloys, and 70 pages to the analysis of titanium-bearing pigments, ores and slags.

Experimental detail is clearly presented, and the lay-out is such that the book may conveniently be used as a laboratory handbook. Within this volume any competent analyst should find the information and guidance that will enable him to deal with any analytical problem relating to titanium which he is likely to encounter. It is unfortunate that in a book of this kind there should be no details of reproducibility of the analytical results for titanium and titanium alloys. In this respect the author is inconsistent, since he gives details of accuracy of some spectrographic and vacuum-fusion methods. It is to be hoped that in any future edition he will provide this kind of information more generally throughout the book, for it would add greatly to its value and help readers to select the analytical technique most suitable to their purpose.

In his preface to "The Chemical Behaviour of Zirconium", Warren B. Blumenthal writes that it was his intention to provide students and research workers with a broad and detailed account of the chemistry of zirconium as an element and as a component of compounds, interstitial solutions and alloys. The space devoted to alloys is so small that the author can scarcely claim to have dealt with this branch of his subject. It is therefore in regard to his other objectives that the book should be judged.

The text is supported by numerous references, and the reader should be able to find the available information on the reactions of zirconium compounds. One difficulty in presenting knowledge on zirconium compounds arises from the lack of conclusive data on the structures of ions and compounds of zirconium. This leads to the presentation of a large number of structural models without the sound experimental backing usually found in other fields of inorganic chemistry. It also enables the author to point out several fruitful fields of study for chemists interested in the structure of inorganic compounds.

The author's claim that " . . . the basic rules are presented that govern the properties of zirconium and its compounds" is scarcely justified. The immense amount of information presented is largely in the form of detailed accounts of the reactions of zirconium compounds without emphasis on the underlying electronic principles. It may be that at this stage a satisfactory and systematic treatment is not possible because so much more experimental work is required before the reactions discussed by the author can be properly understood and correlated. He would probably have been wise to make less ambitious claims for his book, and to put it forward as a record of what is known about zirconium compounds, recognizing the limitations that are imposed by writing at this relatively early stage in the development of the subject.

A. G. QUARRELL

EVOLUTIONARY THEORY AFTER MENDEL

Genetics and Twentieth Century Darwinism

(Cold Spring Harbor Symposia on Quantitative Biology, Vol. 24.) Pp. xv+321. (Cold Spring Harbor, New York: Long Island Biological Association, 1959.) 8 dollars.

BETWEEN an introduction by E. Mayr, surveying the contemporary aspects of evolution, selection and speciation and a concluding synthesis by G. L. Stebbins, which is partly based on the twenty-two contributions by the participants in the symposium, this volume contains a good deal of factual information from many fields. While the general and qualitative conclusions of the specialists are on the whole remarkably uniform and furthermore similar to concepts which Darwin himself held a century ago, one is struck by the vastly greater extent and certainty of our knowledge and also by the superior techniques and quantitative methods which are employed in gaining this knowledge.

The only fundamental difference between our approach and that of Darwin stems from our recognition of particulate and chromosomal inheritance as the basis of much of hereditary variability upon which selection and isolation act; and thus mutation and gene recombination—processes of which Darwin was of necessity ignorant—play very prominent parts in our ideas of evolution. Genes as raw materials of evolution are considered by Dobzhansky, Stubbe and Buzzati-Traverso, while race formation by selection is described by Morley and by Schwanitz in plants, by Mourant (blood groups), Barnicot (climatic influences) and Coon (other ecological factors) in man and by Lamotte in snails. Genetical conditions conducive or refractory to race formation are described by Carson. The interplay between ecology and genetics in the evolution of mimicry is expounded by Sheppard; the differentiation–hybridization cycle and polyploidy in *Achillea* by Ehrendorfer.

Speciation and isolation are described by Kitzmiller and Laven in mosquitoes and by Baker concerning flowering plants. Wallace analyses the influence of genetical systems on geographical distribution.

In addition to those contributions, which deal with evolutionary processes still at work, there are four papers concerning the fossil record and evolutionary rates in early vascular plants (Andrews), mammals (Kurten), fossil (Heberer) and contemporary (Hunt) man. A final rather heterogeneous group of papers, headed "Trends of Evolution", deals with the nature and origin of supraspecific taxa (Simpson), the chromosome evolution in the Australian flora and the progress in the brain and sense organs of animals (Rensch).

As usual in the Cold Spring Harbor series, the individual papers are followed by selections from the discussions in which, in addition to the contributors, a wider circle of listeners participated.

Like its predecessor on the "Origin and Evolution of Man" (1950) the present symposium included geneticists, anthropologists and palæontologists, to which, however, ecologists were added. This fourfold attack resulted in a broader grasp of the subject of evolution: in revealing the existence of considerable gaps and blurs between the descriptions it also shows where further work is needed.

The volume is well produced, illustrated and documented, and I have noticed only one editorial mistake: a completely wrong title in the contents of the paper on p. 115.

H. KALMUS

THE EXPLODING WIRE PHENOMENON

Exploding Wires

Based on Conference on the Exploding Wire Phenomenon, April, 1959, conducted by Geophysics Research Directorate, Air Force Cambridge Research Center, with the co-operation of Lowell Technological Institute Research Foundation. Edited by William G. Chace and Howard K. Moore. Pp. 373. (New York: Plenum Press, Inc.; London: Chapman and Hall, Ltd., 1959.) 76s. net.

CURRENT interest in thermonuclear projects, in high-speed photography, and in phenomena associated with shock waves has provided a powerful stimulus to research on exploding wire phenomena. It is a disappointment to find that the first book on this subject, described by the publishers as a significant monograph, is only a collection of papers presented at a conference, with no index, no record of the discussions, and the minimum of introduction. Apart from the stiff binding and the high quality of the illustrations, the arrangement of the material which has been adopted, putting the diagrams at the end of each paper, and the photographic reproduction of the text, cause this volume to resemble the preprint of a conference rather than an authoritative work.

Some of the papers presented are excellent; but the general emphasis is on experimental methods rather than on results. Roughly half the twenty-five papers presented deal with the use of techniques such as voltage and current oscillography, high-speed photography and radiometry in studying the explosion of wires by condensers storing energies between one and one million joules. Of particular interest are papers dealing with the 'dwell time' between the initial current pulse and the build-up of the main discharge, and Scherrer's elegant work with a water-dielectric condenser. The remainder of the volume is evenly divided between theory and application. In the former category there are three useful papers on cylindrical shock waves; the applications include flash sources for photochemistry, the bonding of nonconductors, plasma acceleration, and as fuses to protect condenser banks.

While this volume will be of value to workers in the field, it is neither sufficiently correlated nor comprehensive enough to be a good, balanced account of the subject. It would have been greatly improved by the inclusion of a long introduction describing the previous work in the field, particularly that of Anderson and Nagaoka and recent Russian contributions. Some unnecessary illustrations, such as the three successive pages of pictures of somewhat pedestrian electronics, could well have been omitted. It is not easy to see why these papers have been collected in a single, highly priced volume, when they could have been published in a scientific journal.

B. A. Thrush

A STUDY OF NON-LINEAR PROBLEMS

Nonlinear Problems in Random Theory

By Prof. Norbert Wiener. (Technology Press Research Monographs.) Pp. ix+131. (Cambridge, Mass.: Technology Press of the Massachusetts Institute of Technology; New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 36s. net.

This is a collection of lectures reproduced by participants of a course given by Prof. N. Wiener at the Massachusetts Institute of Technology. The lectures were recorded by means of a tape-recorder and thus the volume includes the author's spoken words; photographs of formulæ actually written down on the blackboard are reproduced. The resulting informal style fits very well with the contents; there is a wealth of ideas and suggestions, both on theory and applications, but the mathematical reasoning is often somewhat incomplete.

The book deals with non-linear functionals of the sample functions $x(t)$ of a stochastic process, which for the most part is the Brownian motion (Wiener) process. Starting with a description of that process, the author then studies certain homogeneous 'polynomial' functionals $F_n(x) = \int \ldots \int K_n(t_1, \ldots, t_n) dx(t_1) \ldots dx(t_n)$ and their expectations. With the help of an orthogonalization process, which makes such homogeneous functionals of different degree orthogonal to each other, a theory of expansions of arbitrary functionals in terms of homogeneous ones is developed. This is the main tool for the evaluation of the autocorrelation function and the spectrum of special functionals suggested by some applications. Frequency modulation problems, for example, lead to functionals of the type $\exp(i\int \ldots \int f(t + \tau_1, \ldots, t + \tau_n) dx(\tau_1) \ldots dx(\tau_n))$. Comparing the computed spectrum with the spectrum observed in electroencephalography, the author offers as a model for the generation of brain-waves' certain non-linear oscillators excited by a random input. The same methods are used in the discussion of the analysis and synthesis of non-linear networks, where the author first gives reasons why it suffices, in a sense, to consider a Brownian (shot-effect) input. Here, as well as in the preceding lecture, experimental details are briefly discussed.

The author outlines in a rather sketchy way connexions between the Brownian motion process on one hand, and quantum mechanics and statistical mechanics on the other hand. He remarks that the interpretation of the square of the absolute values of the coefficients in the eigenfunction expansion of a wave-function as probabilities has never been made clear in quantum theory, and he suggests such an explanation based on a formal analogy. In his new approach to statistical mechanics, the number of particles in a region of the phase-space is considered as an additive random functional.

In two lectures on coding and decoding, discrete processes are considered instead of continuous ones, and analogies to the earlier orthogonal expansions are treated. Coding consists of representing a given time series by a certain sequence of independent and equally distributed random variables. Decoding consists of the reverse operation, where each member of the sequence is determined by the 'past' of a given time series and conversely.

As stated in the foreword, the series of monographs, of which this is the first volume, is designed to make accessible research studies which are larger in scope than a paper in a specialized journal, but less ambitious than a finished book. It certainly has made a good start.

K. Krickeberg

WEATHER RECORDS OF THE WORLD

World Weather Records, 1941–50

(U.S. Department of Commerce: Weather Bureau.) Pp. ix+1361. (Washington, D.C.: Government Printing Office, 1959.) 4.75 dollars.

A fourth volume has been added to the series of "World Weather Records," this time over the imprimatur of the United States Weather Bureau and produced in collaboration with the staff of Blue Hill Meteorological Observatory, Harvard.

The three previous volumes, due to H. H. and Miss F. L. Clayton, were published in the *Miscellaneous Collections of the Smithsonian Institution* in 1927, 1934 and 1947. These year-by-year records of monthly values of temperature, rainfall and atmospheric pressure are an essential reference for all whose work is concerned with climatic behaviour and trends. The new volume, which principally covers the decade 1941–50, has been eagerly awaited. The data, contributed by the meteorological services of more than eighty nations, refer to some seven hundred points all over the world. In this volume ocean weather ship stations in the North Atlantic and North Pacific make their appearance for the first time, as do the remote islands of Marion, Heard and Macquarie in the Southern Ocean and the stations in the Falkland Islands Dependencies in Antarctica.

Another welcome feature is a great increase in the number of places for which long records have now been made available; notable additions in the present volume are Budapest (from 1780), Toronto and Hobart (both 1841–), St. Helena (pressures 1892–), Jan Mayen Island (1921–), as well as many tropical islands, extra places in the United States, Japan and elsewhere and data for Russian stations since the Revolution. There are also long tabulations of lake-levels, river-levels, dates of freezing and thawing, etc.

This is a fat volume, but the price has been kept encouragingly modest. It is to be hoped that the series will continue in this style, that further old records which have been, or are being, homogenized will be included in future volumes, and that some day the wide gap in the world meteorological network in the South Pacific will be filled by a weather ship.

H. H. Lamb

The Second BBC Naturalist

Edited by Desmond Hawkins. Pp. 124. (London: Adprint, Ltd., 1960.) 10*s.* 6*d.* net.

"THE Second BBC Naturalist" sets out to do as "The BBC Naturalist" did—provide in permanent form a record of the British Broadcasting Corporation's wild-life programmes; but whereas "The BBC Naturalist" contained articles on wild-life in the United Kingdom, the second book has ventured farther afield—to such places as the Galapagos Islands, Africa, the Indian Ocean, etc.

"The Second BBC Naturalist" is a completely independent book. The title is misleading in that it suggests it to be the second volume of a series. However, it is not necessary to possess, or even to have seen, "The BBC Naturalist" in order to enjoy this second book.

It contains twenty-two articles on wild-life, following its introduction, specially written by such well-known naturalists as David Attenborough, James Fisher, Hans Hass, Maxwell Knight, Peter Scott and others equally as famous. Each article is very pleasantly written, and from the wide variety of subjects there should be something to interest everyone.

Each page contains at least one interesting picture or diagram, some in black-and-white, some in colour, many most unusual. There are some particularly fascinating charts showing the speed and height of bird flight, and man's visual field compared with that of the owl, the woodcock and the fish.

It is not necessary to have watched or listened to the B.B.C. programmes to enjoy this book. It is complete in itself and should find its place on the bookshelves of naturalists and laymen, children and adults.

B. J. G. Maitland

National Academy of Sciences—National Research Council

Publication No. 713: Digest of Literature on Dielectrics, Vol. 22, 1958. Pp. xiii + 293. (Washington, D.C.: National Academy of Sciences—National Research Council, 1959.) 5 dollars.

PUBLICATION 713 of the National Academy of Sciences—National Research Council is Volume 22 (1958) of the "Digest of Literature on Dielectrics" prepared by the Committee on Digest of Literature of the Conference on Electrical Insulation, Division of Engineering and Industrial Research, and edited by R. A. Sodermann and L. F. Frisco. The contents consist of four parts—measurements, general and theoretical, insulation, and applications—and an introduction by L. F. Frisco entitled "Trends in Research and Development in 1958". There are twelve chapters, each written by a different set of authors, and the attempt is made in each chapter to assess the overall progress in a particular field and to stress the more important achievements. Part 1 consists of two chapters, the first dealing with dielectric measurements below 100 Mc./s., measurements above 100 Mc./s., cable measurements, and books and reviews, and the second containing tables of dielectric constants, dipole moments and dielectric relaxation times. The subjects covered by the five chapters of Part 2 include conduction phenomena in solid dielectrics, ferro-electric and piezo-electric materials and ferromagnetic materials. During 1958, cadmium sulphide continued to be the most important material for studies of photoconduction. Several new ferro-electrics, mostly water-soluble organic crystals and oxide ferro-electrics, were discovered, and in the study of ferro-electricity and piezo-electricity in ceramics, the shift in emphasis was from barium titanate towards the high Curie-point materials related to lead titanate and lead niobate. Switching mechanisms in ferro-electric single crystals received considerable attention. The bibliographies on ferro-electric and piezo-electric materials, and on ferromagnetic materials, contain 339 and 500 items respectively, and illustrate the great activity in these subjects and the wide coverage of the digest articles on these topics.

Insulation properties discussed in Part 3 include those of rubbers and plastics, insulating films, insulating liquids, and ceramics. Developments in transformer insulation continued to be directed toward higher temperatures and moulded or cast insulating structures. Part 4 consists of one chapter in which a comprehensive review is given of progress in the development of capacitors, wires, cables, wave-guides and radomes. Military interest in components and systems to operate at high temperatures and in the presence of high-intensity nuclear radiation accounts for a considerable amount of the experimental work reported, but commercial interest in units to operate under more moderate conditions but with high uniformity of performance and reliability, was still very pronounced during 1958.

S. Weintroub

Crystal Chemistry of Simple Compounds of Uranium, Thorium, Plutonium, Neptunium

By E. S. Makarov. Translated from the Russian by E. B. Uvarov. Pp. iii + 145. (New York: Consultants Bureau Inc.; London: Chapman and Hall, Ltd., 1959.) 42*s.* net.

THE major part of this book consists of an account of the crystal structures of the polymorphic forms of thorium, uranium, neptunium and plutonium and of their binary alloys and compounds. Complete structural data are given where possible; unit cells and space groups, co-ordination numbers and interatomic distances are listed, together with many diagrams of the various structures, based on data published up to mid-1957. Intermetallic compounds are discussed far more exhaustively than compounds formed with non-metals; the treatment is brief and factual, with little critical discussion.

In addition, there are three chapters on general aspects of the subject. An introductory chapter deals with the relation between bond types and crystal structure; this chapter is so condensed that it is somewhat confusing and it would scarcely be suitable for a student learning the subject. There is a chapter on the atomic radii of the actinides which is simply a summary of an article by W. H. Zachariasen. The crystal chemistry is discussed generally in the last chapter as it bears on the position of these elements in the Periodic Table; this contains a list of compounds of Groups IV*a*, V*a* and VI*a*, and of the lanthanides of the same structural types as the analogous actinide compounds, which are discussed in terms of the well-known dual nature of the earlier members of the actinide series.

This book will be useful to research workers and to teachers of structural chemistry mainly as a guide

to the literature; it provides no substitute for a study of the original papers. The translation is adequate, but there are several typographical errors. There is no index; the compounds are grouped according to the position of the second element in the Periodic Table.
L. E. J. Roberts

Prehistoric Man in Europe

By Frank C. Hibben. Pp. xv+317+24 plates. (London: Constable and Co., Ltd.; Norman, Oklahoma: University of Oklahoma Press, 1959.) 50*s*. net.

NOWADAYS an author should think twice before attempting to describe the whole of prehistoric times in the compass of one volume, even when only a restricted area such as that of Europe is under consideration.

Although the first 102 pages of this book are devoted to the earliest times, one suspects that Mr. Hibben, a resident in America, has interests which lie rather in the post-mesolithic phases of the subject. It might have been wise to have asked some member of the American School of Prehistoric Research at Harvard, which has done so much to further palæolithic studies in Europe, to examine the earlier chapters, as well as the not too well selected bibliography, where the name of Movius is not mentioned and that of Hencken begins with a K, and where in some cases early works only are cited and their authors' later publications on the subject omitted. Mr. Hibben seems somewhat happier in the later part of the book where Bronze Age, Iron Age and Classical cultures are considered.

The illustrations have been kept down to a minimum, but the reason, of course, may well be one of finance; they include a charming photograph of a reconstruction of the Roman Forum in its glory. Of course, there is a lot of information given and the reading is easy, but the book cannot be said, especially as regards the earlier periods, to be a definitive work on the subject.
Miles Burkitt

The Literature of the Social Sciences

An Introductory Survey and Guide. By Peter R. Lewis. Pp. xx+222. (London: Library Association, 1960.) 28*s*.; 4.20 dollars.

ALTHOUGH this book does not claim to be more than an introductory survey and guide, it covers a wider field than its title might suggest. It is apparently intended for the administrator, the business man, the research worker and the general reader, and it also deals to some extent with library administration. On the strictly sociological side it is somewhat slender in view of its title but here and throughout it is sufficiently strong on the periodical literature to render it probable that the conscientious reader will be guided to what he requires. One exception may be noted on the historical side: the *Annals of Science* fills a place where the author recognizes that he has provided very slender cover. For the rest, it is difficult to criticize an admittedly selective compilation when the basis of selection is unknown, but it might be observed of the chapter on political science and public administration that it is surprising to find no reference to Sir Ernest Barker's works and that the section on the Civil Service omits too many important books. The style and production of the book are admirable and there is a good index.

Introduction to Symbolic Logic and its Applications

By Rudolf Carnap. Translated by William H. Meyer and John Wilkinson. Pp. xiv+241. (New York: Dover Publications, Inc.; London: Constable and Co., Ltd., 1958.) 1·85 dollars; 15*s*.

IT is a welcome sign of the times to have Carnap's book (perhaps the most comprehensive "Introduction to Symbolic Logic" in existence) made available in English at a modest price. This is something of immediate value to the student of symbolic logic, and will carry him right up to the frontier of advanced work. He will not find it easy going, but all the essentials are there. Part 1 deals with the system, and Part 2 with the application.

Broadly speaking, the subject as we know it has existed for scarcely more than a century (though its roots lie further back into history), and the reader will soon realize that the Aristotelean logic of the traditional kind only amounts to a trivial fraction of the whole domain. Strictly, to construct a system of symbolic logic is not to build up a language so much as a skeleton of a language. The bones are clothed by the interpretation of certain signs: it is this process which leads to applied logic, because of the great variety of these interpretations.

One of the objects of this discipline is to eliminate pre-suppositions—especially in geometry—which have crept in unawares, for example, in the long history of Euclid's parallel postulate. Another aim is the establishment of a powerful symbolism such as algebra enjoys. Numerous problems and examples are included.

An application of deep interest is Woodger's attempt to axiomize biology, possibly a major factor for the future development of biophysics.
F. I. G. Rawlins

The Use of Stereographic Projection in Structural Geology

By F. C. Phillips. Second edition. Pp. vii+86. (London: Edward Arnold (Publishers), Ltd., 1960.) 16*s*. net.

THE first edition of this book is well known to structural geologists and a new edition is to be welcomed. This concise and commendably inexpensive book provides geologists with a first-rate introduction to the subject. Dr. Phillips writes so clearly that what in some hands might be a formidable topic is reduced to enviably simple terms. The reader is first introduced to the principle of stereographic projection and is then shown its value as a geological tool. Dr. Phillips has not made any major changes in the text and the new edition differs only in detail from its predecessor. Recent advances are, however, noted and the bibliography has been enlarged.

The proof of the pudding is in the eating, and Dr. Phillips can quite justifiably state, as he does in his prefatory note to the second edition, that "The call for this edition proves that a concise account of these methods is an acceptable and useful addition to geological literature".

It is largely because of the work of Dr. Phillips that such methods are now more widely used by geologists than when this book first appeared. When a third edition is called for, a short review of some of the more interesting of recent applications of stereographic methods to tectonic syntheses might, in my opinion, be useful.
J. Sutton

MICHAEL FARADAY AND THE EVOLUTION OF THE CONCEPT OF THE ELECTRIC AND MAGNETIC FIELD*

By PROF. L. PEARCE WILLIAMS
Department of History, Cornell University, Ithaca, New York

ALL forms of human activity have their myths which serve for a time to codify and crystallize ideas and methods into a tradition. When the historical conditions out of which these myths have sprung are altered, however, the myths themselves often linger on to challenge and bedevil future generations.

The myth of Michael Faraday, the strict experimentalist, is one of these. Its origins are, I think, fairly clear. The first half of the nineteenth century witnessed the creation of a whole host of new sciences. Chemistry, biology, electrochemistry, physiology, to mention only a few, were then erected into truly scientific disciplines. The birth of a new science is almost invariably accompanied by enormous enthusiasm. The new facts, or the new way of looking at old facts, which mark the beginning of a new departure stimulate waves of speculation in which the attempt is made to build overnight what generally takes decades to achieve. Many of these enthusiastic guesses may later be shown to be of real value although at the time they were ignored. A young science, however, has few criteria for the testing of general speculations. Only when the science has matured is there a 'sense of the possible' which permits the critical examination of hypotheses and the separation of the whole grain from the straw. In the nascent stage, therefore, heavy emphasis must be put upon the foundations; no matter how beautiful or seductive a suggested superstructure may be, there will be enormous pressure to ignore it (and to discourage the activities which give rise to these speculations) and get on with the more immediate task. Faraday was midwife to a number of such new sciences. His work on electrochemistry, electrostatic induction, electromagnetism, light, and the magnetic condition of matter mark the beginning of a new tradition in these studies. Faraday's more conservative and less-gifted contemporaries recognized his genius by depicting him as a foundation builder of unsurpassed skill. Here is the familiar figure of Faraday the empiricist gently coaxing from Nature the new facts upon which others could erect general theories. Here I wish to modify this picture by adding a new dimension. Faraday, the layer of empirical foundations for new sciences, is known to all; I wish to introduce Michael Faraday as a master architect, to whom new facts were the raw materials for the construction of a theoretical edifice of startling beauty and symmetry.

The concept of the field to-day underlies the whole picture of modern physical reality. The phrase 'physical reality' should be stressed, for field theory, bristling with complicated mathematical equations and dealing with the strange properties of space, seems far removed from ordinary ideas of everyday experience. It also seems out of place when the subject is Michael Faraday, self-confessed mathematical illiterate, and the epitome of self-taught common sense. Yet my purpose here is to indicate precisely how the idea of the field slowly emerged from Faraday's considerations of the nature of matter and its forces. As I shall attempt to show, the specific discoveries which earned Faraday immortality in the history of science—the laws of electrochemistry, the discovery of specific inductive capacity, the rotation of the plane of polarized light by a magnetic field, diamagnetism—were the logical deductions from an overall theory which guided him in his investigations and culminated in the concept of the field.

In a charming passage of a letter to his friend Benjamin Abbott, dated August 1, 1812, he recounts the following anecdote: "Six or seven years ago whilst standing at the door of a gentleman's house and waiting until my knock should be answered, I thrust my head through some iron railing that separated the doorway from another and then I began to consider on which side of the rail I was. In my mind I affirmed that the side possessing my head was my station for there was my perception, my senses. I had just sufficient time to ascertain this when the door opened and my nose began bleeding by the contact of the rail and such matter as that quickly put flight to my rude metaphysics. Simple as is this instance it did more in illustrating this case to me than all the arguments I have heard since on the subject, or all the affirmations that have been made".

This "rude metaphysics" was later refined in discussions with his friends from the City Philosophical Society, and Faraday seems quite early to have accepted the main points of the view first put forward by Bishop Berkeley. In essence, this philosophy rejected the idea of a separate 'matter' of which the perceptible qualities of bodies were properties. Where Locke had stated that there was something (matter) which remained when all perceptible qualities had been stripped away, Bishop Berkeley insisted that reality consisted solely of these perceptions and that 'matter' was a mere figment of the imagination.

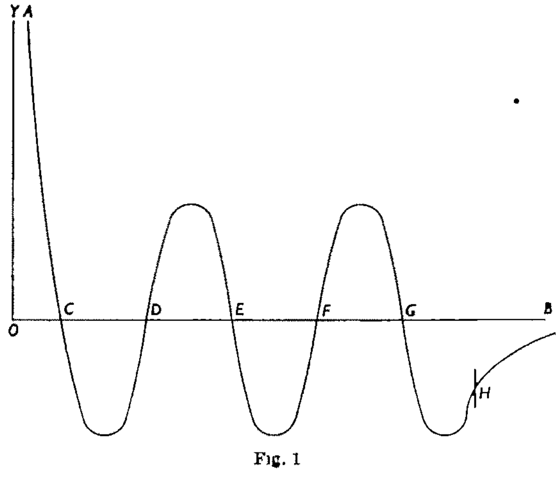


Fig. 1

---

*Evening discourse at the Royal Institution delivered on May 4.

This philosophical point of view enabled Faraday to accept an atomic doctrine which also banished matter from the world. In the eighteenth century a Jesuit, Father R. Boscovich, had, for purely physical reasons, rejected the 'billiard ball' atoms of Newtonian science and substituted point centres of force. Fig. 1 represents such an atom with its centre at O. Approaching O along OB, one follows the hyperbola of Newton's inverse square law to H, where the force becomes more steeply attractive. H marks the boundary between the macroscopic and atomic realms. From H to O, there are shells of attractive (below OB) and repulsive (above OB) force. From C, the force becomes increasingly repulsive so that no two point centres can ever coincide. Faraday himself pointed out in 1844 that this idea of an atom makes a minimum number of assumptions. We experience directly the attractive and repulsive forces of matter; we never experience 'matter' without these forces. Thus, although seemingly an extremely abstract concept, this theory of matter actually corresponds most directly with our experience of the world.

Point atoms preserve all the properties of billiard balls—impenetrability, obedience to universal attraction, extension—but have advantages that billiard balls do not. In chemistry, particularly, they could be put to excellent use. The meshing of forces to yield specific and stable compounds provided a theoretical framework for the understanding of the law of definite proportions which the clumping of billiard balls could not rival. Similarly, the theory explained changes of state, the regularity and stability of crystalline forms, and the origin of chemical qualities as the result of molecular form with considerable elegance. Faraday, it will be remembered, was trained as a chemist by Sir Humphry Davy, and Davy was a disciple of Boscovich. With Berkeley and Boscovich providing the philosophical orientation, in 1831 Faraday began those "Experimental Researches in Electricity" which by 1855 were to lead him to the concept of the field.

In 1831, Faraday discovered the induction of an electric current by a moving magnet, and almost immediately after, by another current. It was this latter phenomenon which intrigued him. Why should a current be produced in the secondary when the current ceased in the primary? The particles (and by particles Faraday meant compounds of point atoms) of the secondary, he reasoned, must be in a peculiar state induced by the current in the primary. When this current ceased, the particles returned to normal, producing a deflexion of the galvanometer needle. Such a state must be one of tension among the particles, the release of which created the observed current. The state of tension Faraday called the 'electrotonic state', and it was to take a central role in his further investigations.

The idea that a state of tension might be induced by electrical forces among the constituent molecules of bodies provided a valuable insight into the mechanism of electrochemical decomposition. How and why the chemical components of bodies in solution through which an electric current could pass should be separately obtained at the electrodes without any evidence of their passage through the solution had long puzzled people. The electrotonic state offered a possible answer. As the electrical force was applied at the electrodes, the compound molecules could be strained in tension between them until a certain critical point was reached. At that point the electro-negative and electro-positive particles of the compound would break asunder and move in opposite directions, where they would immediately meet with an oppositely charged particle from the neighbouring molecule travelling in the other direction. At any given moment the constituent particles would be passing in opposite directions but tied together constantly in chemical combination, to be released only at the electrodes.

This scheme, supported by a number of clever experiments, accounted satisfactorily for the observed phenomena. But it also had revolutionary implications. Most important of these was the denial of action at a distance which had previously been invoked to explain ionic migration. To Faraday, force was transmitted by contiguous particles and not across space. To prove this, he argued that the uniform deposition of chemical entities upon the electrodes indicated that the transmission of force was in curved lines. This could not be reconciled with action at a distance, which ought to take place along straight lines. He also hinted at a new definition of an electric current (to which, however, he refused to commit himself here). The rise and fall of the electrotonic state and the consequent transmission of force in opposite directions pleased him more than the hypothesis of one or two electric fluids, which no one had yet succeeded in detecting separate from ordinary ponderable matter. The major weakness in Faraday's interpretation was the purely hypothetical existence of the electrotonic state itself. He had deduced it from phenomena but had been unable to observe it. Its rise and collapse he felt was so rapid that the state was too evanescent to detect. This evanescence was due solely to the mobility of the molecules in solution. If the same particles could be immobilized, surely the electrotonic state could still be induced and then detected!

A piece of borate of lead which, when fluid, acted as an electrolyte, was used in the attempt to observe the existence of the electrotonic condition. When it was placed in an electrostatic field and polarized light passed through it, nothing happened. The conclusion that Faraday, "the strict empiricist", drew from this was striking. He did not conclude that the electrotonic state did not exist but that: "notwithstanding the new and extraordinary state which must be assumed by an electrolyte, either during decomposition . . . or in the state of tension which is assumed as preceding decomposition, and which might be supposed to be retained in the solid form of the electrolyte, still it has no power of affecting a polarized ray of light".

In spite of the experimental evidence, therefore, Faraday remained convinced that the electrotonic state did exist in solids. To relinquish this concept would plunge him back into the old confusion of 'electric fluids' and action at a distance. With it (even though it remained hidden from sight) he could move ahead into other areas. In particular, it provided an important clue to the mechanism of electrostatic induction. In this case, as with electrolysis, the application of electric force set up a state of tension in which the contiguous particles were deformed and polarized. Discharge through a dielectric occurred when the tension grew too great for the particles to withstand, and, with great release of energy, the electrotonic state collapsed. Almost incidentally, Faraday showed that the breaking point ought to depend on the nature of the dielectric, that is, a specific inductive capacity should exist.

Again, the passage of electric force could be accounted for without the supposition of specific fluids acting mysteriously at a distance. Experiment here could decide between the two rivals. The fundamental problem to be resolved was: Did electrostatic induction occur along straight or curved lines? With infinite patience Faraday mapped the lines of inductive force and announced triumphantly that they were curves. They must be, consequently, the result of the strain of contiguous particles.

In this masterful series of researches, Faraday had brought together a number of seemingly separate phenomena under the single law of induction. The three separate cases of metallic conduction, electrolytic conduction and disruptive discharge he had shown were reducible to the degree of strain of which the constituent particles were susceptible. Metals could take very little, so the rise and collapse of the electrotonic state was almost instantaneous; electrolytic conduction depended on the strength of chemical affinity binding the particles together, and the collapse of the electrotonic state was accompanied by ionic transfer; disruptive discharge took place when the highly strained particles, locked in their positions by the forces of solid cohesion, gave way with a snap. In each case, induction preceded conduction and conduction was viewed as the breakdown of the induced electrotonic state.

By the end of 1838, after seven years of sustained experimental and theoretical effort and with the last brick in place in his theory of electrical action, Faraday's health finally gave way. He was forced to rest, and only slowly did he recover his powers of concentration and the strength to begin a new series of researches.

The new starting point was a fairly obvious one. He had shown, at least to his own satisfaction, that electrical effects were the results of the action of contiguous particles and that electrical forces were transmitted in curved lines by means of these particles. The next step was to find out if magnetic effects, so clearly involving curved lines of force, were not also dependent upon the deformation and tension of contiguous particles. Faraday's reasoning here is exactly the same as that used in the case of electrostatic induction. Since the magnetic influence could pass through non-magnetic substances (as electrostatic forces could through non-conductors), should there not be a state of magnetic strain induced upon the particles by which the force was transmitted? To detect this state of strain he had recourse once again to a ray of plane-polarized light passed through a piece of heavy lead glass in a strong magnetic field. This time the plane of the light was rotated. Fourteen years after he had first suspected its existence, something akin to the electrotonic state had finally been detected.

Since bodies which permitted the electric force to work through them but were otherwise unaffected by electricity had been named 'dielectrics', Faraday christened substances through which the magnetic forces could work without being themselves magnetic, 'diamagnetics'. Surely, however, these bodies in which a magnetically induced strain existed could not be totally indifferent to the magnetic forces. Coulomb had claimed in the 1780's that all bodies were magnetic but, except for iron and nickel, so faintly so that any effect was almost impossible to discover. By 1845, when Faraday discovered diamagnetism, most investigators had despaired of finding the effect suggested by Coulomb. With the evidence of the magnetic susceptibility of diamagnetics before him, Faraday returned to the task, using the most intense magnetic field he could find. According to Coulomb, diamagnetics should line up along the lines of magnetic force and exhibit the same, although much weaker, polarity as iron. To Faraday's surprise, diamagnetics tried to move away from the intense parts of the magnetic field and aligned themselves across the lines of force.

Faraday had not anticipated this result (the only effect so far which had not been a logical consequence of his theoretical views) but it did not at first perturb him. As he experimented with this new effect, observed the action of many different materials in the magnetic field and attempted to account for his observations within the old framework of the strain of contiguous particles, he met with serious obstacles which were ultimately to prove insurmountable. I cannot, in the limited space available here, detail his twistings and turnings as he attempted to save the hypothesis which had served him so well. Instead, I must over-simplify the tale a bit but not, I think, with any risk of distortion of the main lines of the evolution of his thought. Let us look at the next seven years (1845–52) in the light of three questions the answers to which ought to be found, according to Faraday, in terms of the strain of the constituent molecules: (1) How can the transverse alignment of diamagnetic substances be explained? (2) What kind of polarity should diamagnetics have? (3) How can the magnetic properties of gases and space be fitted within the framework of the theory of molecular strain?

At first, Faraday felt that the transverse alignment of diamagnetics involved no theoretical difficulties. Diamagnetics can transmit the magnetic force only weakly; if they are placed in media which can take up a greater degree of strain, the effect would be to align the diamagnetic transversely to the magnetic lines of force and also to push it out of the field as the more highly magnetic medium displaced it. Diamagnetics, then, were not really different from magnetic bodies; they were only weaker. This being so, they should have the same *kind* of polarity as magnetics but of a much feebler strength. When tests for polarity were made, however, another unforeseen result was found. Diamagnetics had *no* polarity. If finely divided bismuth were sprinkled upon a sheet of paper under which a magnet was placed, the only effect was the repulsion of the bismuth particles from the magnetic pole; there was no mutual effect of the bismuth particles upon one another. Nor with other tests could any polarity be detected.

Another difficulty was encountered when empty space was the medium. Iron pointed axially and bismuth pointed transversally in a vacuum. Boscovichean point-atoms, let it be noted, were infinite in extent since the force of attraction extended to infinity, so that the alignment of the iron might still be reduced to the strain of 'contiguous' particles. But the differential action required for the transversal alignment of a diamagnetic could not be accounted for, since it involved an increase in longitudinal forces as these forces were diluted by distance—a clear contradiction.

Finally, the behaviour of gases was irreconcilable with the molecular hypothesis. Oxygen is magnetic; according to the theory of molecular strain, the oxygen molecules ought to be deformed and strained along the lines of force and the volume should decrease. Similarly, the molecules of a diamagnetic gas should be repelled by the field with a consequent expansion of volume. Using extremely sensitive gauges, Faraday sought to find these effects and failed.

For seven years he came back again and again to these problems, trying somehow to preserve the conjecture which had served him so well. Those who insist that Faraday was a strict experimentalist who, at best, devised *ad hoc* hypotheses to aid him in specific researches and quickly discarded them once the results were forthcoming, should read his laboratory journal for these years to see the hold that theory had over him.

Gradually, however, he recognized that the facts could not be forced into his hypothesis, and he quietly abandoned it as it applied to magnetism and diamagnetism. In 1852, he published a remarkable paper in the *Philosophical Magazine* entitled "On the Physical Character of the Lines of Magnetic Force". The development of the ideas contained therein may be traced back to his discovery of diamagnetism, but they are here presented in all their fullness. For many years he had spoken of lines of force, and, at least in his own mind, had meant the lines of molecular strain. We have, indeed, followed this idea from electrochemistry through electrostatic induction to the discovery of diamagnetism. By 1852, however, the physical basis of the strain had been eliminated. What Faraday would not eliminate, could not eliminate, because it presented itself so obviously to his eyes and understanding, were the lines of force themselves. That they existed independently of their means of detection—for example, iron filings or a wire cutting them to generate a current—he felt must be admitted; that the action was not simply at a distance was indicated by their curved form. But he recognized the lack of a material carrier of the force. "I cannot conceive curved lines of force without the conditions of a physical existence in that intermediate space. If they exist, it is not by a succession of particles, as in the case of static electric induction, but by the condition of space free from such material particles".

What a strange thing we now have—a strain with nothing to be strained. But wait, there is always that Aladdin's genie of the nineteenth century—the ether—to be brought in to solve all difficulties. Will not all difficulties disappear if space be filled by a subtle ethereal fluid capable of being strained by electric, magnetic and gravitational forces ? Faraday does say that a line of force "may be a vibration of the hypothetical aether, or a state of tension of that aether equivalent to either a dynamic or a static conduction". But he also goes on to point out that "it may be some other state" difficult to conceive. It may be that Faraday simply suspended his judgment over the physical basis of the strain. I cannot prove that he did not, but there is some very tenuous evidence to suggest that he saw these lines in a quite definite manner.

In January 1855, John Tyndall noted in his diary "Heard Faraday lecture. . . . Some strange views of force—I think he deceives himself by attributing an objective existence to his mental images".

Let us go back to the boy with his head stuck through the iron railings of a fence and asking on which side reality lay. Let us see the man accepting Berkeley and Boscovich and who would freely (after exhaustive empirical investigation) accept the 'objective existence' of his mental images. What would he have replied had he been asked, "What is strained in the lines of force if they can exist in space ?" I think he would have said, "Space itself". Nor should this really come as a surprise. What, after all, are the Boscovichean atoms but forces (that is, strains of some kind) in space. Or, to put it another way, to ask for a physical sub-stratum to be strained is equivalent to the demand of a material sub-stratum of force. Faraday had rejected the one; I think he saw no over-riding reason for not rejecting the other.

What then was the field ? I submit Faraday saw it as a strain in space. Matter, too, was a strain in space but it differed from the magnetic, gravitational and electric field in that it was radial (or polar), while the field was linear. The interaction of these two basic strains provided the fundamental and universal laws of the universe.

I cannot end without attempting to explain why Faraday did not come out bluntly and say that the field was a strain in space. The reason is, I feel, very simple ; he knew people would think him either mad or senile (as Tyndall hints). The incredulity which greeted Einstein's statement of much the same thing, some fifty years later, after the existence of the ether had been conclusively disproved, can serve as a rough measure of what Faraday would have faced. What Faraday left were the hints from which modern field theory has been constructed. To his contemporaries, the hints were the vapourings of an extraordinary mind which seemed to get lost in areas beyond the competence of a strict empiricist. It was more comforting to entomb him in a myth, than to follow his ideas to their revolutionary conclusion —modern field theory.

THE R. W. PAUL INSTRUMENT FUND

A REPORT ON ITS ACTIVITIES

UNDER the will of Mr. R. W. Paul, who died in 1943, a Committee was set up to administer the R. W. Paul Instrument Fund and to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science. Since its inception the Committee has voted nearly £165,000 in respect of some forty-two instruments. An account of some of these was published in 1954 (ref. 1) ; a survey of further instruments constructed or being devised is given below.

While any new instrument frequently has additional uses to the one primarily intended, it may be convenient for reading to group the instruments according to their main purposes. The absence of a particular field of physical instrument design from the following account does not mean that it would not be eligible for support from the Paul Fund. On the contrary, its absence from this account probably means that there has been no relevant application hitherto, and that such an application would have a good chance of support.

Astronomy. Astronomical interests have been the subjects of grants made to Dr. B. V. Bowden, Prof. S. Devons and Prof. R. O. Redman.

The grant to Dr. Bowden at the Manchester College of Science and Technology was originally made to the late Dr. A. Burawoy; it is being used to develop Dr. Burawoy's ideas for large optical filters with sharp transmission characteristics. These filters depend on the employment of organic compounds with better characteristics than dyes previously used, and are intended for use with telescopes of high light-gathering power.

The grant to Prof. Devons at the University of Manchester has enabled an investigation to be made into the design of a meniscus Schmidt camera for photographing emission nebulæ in *Hα* light in conjunction with narrow-band filters. The fact that the camera is designed for light of a specific wave-length enables the relative aperture to be made as high as *f*/0·7. It is hoped to publish the design details.

Prof. Redman is investigating the possibility of using comparatively thin flexible mirrors for astronomical telescopes. This would have the advantage of reducing many mechanical problems in telescope construction, since the weight of the structure could be substantially less than that of conventional telescopes. Moreover, the smaller mass of the mirror would enable it to attain thermal equilibrium more quickly. It is proposed to support the mirror by air cushions to maintain its figure as the telescope is rotated. The experimental mirror will be of 36-in. aperture, and approximately 1-in. thickness; the present investigation is concerned with finding a way of polishing and figuring such a mirror, and of designing the appropriate air supports. Another project in the University Observatories at Cambridge has been the development of multichannel spectroscopy using a Michelson-type interferometer. This development, which was initiated by Dr. P. B. Fellgett[2], has since been extended by many other workers, and is an important addition to spectroscopic techniques for use with weak sources such as occur in astronomy and in far infra-red investigations.

Nuclear and atomic physics. In nuclear and atomic physics, grants have been made to Prof. B. Bleaney and Dr. H. G. Kuhn, Dr. J. Moffatt, Mr. R. M. Sillitto and Prof. D. Gabor.

The first of these grants has facilitated the construction by Dr. G. K. Woodgate of an atomic beam magnetic-resonance apparatus[3] which has been used to measure the hyperfine structure of the ground-state of radioactive silver, ${}^{111}_{47}\mathrm{Ag}$. More recently, the apparatus has been used to develop a new method for measuring nuclear magnetic moments directly[4], and by this method it has become possible for the first time to measure the magnetic moment of a rare-earth nucleus. Such experiments have been done on the stable isotopes of europium.

The grant to Dr. Moffatt, originally made to Dr. R. Wilson, who is now in America, has been used to construct a Čerenkov radiation detector for 100-MeV. gamma-rays. A crystal of thallous chloride, 12 cm. long and 9·5 cm. in diameter, grown by the U.S. Army Engineer Laboratories at Fort Belvoir, has been used as the Čerenkov medium. The resolution (approximately 30 per cent) does not compare with that of a pair spectrometer, but the very high efficiency of detection is useful for investigating high-energy photon scattering.

Mr. R. M. Sillitto has constructed a 30-channel pulse-height analyser using transistors and cold-cathode 'Dekatron' counting tubes, and Prof. Gabor has built a new type of Wilson chamber. This uses a resonant cavity in which an electric field, very near the breakdown strength of the gas filling, is produced by a powerful 10-cm. microwave generator during the sensitive phase of the chamber. The microwave field produces an excess of tertiary electrons at its peaks, twice per cycle, and if the gas is one with high electron attachment, these tertiary electrons will turn into ion pairs inside a half-cycle, and produce periodic thickening of the tracks. This principle enables time-marks to be applied to the particle tracks at intervals of $1 \cdot 67 \times 10^{-10}$ sec., and this promises to give direct measurement of the velocity of particles in the Wilson chamber and thence their masses.

Spectroscopic analysis. Grants have been made for spectroscopic purposes to Sir Charles Dodds, Dr. P. M. B. Walker and Prof. R. V. Jones and Dr. A. H. Holbourn.

With the first of these grants a new flame spectrophotometer has been designed and constructed by Mr. R. L. Warren at the Courtauld Institute of Biochemistry, London. It is to be used for estimating trace metals in biological material. As an example of the high sensitivity achieved, less than 4×10^{-9} gm. of strontium can be determined. Details will be published shortly[5].

Dr. Walker, at the University of Edinburgh, is developing a high-speed integrating microspectrophotometer to facilitate the analysis of biological cells or liquid droplets of the order of $10^{3}\mu^{3}$ volume. One of the problems in these applications is that the distribution of the material in the specimen is non-uniform; moreover, in the biological application it is also often necessary to exclude from the measurement unwanted structures lying within the field of integration. This instrument is therefore designed to integrate the absorption of a specimen which can be resolved by the microscope, and at the same time to allow the limits of the integrated area to be accurately and quickly defined by the operator before measurement begins.

Dr. A. H. Holbourn, at the University of Aberdeen, is constructing a ruling engine for 8 cm. × 5 cm. diffraction gratings. The spacing of the lines in the grating is controlled by connecting the grating blank to the movable mirror of a Michelson interferometer. In the short lengths of gratings so far ruled there are no periodic errors, and random errors in line position are less than 2×10^{-6} cm.

Image devices. One of the most interesting developments in observational techniques has been the production of various types of image devices. In this connexion, grants have been made to Prof. G. F. J. Garlick, Dr. H. H. Hopkins, Prof. J. D. McGee and Dr. C. N. Smyth.

Prof. Garlick and Mr. M. Springford, in the University of Hull, are investigating physical problems in the design of solid-state image intensifiers. The important limiting factors have been found to lie in the photoconductor component of the device. Attempts are being made to produce cadmium sulphide and selenide layers of good sensitivity (especially to X-rays) and with more rapid response than existing materials. Stacked single crystals have been successfully used in combination with electroluminescent layers, but a more easily manufactured form of photoconductor is still being sought.

Dr. Hopkins, at the Imperial College of Science and Technology, London, has designed a static scanning fibroscope for transporting optical images without using lenses. The element of the system is a composite glass fibre, the core having a high refractive index and the sheath a low one. The fibres are assembled into flexible bundles, and light falling on the end of any one fibre is transmitted to the other end of the bundle. Since the relative positions of the individual fibres are made the same at both ends of the bundle, an image incident on one end is reproduced at the other. If flexibility is not required, the bundles can be fused together, giving a matrix of low index glass traversed by the high index fibres. In this form the device can be used as an exit window for an image intensifier, the phosphor being on the inner side of the window, and a photographic plate being in contact with the outer surface. In principle, this technique can be used to give a very large angle of collection of light without the use of lenses. Flexible bundles can be used for medical and industrial endoscopy.

Prof. J. D. McGee, also at the Imperial College, is investigating the problem of an image intensifier for X-rays. After examining the use of a television-type tube in which the photoconductive target is replaced by one highly sensitive to X-rays, Prof. McGee decided that a better approach would be to develop a high-gain image intensifier capable of detecting single photo-electrons. This image intensifier is then used to intensify the light coming from a conventional X-ray fluorescent screen. The primary limit on the quality of pictures would then be set by the fluctuations in the X-ray quanta absorbed by the screen. Development of several types of image intensifier was carried on by Prof. McGee's group, and one of these, developed by Dr. Wilcock, Mr. Emberson and Mr. Weekley, has recently approached the high performance required.

Another form of image device is the ultrasonic image camera, of which a prototype has been built by Dr. Smyth. The instrument enables a picture of internal flaws and structural details in a body to be presented on a cathode-ray screen. The body is irradiated with ultrasonic waves, and the energy scattered by inhomogeneities is focused by a plastic lens on to a quartz plate which constitutes the end surface of an electronic image tube. The piezo-electric charge pattern produced by the ultrasonic image is scanned by the electron beam in the tube, and a signal derived from the beam is made to give a visible image by normal television techniques. The prototype image has a field of 2 sq. cm. with 1,000-point resolution, and work is now proceeding to increase both the size and quality of the picture. The instrument could have applications in the inspection of materials and of objects such as the human body.

Microwaves. Although the development of microwave techniques has been very rapid during the past twenty years, there remain substantial problems in connexion with power measurement at microwave frequencies, and in the generation of waves of still shorter wave-lengths. In the former connexion, grants have been made to Prof. H. M. Barlow, at University College, London, and Prof. A. L. Cullen, at Sheffield.

Four instruments have been developed at University College, depending for their action on mechanical forces produced by the electromagnetic field and for their calibration in length, mass and time only. These instruments provide reliable standards for microwave power measurements over a wide range of values both in the 3-cm. and 8-mm. wave-bands. The 8-mm. wattmeter employs a resonant cavity, and appears to be the first instrument capable of absolute power measurements in the millimetre wave-band. A fifth instrument depends for its operation on the Hall effect produced in a small piece of semiconductor situated in an electromagnetic field. A satisfactory instrument has been developed in the 7·5-cm. and 3-cm. wave-bands for powers of the order of a few hundred milliwatts[4].

Prof. Cullen's work with Mr. M. J. de Belm at Sheffield is an extension of the work[5] which Prof. Cullen was doing under the Paul Instrument Fund grant at University College, and is concerned with the detection of microwave power at the level of microwatts or less. The measuring technique uses the fact that electromechanical forces such as radiation pressure and electrostriction depend on the square of the amplitude, so that if two separate microwave sources are used, of frequencies f_1 and f_2, the resultant mechanical force will contain a term fluctuating at the frequency f_1-f_2. It is proposed to use a quartz vibrator, resonant at this difference frequency as the sensitive element; piezo-electric voltage developed by the crystal will provide the output of the instrument.

Dating techniques. The development of physical dating techniques has been supported by grants to Dr. S. C. Curran and to Dr. E. T. Hall.

Dr. Curran, of the Royal College of Science and Technology, Glasgow, had as his objective the development of a very sensitive proportional counter of large dimensions, giving special attention to the reduction of background-rate. This incorporates shielding proportional counters, and the large inner detector is effectively wall-less. In this way the disturbance due to penetrating radiation interacting with the walls is reduced to almost negligible values. A background-rate as low as 0·4 count per min. per litre of effective volumes has been achieved, and of this more than half is due to the unavoidable interaction of penetrating radiation with the gas filling. The electronic equipment rejects all extraneous pulses with 100 per cent certainty. The system has been shown to be suitable for the examination of very ancient specimens[6], and at the same time it has been established that it will have application to other investigations such as the measurement of L/K-capture ratios[7].

The work supported by the Paul Fund and being done by Dr. E. T. Hall at Oxford is concerned with the remanent magnetism in baked clay, which can be used to obtain geophysical information about the Earth's magnetic field in archæological times and also conversely to date archæological samples of unknown age. A spinning magnetometer suitable for use with large samples (up to 18 in. in dimension) has been constructed; the speed of rotation is limited to 300 r.p.m. to avoid risk of damage to valuable specimens, and the first application of the instrument has been to the Chinese Yüeh vases. These were baked in an upright position and consequently retain the contemporary angle of dip. In the same laboratory the construction of a fully automatic gamma-ray spectrometer, employing electronic Compton spectrum subtraction, has permitted large-scale programmes of neutron activation analyses of early Greek silver coins and Roman pottery[10]. Because the technique is entirely non-destructive, it has been possible to analyse some 500 coins, probably more than the sum total of all archæological coin analyses done by other methods.

Information about application for grants from the R. W. Paul Instrument Fund can be obtained from the Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1.

---

[1] *Nature*, 173, 183 (1954).

[2] Fellgett, P. B., A propos de la Théorie du Spectromètre Interférentiel Multiplex (1958). Spectromètre Interférentiel Multiplex pour Mesures Infra-Rouges sur les Étoiles (1958). "Les Progrès Récents en Spectroscopie Interférentielle", éditions du C.N.R.S. Paris.

[3] Woodgate, G. K., and Hellwarth, R. W., *Nature*, 176, 396 (1955).

[4] Woodgate, G. K., and Sandars, P. G. H., *Nature*, 181, 1395 (1958).

[5] Warren R. L., VIII Colloquium Spectroscopicum Internationale. Publication of Scientific Papers, *Chimia* (to be published).

[6] Barlow, H. M., *Proc. Inst. Elect. Eng.*, B, No. 2, 102, 179 (1955). Barlow, H. M., and Stephenson, L. M., *ibid.*, B, No. 7, 103, 110 (1956). Barlow, H. M., *ibid.*, C, Monograph No. 191R (1956). Barlow, H. M., and Kataoka, S., *ibid.*, B, No. 19, 105, 53 (1958). Stephenson, L. M., and Barlow, H. M., *ibid.*, B, No. 25, 106, 27 (1959).

[7] Cullen, A. L., and Stephenson, L. M., *Proc. Inst. Elect. Eng.*, IV, No. 4, 99, 294 (1952). Cullen, A. L., and French, H. A., *ibid.*, C, No. 6, 104, 456 (1957).

[8] Moljk, A., Drever, R. W. P., and Curran, S. C., *Proc. Roy. Soc.*, A, 239, 433 (1957).

[9] Drever, R. W. P., Moljk, A., and Curran, S. C., *Nuclear Instruments*, 1, 41 (1957).

[10] Emeleus, V. M., and Simpson, G., *Nature*, 185, 196 (1960).

CONTENT OF CÆSIUM-137 AND (ZIRCONIUM + NIOBIUM)-95 IN SWEDISH SOILS

By KERSTIN LÖW and K. EDVARSON

Research Institute of National Defence, Department 4, Stockholm, 80

FOR determining the accumulated fall-out deposit on the ground, γ-spectrometric determination of fission products in the surface layers of soil seems to have distinct advantages compared with other methods[1-3]. Evaluation of the deposit from measurements of activity in precipitation has a disadvantage in that the sampling efficiency of the collecting device differs from that of the ground, and further makes it necessary to add up contributions from a number of samples, which, in the case of long-lived components, will become very large. Radiochemical determinations of the fission-products in soil are rather time-consuming and involve difficulties as regards determination of the chemical yields. γ-spectrometric determination of a nuclide in soil is possible if it has a γ-line well resolved from other γ-lines and with an intensity comparable to the natural γ-activity of the soil. In this article, measurements on soils sampled in June 1959 are reported. In this case it was possible to determine cæsium-137 and zirconium + niobium-95.

The samples were taken on June 10–12, 1959, on pasture-ground not cultivated during the past five years at two latitudes across the country, 60° N. and 63° N. respectively (Fig. 1). As it was of interest to correlate the deposit with the amount of precipitation, the samples were collected in the immediate vicinity of weather stations. At each site three cores with an area of 320 cm.^{2} and a depth of 10 cm. were taken at a distance of a few metres. The cores were cut in four layers with a thickness of 2·5 cm. each. The vegetation was included in the top layer. After drying at 110° C. the corresponding layers from the three cores were thoroughly mixed. Due to the different soil characteristics, the volume of these bulk samples varied between 1·5 and 3 litres. The γ-spectrometric determinations were made with the apparatus already described[2] (10 cm. × 10 cm. sodium (thallium) iodide-detector and 70-channel

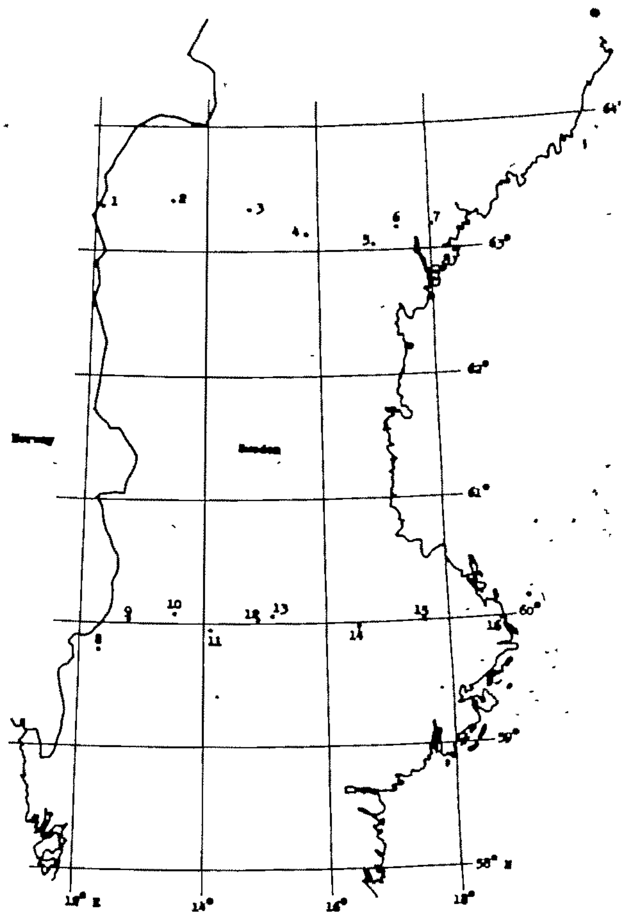


Fig. 1

kicksorter). The sample container had a volume of 1·0 litre and the measured samples thus corresponded to an area of 350–700 cm.^{2}. In five cases a duplicate determination on different parts of the bulk samples was made. The bottom layer was assumed to contain no fission product γ-activity, and its spectrum was used for the subtraction of the natural activity contribution in the spectra of the two upper layers in the manner already described[3]. As it was found that the fission-product activity in the 2·5–5 cm. layer was much lower than in the top layer, it was not considered necessary to measure the 5–7·5 cm. layer.

The results are summarized in Table 1. When recalculating the zirconium + niobium-95 values to the sampling date, a half-life of 65 days has been used, as the latest probable origin of the activity is the tests in the autumn 1958 and thus a transient equilibrium between zirconium and niobium-95 can be assumed. A determination of a sample from Bergen, Norway, taken in November 1959, is also included. (This sample was kindly provided by Mr. T. Hvinden at the Norwegian Defence Research Establishment.)

The random errors in the measurements are estimated as 3 per cent for zirconium + niobium-95 and 7 per cent for caesium-137 in the top layers. For the 2·5–5 cm. layers, the absolute random errors are of the same order of magnitude, thus giving a total random error in the determination of the deposition on each location of 5 per cent for zirconium + niobium-95 and 10 per cent for caesium-137. There might further be an error due to incomplete mixing of the bulk samples. The differences found between duplicate samples indicate that this error is considerably less than 10 per cent. Apart from the random errors there is a constant systematic calibration error of < 10 per cent.

As the half-life of caesium-137 is long, compared with the period of fall-out from nuclear explosions, the deposit of this nuclide represents the accumulated fall-out since the beginning of nuclear weapon tests. The deposit of zirconium + niobium-95 (half-life 65 days) will mainly originate from recent tests. In the present case it could be assumed[4] that almost all the zirconium + niobium-95 deposit originated from the tests carried out in the autumn of 1958.

If it is assumed that the fall-out is a function of the precipitation, it will thus be of interest to correlate the caesium-137 deposit with the total precipitation

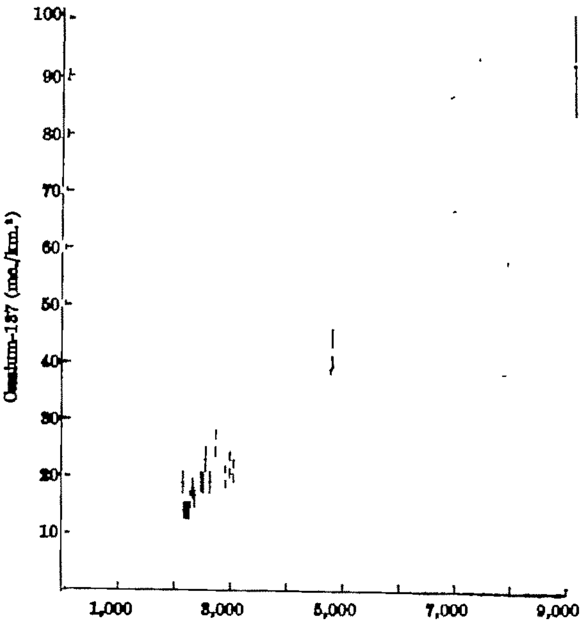


Fig. 2

Table 1

Sampling site (1)	Date of measurement (2)	Cs-137 (mc./km.²) (3)		(Zr+Nb)-95 (mc./km.²) at June 12, 1959 (4)		Precipitation (mm.) Jan. 1, 1955, to sampling date (5)	Precipitation (mm.) Nov. 1, 1958, to sampling date (6)
1	17.9.59	37·6 4·1	42	344 8	352	4,780	524
2	17.9	17·1, 15·6 0	16	110, 107 0	109	2,360	263
3	17.9	14·8, 15·7 5·9, 2·8	19	92, 103 0	97	2,150	237
4	28.8	13·8 0	14	62 0	62	2,180	275
5	18.8	13·1 0·4	14	75 4	79	2,200	273
6	18.8	12·2 1·9	14	58 0	58	2,240	282
7	17.8	18·6 0	19	105 4	109	2,510	362
8	20.8	14·7 4·7	19	113 9	122	2,630	404
9	18.9	19·0 1·6	21	114 0	114	3,050	430
10	20.8	15·0 3·8	19	119 20	139	2,500	350
11	20.8	21·0 1·4	22	108 7	115	2,970	392
12	21.8	16·2 4·3	20	93 10	103	2,910	447
13	19.8	21·9 4·4	26	147 7	154	2,730	396
14	22.9	17·4, 18·9 0	18	96, 96 0	96	2,340	331
15	16.9	15·0, 14·3 1·2	16	105, 94 0	100	2,270	284
16	19.9	19·7 3·3	23	88 9	97	2,550	344
Bergen	8.12	76, 87, 87 8, 9, 9	92	581, 601, 574 74, 54, 54	646	9,100	—

In columns 3 and 4 the upper value is the activity in the 0–2·5 cm. layer, the lower the activity in the 2·5–5 cm. layer. The sum is given to the right. The samples 1–16 were taken during June 10–12, 1959, the sample from Bergen in November 1959.

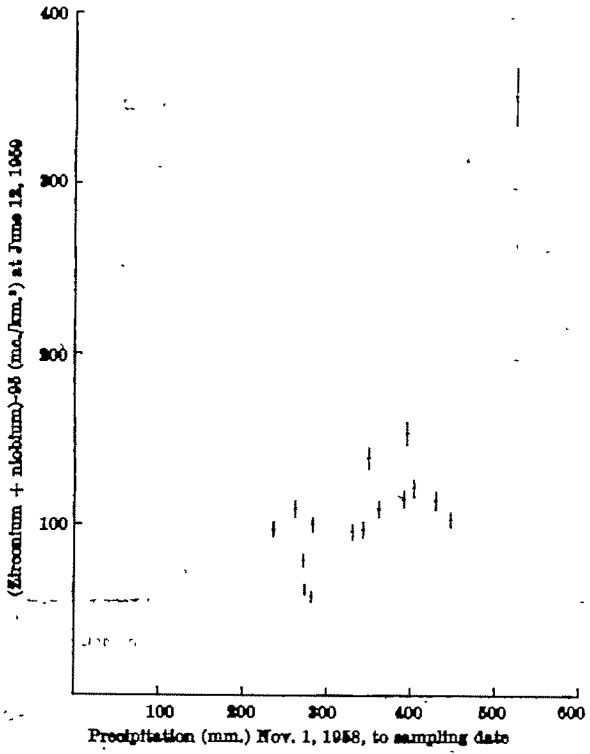


Fig. 3

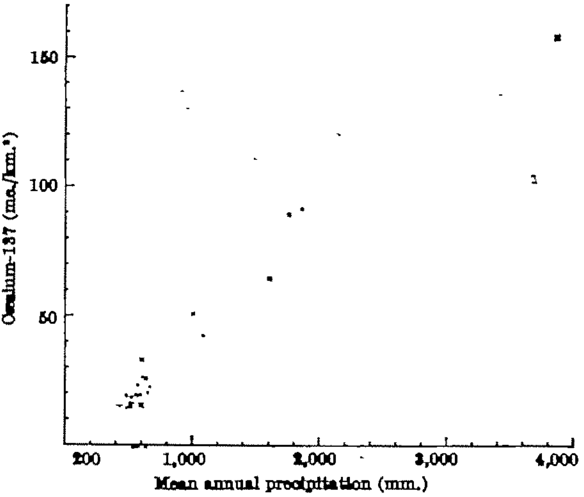


Fig. 4

since the beginning of considerable global fall-out, and the zirconium + niobium-95 deposit with the precipitation since the autumn, 1958.

As can be seen in Figs. 2 and 3, a strong linear relationship seems to exist between caesium-137 deposit and precipitation (ρ = 0·99 with the 95 per cent confidence limit 0·95 and 1·00), whereas the zirconium + niobium-95 values are more scattered (ρ = 0·74 with the 95 per cent confidence limits 0·35 and 0·90). In the case of zirconium + niobium-95, the value for Bergen has not been included because of the later sampling date.

The larger irregularities in the zirconium + niobium-95 values are not unexpected. Large variations in the specific activity of precipitation have been observed between samples taken simultaneously at different locations[4], and such variations will be reflected in Fig. 2. Corresponding variations in the case of caesium-137 will be levelled out because of the long period of accumulation. Of course it is also quite possible that the variations in the specific caesium-137 activity in precipitation are smaller.

If the values for Bergen and station 1 are excluded the mean value of the caesium-137 deposit is 18·7 mc./km.² and the standard deviation is 3·5 mc./km.². The corresponding precipitation values vary within ± 20 per cent. This precipitation interval applies to the greater part of Sweden, and the above value can thus be regarded as a reasonable mean value for the country.

Peirson has recently published a corresponding study concerning the deposit in the United Kingdom on samples taken during the summer, 1959[3]. In Fig. 4, Peirson's and our values of the caesium-137 deposit are plotted against the mean annual precipitation. No significant differences between the two sets of values can be detected. As the latitude of the British sampling sites is 50–55° N., while the Swedish sites are at 60–63° N., this concordance is of interest.

For the selection of sampling sites and for carrying out the sampling we are indebted to Dr. L. Fredriksson at the Royal Agricultural College, Ultuna.

---

[1] Gustafson, P. F., *Science*, 127, 1240 (1958).

[2] Löw, K., and Edvarson, K., *Nature*, 183, 1104 (1959).

[3] Peirson, D. H., and Salmon, L., *Nature*, 184, 1678 (1959).

[4] Edvarson, K., and Löw, K., The Concentration of Some Fission Product Nuclides in the Ground Level Air during the Period Sept. 1957–Dec. 1959, F.O.A. 4 *A* 4132–4727, 1960 (to be published).

[5] Lindblom, G. (private communication).

OBITUARY

Prof. Max von Laue, For.Mem.R.S.

Prof. Max von Laue, former director of the Fritz-Haber-Institut of the Max Planck Gesellschaft in Berlin Dahlem, died in Berlin on April 24 a few months after his eightieth birthday.

In an autobiographical note, Max von Laue once described the early influence upon him of his excellent science teacher at the *Gymnasium* in Strassburg, and also his great interest in H. v. Helmholtz's popular lectures. These were the determining factors which made him choose physics and mathematics, and in 1898 he began to read physics at the University of Strassburg—probably against the will of his father and step-mother, who would have liked him to become an officer in the Prussian Army. In 1899 he moved to Göttingen, where he came under the spell of David Hilbert, whom he regarded as probably the greatest genius he ever met in his life. However, it was Waldemar Voigt who taught him to apply mathematical methods to physics. v. Laue became a theoretical physicist, and, after a short interlude in

Munich—short, because Boltzmann's chair was still vacant and there was no one to teach theoretical physics—he went to Berlin. It is likely that during these years, 1902–4, the fundamentals were laid for the discovery which, ten years later, brought Laue world fame and a Nobel Prize in Physics. It was indeed one of the greatest discoveries of the century. He attended Max Planck's lectures on theoretical optics and Lummer's on special problems of optics. Laue remarked that during these formative years he acquired his 'optical instinct' which stood him in such good stead later. The subject given to him by Planck for his dissertation was "Theory of Interference on Plane Parallel Plates".

Laue became the devoted pupil of Planck, and Berlin his spiritual home. After two more years postgraduate work in Göttingen, he returned in 1905 to Berlin as lecturer and as Planck's assistant. It was Einstein's *annus mirabilis*. Laue's early work on relativity—with his many contributions to thermodynamics, the theory of radiation and also his phenomenological theory of superconductivity—seem, to-day, unjustly eclipsed by his X-ray diffraction work. It led to his monograph on the special theory of relativity (1910)—the first ever written—and later to another on the general theory of relativity.

In 1909, v. Laue moved to Munich, and it was there, in 1912, that he made one of the greatest and most far-reaching discoveries of our own age, the diffraction of X-rays by crystals. The scientific atmosphere in Munich at this time was especially favourable for this discovery. W. C. Röntgen was still active, and A. Sommerfeld, a firm believer in the wave nature of X-rays, had succeeded Boltzmann. Sommerfeld's influence in theoretical physics through his own research and by his teaching was probably greater than that of anyone else. Also in Munich was Paul von Groth, the mineralogist, continuing the tradition of Leonhard Sohncke, who in his time had contributed greatly to the theory of crystals. There was, too, young P. P. Ewald seeking advice on wave optics, whose work suggested to v. Laue the idea of the experiment performed by W. Friedrich and P. Knipping. The second experiment, using copper sulphate as crystal, showed the result which v. Laue predicted. Many research workers before this had sent X-rays through crystals, limiting their observations to the direct beam, without noticing anything of interest. It was left to v. Laue's genius to expect, and find, diffracted rays on the photographic plate. The theory of one- and two-dimensional gratings, so well known to v. Laue, was easily extended to a three-dimensional grating such as he proved to exist in the regular arrangement of atoms in crystals. Max von Laue's discovery was made "by the sheer power of believing more concretely than anyone else in the accepted theory of crystals and X-rays. These advances were no less bold and hazardous than were the innovations of Copernicus, Planck or Einstein" (M. Polanyi).

It is impossible to describe shortly the consequences of this discovery on the development of almost every branch of science. This door, opened in 1912, is still wide open nearly fifty years later. Only recently the results have been described in *Nature* of fundamental work by Kendrew and Perutz which would not have been possible but for the historical experiment in Munich. Sir Lawrence Bragg, confining himself to X-ray analysis only, has given a masterly account of the advances in the determination of crystal structures in a volume dedicated to three octogenarians—Lise Meitner, Otto Hahn and Max von Laue. v. Laue himself was never interested in developing his discovery into a tool for crystal structure analysis; instead, he followed the course of developing the optical background of X-ray diffraction, work which is recorded in the various editions of his book, "Röntgenstrahl Interferenzen".

After a short spell as professor in Zurich and Frankfurt, von Laue returned to Berlin as professor of theoretical physics and co-director, with his life-long friend, A. Einstein, of the Kaiser-Wilhelm-Institut fur Physik. He remained in Berlin all his life, becoming, after the Second World War, director of the Fritz-Haber-Institut. Well over 200 papers, on almost every aspect of theoretical physics, and a number of books—among them a short history of physics—were the result of his work. However, in spite of his lively interest, he never contributed to the development of quantum mechanics. He shared, with his friends Planck and Einstein, certain reservations towards its final consequences.

Berlin, after the First World War and before 1933, had become one of the great centres of learning. A regular scientific event was the "Laue Colloquium" at the Physics Department in Reichstagsufer, unforgettable to anybody who had the good fortune to attend it regularly. Every week, and under the chairmanship of v. Laue, there took place a gathering of eminent men of science, of those who later became eminent, and of everybody else interested in new developments of physics. Planck, Nernst, Einstein, Schroedinger, Lise Meitner, R. Ladenburg and, later, Debye and G. Hertz all attended regularly. Among those who came to great eminence later on were F. Simon, J. von Neumann, L. Szilard, E. Wigner and F. London. It was a very democratic institution, and everybody was allowed to ask questions, intelligent and, sometimes, silly ones. All this, and the spiritual values of this period, came to an abrupt end in 1933. The material destruction which followed during the War was a direct consequence of the political events of 1933. It was during these fateful years that von Laue showed the greatness of his personality. He became a lonely and very courageous fighter for truth and integrity against tyranny and the evils of a wicked regime. He was probably the only member of the Academy who launched a solemn protest against Einstein's expulsion from the Prussian Academy of Sciences. The era of 'Aryan physics' began, and it was decreed, mainly by obscure men, but unfortunately also by two great physicists, who sprang out of oblivion, that Einstein's and other Jewish physicists' names and work must in future be ignored. Again, it was Laue, at a meeting of the German Physical Society (Würzburg, September 1933), who replied spontaneously to an address by Johannes Stark on the role and task of physics in the Third Reich. Laue reminded the audience that, almost exactly 300 years before, Galileo was forced, under threat of torture by the Inquisition, to renounce his doctrine. He passionately appealed to the physicists to bear in mind Galileo's famous words: "It moves, nevertheless!" The following year his obituary of Fritz Haber, published in *Die Naturwissenschaften*, would have had dangerous consequences for v. Laue had not the Gestapo been afraid of the reaction of the civilized world to the persecution of the man who dared to say: "Just as Themistocles has become immortal as the victor of

Salamis, and not as the conqueror of the Persian king, Fritz Haber has become immortal by his scientific work".

During the War, v. Laue became somewhat of a recluse. His only son was safe in the United States studying history. His house, where he lived with his wife and daughter, was visited by a handful of friends who thought as he did, by the sons and friends of Dutch and Norwegian scientists sent as slave workers to Germany, by French prisoners of war and many more who needed his help or advice. In 1941 he went with half a dozen friends to the derelict Jewish cemetery to pay his last respects to his old friend, Dr. Arnold Berliner, founder and, for twenty-five years, editor of *Die Naturwissenschaften*. Berliner had been forced to resign by the Nazis, and had committed suicide rather than be expelled from his home and sent to a concentration camp. Carbon copies of the obituary Laue wrote were sent to several of his friends for safe keeping, and published after the War. v. Laue never had the slightest doubt that Germany would lose the War. In 1943 he was seriously rebuked by the Nazi Minister of Education for mentioning Einstein's name in a lecture. In reply to this, he published shortly afterwards a paper, "Ein relativistischer Beweis fur das Wien'sche Verschiebungsgesetz".

When the end of the War came, v. Laue was in Hechingen, where the Institute had been evacuated. With a team of German atomic scientists, known as the 'Uran-Verein', v. Laue was sent as a 'prisoner' to England. Naturally, v. Laue was not 'trustworthy' enough to have become a member of this team, and in any event he would have refused his co-operation. Some of the letters he wrote to friends at this time about the reaction of his colleagues to Hiroshima, and their subsequent discussions on the atom bomb, are carefully preserved documents of great historical interest.

Returning to Germany, he put all his efforts into rebuilding science. In 1946 he was, with Max Planck, the first German to be invited to England. He received many honours and was elected a foreign member of the Royal Society in 1949. His ashes are buried at Göttingen cemetery beside the graves of Walther Nernst, Adolf Windaus and Max Planck—four members of a great period of science in Germany.

P. ROSBAUD

NEWS and VIEWS

Botany at Adelaide: Prof. R. N. Robertson

PROF. R. N. ROBERTSON, who is to succeed the late Prof. J. G. Wood as professor of botany in the University of Adelaide, graduated from the University of Sydney in 1934. In 1936, he went to St. John's College, Cambridge, as a Scholar of the Royal Commission for the 1851 Exhibition. After graduating with a Ph.D. degree in plant physiology, he joined the lecturing staff of the University of Sydney in 1939. In 1946 he joined the Commonwealth Scientific and Industrial Research Organization, in which he afterwards became a chief research officer and is now a member of the executive. With Prof. F. V. Mercer, he founded the Plant Physiology Unit, which is run jointly by the Department of Botany, University of Sydney, and the Organization's Division of Food Preservation and Transport. During 1958–59 Prof. Robertson was a visiting professor in the Department of Horticultural Science of the University of California at Los Angeles. His research has been concerned with problems of salt accumulation and respiration in plant cells and in plant mitochondria. In addition, he has carried out work on the developmental physiology of fruits with special reference to respiration. Because of his commitments to the Commonwealth Scientific and Industrial Research Organization's Executive, Prof. Robertson will not take up his duties in Adelaide until the beginning of 1962, and in the meantime Dr. H. B. S. Womersley has been appointed as acting-head of the Department.

International Meteorological Organization Prize: Prof. J. van Mieghem

THE Executive Committee of the World Meteorological Organization has this year awarded the annual prize paid for from the funds left to it by the International Meteorological Organization to the eminent Belgian meteorologist, Prof. J. van Mieghem. The prize consists of a gold medal, 1,200 U.S. dollars and a diploma. Prof. van Mieghem is chief of the service for theoretical and experimental aerology of the Royal Meteorological Institute of Belgium. He is also professor of meteorology in the Free University of Brussels and chairman of the Belgian National Centre for Polar Research. In its selection, the Committee takes into account both scientific eminence and the record of work done in the field of international meteorological organization. Under the first heading, Prof. van Mieghem is a mathematician of the first order, who has published about a hundred papers on the dynamics and thermodynamics of the atmosphere, with the subject of energy transformations as his major field of research. His contributions to the international organization of meteorology are also very large. He was president of the Technical Commission for Aerology of the World Meteorological Organization during 1951–57, and in the International Union of Geodesy and Geophysics he has been secretary (1948–54), vice-president (1954–57) and president (from 1957) of the International Association of Meteorology and Atmospheric Physics. Probably his major work in this sphere, however, was as chairman of the World Meteorological Organization Working Group for the International Geophysical Year and representative of the Organization on the Special Committee for the International Geophysical Year.

The Swinburne Medal of the Plastics Institute

THE first award of the Swinburne Medal of the Plastics Institute has been made to Prof. G. Gee, professor of chemistry in the University of Manchester, for his outstanding contributions to the advancement of polymer chemistry. Prof. Gee will deliver his Swinburne Address at the Royal Institution on Thursday, February 16, 1961, when he will be presented with the Gold Medal and the sum of money which accompanies the award. The award was instituted in 1959 to commemorate Sir James Swinburne, who died at the age of a hundred in the previous year; it has been generously endowed by Bakelite, Ltd.

Editorship of *Discovery*: Mr. S. E. Gamarekian

S. Edward Gamarekian has been appointed editor of *Discovery*. He carried out research and development work at the General Electric Company's Laboratories in Schenectady, New York, for many years and lectured at Rutgers University, Rensselaer Polytechnic Institute and the Georgian Institute of Technology. He later became the scientific correspondent for *The Washington Post* and recently came to Britain to report on scientific developments for *The Guardian* during a three-month exchange of science correspondents between the two newspapers.

Recovery of Capsules from *Discoverer* Satellites

The first success in retrieving an object which had returned to Earth after being in orbit in space was achieved on August 12, when the re-entry capsule from the United States satellite *Discoverer* 13 was recovered from the North Pacific. *Discoverer* 13 (1960 θ) was launched from Vandenberg Air Force Base, California, at 20h. 40m. U.T. on August 10, and entered an orbit inclined at 83° to the equator. Its height varied between 260 km. at perigee and 700 km. at apogee, the orbital period being 94·1 min. Seventeen revolutions later, the re-entry capsule was detached from the main body of the satellite when it was travelling south near the Aleutian Islands, and, after its speed had been substantially reduced by a retro-rocket, it descended through the atmosphere. In the last few miles of its descent it was further retarded by parachute and was finally recovered from the sea north of Hawaii. It was found to have withstood well the heating encountered during its descent. On August 19 there was successful recovery of a second capsule, ejected from the satellite *Discoverer* 14 (1960 κ), which was launched at 19h. 58m. U.T. on August 18 into an orbit similar to that of its predecessor. On this occasion the capsule, which weighed 85 lb., was intercepted during its final parachute descent, being caught by an aircraft at an altitude of about 10,000 ft. over the north Pacific.

The Satellite *Echo* 1 (1960 ι)

The first successful balloon-satellite was launched from Cape Canaveral in Florida at 09h. 40m. U.T. on August 12. The satellite, known as *Echo* 1, consists of an aluminium-coated plastic sphere 100 ft. in diameter, which was inflated at high altitude. Its orbit is inclined at 47° to the equator, with a period of revolution of 118·2 min. initially. The orbit is nearly circular, the height being 1,530 km. at perigee and 1,690 km. at apogee. The satellite, which is designated 1960 ι 1, is accompanied in orbit by its final-stage rocket (1960 ι 2), and three other fragments. The main purpose of the satellite is to act as a reflector for radio waves, and many transmissions have been successfully received via the satellite. It thus serves as a first step towards a world-wide communications system which would be independent of ionospheric disturbances. The satellite is also admirable for optical tracking, and during its first week in orbit was easily visible from most of the northern hemisphere, as a slow-moving object of stellar magnitude zero. The satellite should also yield the first information on air density at heights above 1,000 km., and evidence of its behaviour under the impact of meteorites is awaited with interest.

Australia's Second Atomic Reactor

Australia's second atomic reactor is to be called by the aboriginal name of *Moata*. This is the first in the world to bear a tribal name. The name *Moata* is used by the Ngerikudi tribe in Northern Queensland to describe instruments for making heat or 'native firesticks'. *Moata*, an Argonaut type of experimental reactor, is now under construction at the Advanced Technology Laboratories at Mountain View, California, and will be installed at Lucas Heights early next year.

Information Centre for Food Irradiation

An international information centre for food irradiation has been set up as a result of a contract signed between the European Productivity Agency of the Organization for European Economic Co-operation and the Centre d'Etudes Nucléaires at Saclay, France. M. Pierre Lévèque has been appointed director of the Centre, which will be set up at Saclay. The functions of the Centre include the preparation, publication and distribution of a quarterly international newsletter on food irradiation in both English and French. The Centre will also serve as a point of contact between scientists, food technologists and the government and industrial circles interested, and will encourage closer international co-operation in the development and application of knowledge in the field of food irradiation. The contract, which has been signed for an initial period of two years, provides for the payment by the sponsoring bodies of a sum of 32,000 new francs to cover printing and translation costs and other incidental expenses of the Centre. It is hoped that the work of the European Information Centre for Food Irradiation will encourage investigation and research and promote the successful industrialization of the results obtained.

Bibliographies on Technical and Vocational Education

A series of bibliographies on technical and vocational education has been launched by Unesco. Besides an international bibliography, surveys have been published giving details of publications in the United Kingdom and in the U.S.S.R. concerned with the technical and vocational aspects of education. To these is now added a bibliography of technical education publications in the United States (Educational Studies and Documents No. 36: Technical and Vocational Education in the U.S.A.—a Bibliographical Survey prepared by the United States Office of Education. Pp. 24. (Paris: Unesco; London: H.M. Stationery Office, 1959.) 3*s.* 6*d.*) The booklet is in five parts and lists separately publications dealing with general technical and vocational education, agriculture, distribution, home economics and industrial education; there is an explanatory note to cover each publication described, stating briefly its contents and purpose.

Low-priced Books for Overseas

Since this scheme was first started, some 2,000 titles have been submitted by publishers and others to the Advisory Committee on the Selection of Low-priced Books for Overseas under the chairmanship of Mr. A. L. P. Norrington, president of Trinity College, Oxford, and vice-chancellor (designate) of the University. The Committee will shortly be submitting its list of recommendations to the Ministers concerned. Some measure of priority is being given to university text-books, as the importance attached to the supply of books of educational, scientific and technical value was clearly brought out at the

Commonwealth Education Conference held in July 1959. The Advisory Committee is therefore studying a first list of some twenty-five scientific and technical text-books for issue in low-priced editions to universities and college libraries, instructors and individual students. Initially the arrangement will be applied to India. It is hoped that the books will be made available for distribution in India this winter.

The Proterozoic in the U.S.S.R.

THE rocks belonging to the Upper Pre-Cambrian or Proterozoic group in China, named by Grabau as belonging to the Sinian system, during the past two decades have been proved to be very abundant in the Urals and other parts of the U.S.S.R. In the absence of characteristic fossils which would allow a correlation with the Sinian, the prominent Soviet geologist, N. S. Shatsky, in 1945 proposed the name of Rhiphaean system, from Rhiphaean Mountains, an old name for the Ural Mountains. Recent work on the determination of the absolute age of these formations, as presented by B. M. Keller (*Priroda*, 9, 30; 1959), gives the following figures: Taratash gneiss underlying Rhiphaean series, 1,100 m.y.; uppermost Rhiphaean deposits—Inzer sandstone, 865 m.y.; Serdobian suite rocks, 680 m.y.; Larminarites suite, 540–560 m.y. Thus, the Rhiphaean system may be demarcated in age as 1,100–500 m.y. It is divided into the Upper Timanian suite and the Lower Yakutian suite. The rocks of the Yakutian suite are characterized by a peculiar calcareous alga of a stromatolite type named *Conophyton*, while in the Timanian suite a branching alga named *Collenia* is found. These two algal types form very thick layers of limestone, but no remains of animals have as yet been found in these rocks. While V. P. Maslov studied these algae, S. N. Naumova has discovered spores of land or, more probably, of shore plants, which was rather unexpected. In Siberia, especially in the region of the Lake Baikal, the Upper Rhiphaean strata are folded and intruded by granite, and so N. S. Shatsky applied the name Baikalian to the orogenetic and magmatic epoch of this age. Within the area of the present Russian platform the Baikalian tectonic movements led to the production of three major shields—Baltic, Sarmatian and Tartarian—and two major geosynclines—Scandinavian and Uralian. The geosynclinal Rhiphaean sediments were deposited in well-marked sedimentary cycles, beginning with coarse conglomerates and breccia and finishing with fine-grained sediments.

Excavations at Dzibilchaltun in Yucatan

AN account of excavations carried out during three seasons by the National Geographic Society and Tulane University at Dzibilchaltun in north-western Yucatan, Mexico, has now been published (*Proc. Amer. Phil. Soc.*, 104, No. 3; June 15, 1960). Little has been known about the early phases of culture in this part of the world, and the exploration of some large buildings and temples and the determination of a definite stratigraphy are of great interest. To the prehistorian the date of the constructions (round about A.D. 500) might seem somewhat modern, but much hitherto unknown information of the earlier cultures in those little explored areas is here unfolded.

Nature Conservancy Awards for 1960

THE Nature Conservancy announces the following awards of research studentships for postgraduate training in ecology, tenable for periods up to three years at the universities shown: *Botany:* Miss M. C. Anderson (Cambridge), P. E. Gibbs (Liverpool), Miss M. M. McGrath (University College of North Wales, Bangor), J. G. Pusey (Oxford); *Zoology:* R. A. Avery (Bristol), D. E. Baird (Oxford), P. P. G. Bateson (Cambridge), Miss V. Healey (Manchester), D. J. Hobden (Southampton), W. W. Murdock (Oxford), Miss M. A. Murphy (Manchester), D. C. Seel (Oxford), J. B. Whittaker (Durham); *Geography:* Miss J. Wain (London); *Diploma Course in Conservation and Ecology at University College, London:* G. P. Allen, J. M. Davidson, K. East, A. J. Kerr, Miss J. J. Rowe, D. A. White.

The Beilby Medal and Prize, 1961

SINCE 1930, at intervals of one or more years, awards have been made by the administrators of the Sir George Beilby Memorial Fund, representing the Royal Institute of Chemistry, the Society of Chemical Industry and the Institute of Metals. In 1958 two awards, each of 150 guineas, were made. It was then agreed that no further award would be made before 1960. The administrators have now decided that henceforth each award shall consist of a gold medal as well as a substantial sum of money, and shall be known as "The Beilby Medal and Prize" and specified as being "For Advancement in Science and Practice". Such an award will be offered at intervals of two years, but more than one may be made on the same occasion if there are several candidates of sufficiently outstanding merit. Consideration will be given in due course to the making of an award (or awards) from the Fund in 1961, for outstanding work on the development and application of scientific principles in any field related to the special interests of Sir George Beilby, namely, in chemical engineering, fuel technology or metallurgy. Applications must be submitted not later than December 31, 1960, by letter addressed to the Convenor of the Administrators, Sir George Beilby Memorial Fund, Royal Institute of Chemistry, 30 Russell Square, London, W.C.1.

The Scientific Instrument Manufacturers' Association

THE following have been elected officers and council of the Scientific Instrument Manufacturers' Association of Great Britain for the year 1960–61: *President*, Mr. G. C. Ottway (W. Ottway and Co., Ltd.); *Vice-Presidents*, Mr. A. W. Jones (Fleming Radio (Developments), Ltd.), and Mr. L. A. Woodhead (Conor Instruments, Ltd., and retiring president). *Honorary Treasurer*, Mr. A. W. A. Rundle (A. Gallenkamp and Co., Ltd.); *Honorary Secretary*, Mr. E. R. Ponsford (Solartron Electronic Group, Ltd.); *Council Members*, Mr. S. T. Pickering (Chance Pilkington Optical Works), Mr. G. M. Sisson (Sir Howard Grubb Parsons and Co., Ltd.), Mr. G. S. Sturrock (Kelvin and Hughes, Ltd.) and Mr. R. Foxwell (The Wayne Kerr Laboratories, Ltd.).

University News: Churchill College, Cambridge

MR. C. ST. J. WILSON, of Corpus Christi College, has been elected to a fellowship as from October 1. The following elections to junior research fellowships from October 1 are announced: R. A. Y. Jones, of Clare College; A. O. Gilchrist, of Trinity Hall (Sydney Harvey Fellowship); C. B. Cottrell, University of the Witwatersrand and Queens' College

(Gulbenkian Fellowship); A. Howie, University of Edinburgh and Trinity College.

The following have been elected to Overseas Fellowships: Prof. E. E. Saltpeter, of Cornell University (from April 1, 1961); Dr. J. D. Watson, of Harvard University (from October 1, 1961).

Leicester

The following appointments have been made: Dr. S. G. M. Lee (Bedford College, London), to the new chair of psychology; Dr. M. C. R. Symons (Southampton), to the new chair of physical chemistry; Dr. H. L. Kornberg (Oxford), to the new chair of biochemistry.

Senior lecturers have been appointed as follows: W. B. Birmingham (economics); Dr. J. E. Brown (engineering); Dr. O. P. D. Cutteridge and Dr. R. W. Maxwell (engineering). Lecturers appointed include P. S. Cohen (sociology), D. J. Cockrell (engineering), and Dr. W. Sluckin (psychology).

London

Dr. Richard Creese, senior lecturer in physiology at the London Hospital Medical College, has been appointed to the readership in physiology tenable at St. Mary's Hospital Medical School.

Dr. L. M. Jackman, lecturer in organic chemistry in the Imperial College of Science and Technology, has been appointed to the University readership in organic chemistry tenable at that College.

Nottingham

Prof. A. G. Smith, professor of aircraft propulsion at the College of Aeronautics, Cranfield (see *Nature*, 181, 528; 1958), has been elected the first holder of the Hives chair of thermodynamics, endowed by Rolls-Royce, Ltd., in the University of Nottingham. Prof. Smith will be the head of the Department of Mechanical Engineering in succession to Prof. J. A. Pope.

Southampton

Westland Aircraft Ltd. has made a contribution of £17,500 to the centenary appeal issued by the University to provide, over a seven-year period, for a readership in helicopter engineering. The University has also gratefully accepted the offer by Union Carbide Ltd. of £2,150 per annum, for three years in the first place, to provide for a research fellowship and a research studentship in the Department of Chemistry.

Announcements

The Minister for Science, Lord Hailsham, has re-appointed the following part-time members of the United Kingdom Atomic Energy Authority: Lord Citrine, from January 1, 1961, when his present term of office expires, to December 31, 1961; Sir James Chadwick, from August 21, 1960, to August 20, 1962; Mr. C. F. Kearton, from October 17, 1960, to October 16, 1965.

Mr. James C. Bradley has been appointed as assistant secretary (management) of the Smithsonian Institution. Mr. Bradley succeeds Dr. John L. Keddy, who retired recently. Since January 1959, Mr. Bradley has served as assistant to the secretary, Dr. Leonard Carmichael, in the administration of the Institution's scientific, technological and cultural programme.

Dr. Marcel Autret, known for his work in the field of kwashiorkor and other protein-deficiency diseases, has been appointed director of the Nutrition Division of the Food and Agriculture Organization, in succession to Dr. W. R. Aykroyd. Dr. Autret joined the Organization in 1949, after a career in the French Colonial Service; he first became interested in nutrition while stationed in French Indo-China as head of the Chemistry Department of the Pasteur Institute in Saigon.

Miss Jennifer Remfry (Bedford College) has been appointed Junior Universities Federation for Animal Welfare (UFAW) Research Fellow to assist Dr. Phyllis G. Croft, UFAW Research Fellow, at the Royal Veterinary College, in research relating to anæsthetics and relaxants.

The next award of the Meldola Medal, the gift of the Society of Maccabaeans, will be made early in 1961 to the chemist who, being a British subject and less than thirty years of age on December 31, 1960, shows the most promise as indicated by his or her published chemical work. Further information can be obtained from the President, Royal Institute of Chemistry, 30 Russell Square, London, W.C.1, the envelope being marked 'Meldola Medal'.

For the sole use and convenience of its members the Physical Society of Japan has from time to time issued in a single volume a series of selected papers reprinted, with permission of the various publishers, from different American and European journals and dealing with a specific field of research. The latest in the series contains sixteen papers on the theory of atomic nuclei and includes articles, by N. Bohr, J. Frenkel, W. Heisenberg, L. Landau, E. Teller, V. F. Weisskopf and J. Wheeler. The period covered is 1932–40.

A course of lectures on "Problems of Radioactivity at Water and Sewage Works" will be held in the Manchester College of Science and Technology during September 29 and 30. Applications to attend must be sent to the Registrar of the College not later than September 19.

The Second Accelerator Conference is being organized by the High Voltage Engineering Corporation and its Dutch subsidiary and will be held in Amsterdam during October 4–6. It is hoped to cover most aspects of low-energy accelerator techniques in physics and in industry. Further information can be obtained from High Voltage Engineering (Europa) N.V., Post Box 99, Amsterdamseweg 57, Amersfoort, The Netherlands.

A symposium of five papers on "Drugs for the Treatment of Hypertension", arranged by the Royal Institute of Chemistry (Manchester and District Section) and the Society of Chemical Industry (Manchester Section and Fine Chemicals Group), will be held in the Tenants Hall, I.C.I. (Pharmaceuticals Division), Alderley Park, near Macclesfield, Cheshire, on September 30. After the symposium there will be a tour of the Research Department of I.C.I. (Pharmaceuticals Division). Further information can be obtained from Dr. G. A. Gamlen, Research Department, I.C.I. Ltd., Dyestuffs Division, Hexagon House, Blackley, Manchester 9.

Erratum. Dr. T. E. Cleghorn points out that a printing mistake occurred in the title of his communication in *Nature*, 184, 1324 (1959); this should read "A 'New' Human Blood Group Antigen, Sw^a".

SPACE RESEARCH IN BRITAIN: GRANTS

SIXTEEN grants to British universities for space research projects, totalling £184,540, have been made on the recommendation of the British National Committee on Space Research, set up by the Royal Society under the chairmanship of Sir Harrie Massey. The grants, which cover a variety of periods, are for salaries of staff, travel and subsistence, and development or purchase of special equipment. These grants have been approved by the Steering Group for Space Research, set up by the Minister for Science under the chairmanship of Sir Edward Bullard, and the financial responsibility for them is with the Department of Scientific and Industrial Research:

University College of Wales, Aberystwyth, £16,530 over 3 years, to Prof. W. J. G. Beynon for measurement of electron density/height profiles with rockets using the Doppler method and the pulse method.

Queen's University, Belfast, £15,005 over 2 years, to Prof. D. R. Bates for upper atmospheric rocket research, including artificial air-glow, altitudes of night-glow layers, and a study of micrometeorites.

University of Birmingham, £26,000 over 3 years, to Prof. J. Sayers for electron and ion-population studies of the upper atmosphere and interplanetary space.

University of Cambridge, £1,694 over 2 years, to Dr. K. G. Budden for research into the theory of propagation of radiations from artificial satellites; £2,678 over 2 years, to Prof. M. Ryle for the recording and the interpretation of Doppler and Faraday effects in the radiations from artificial satellites; and £11,230 over 26 months, to Dr. F. G. Smith for the measurement of cosmic radio noise by receivers mounted on rockets and satellites.

University of Leicester, £13,006 over 39 months, to Prof. E. A. Stewardson for investigations of solar and stellar soft X-ray emissions.

Imperial College of Science and Technology, London, to Dr. H. E. Elliot, £7,275 over 2 years for satellite measurements of the primary cosmic-ray energy spectron, and £1,500 over 2 years for an investigation into cosmic-ray intensity variations at rocket altitudes; also £7,935 over 3 years to Dr. S. H. Hall for geomagnetic field measurements in the Earth's upper atmosphere.

University College, London, to Dr. R. L. F. Boyd, £8,880 over 3 years for the development and use of photoelectric satellite tracking equipment, and £35,450 over 3 years for rocket research in the upper atmosphere of: (1) atmospheric temperature, density and winds; (2) ionospheric temperature, density and composition; (3) short-wave-length solar radiation; and (4) stellar ultra-violet light.

University of Manchester, to Dr. R. C. Jennison, £15,277 over 40 months for micrometeorite investigations from an Earth satellite (to be carried out at the Nuffield Radio Astronomy Laboratories, Jodrell Bank), and £15,020 over 44 months for low-frequency radio astronomy from an Earth satellite (to be carried out at the Nuffield Radio Astronomy Laboratories, Jodrell Bank); also £2,500 over 1 year, to Prof. A. C. B. Lovell for the tracking of satellites and space probes (to be carried out at the Nuffield Radio Astronomy Laboratories, Jodrell Bank).

University of Oxford, £4,560 over 18 months, to Dr. J. T. Houghton for the development of photoconductive material for satellite measurements of infra-red radiation.

THE BANGOR RESEARCH STATION OF THE NATURE CONSERVANCY

THE new Welsh headquarters of the Nature Conservancy was formally opened on July 20 by Prof. W. H. Pearsall, chairman of the Scientific Policy Committee of the Nature Conservancy. The building, of rough-cast stone and slate-roofed in the local Welsh style, is primarily designed as a laboratory, and its chief function is to act as the Conservancy's research station in Wales. It will, however, also house regional officers mainly concerned with the management of nature reserves and with the cartographic and advisory work of the region. The whole will be under the supervision of Dr. R. Elfyn Hughes, who has been appointed director (Wales), so that the Welsh organization of the Nature Conservancy now resembles that in force in Scotland.

As at present organized, the laboratories are equipped mainly for research in plant ecology. The special equipment is designed mainly for plant analysis and for detailed soil studies, especially the estimation of mineral elements and the properties of clay minerals. A notable feature is the provision of an X-ray fluorescence spectrograph, a new type of apparatus which it is expected will speed up and greatly extend the range of mineral analysis.

The facilities available are suitable for studying the general problems present in all nature reserves, the relation of vegetation to soil and the trends of change affecting these relationships. There are, however, special problems in Wales which are of fundamental importance and of the widest interest to highland Britain as a whole. The great range of rainfall easily accessible in Snowdonia as well as the diversity of rock type make it a most favourable centre for research on the effects of these factors, singly or interacting, upon the development of soils and vegetation. In Snowdonia the interest in this field lies especially in the grasslands and their animal life, and notably in the pattern of grazing by sheep. The evidence already obtained by Dr. Hughes stresses the great importance of the minerals derived from the soil in the interchanges and inter-relations between soil, plant and animal. It also raises the interesting possibility that high rainfall in the west of Britain may have an ameliorative effect as well as that to be expected from soil leaching.

In order to study these complex relations, it has been necessary also to envisage technical advances in the development of statistical methods for the analysis of the vegetation mosaics and their correlation with the complex soil characters, and the diversity of rainfall.

No part of Great Britain has, however, remained unaffected by the impoverishment of flora, fauna and soil induced by human activities in the past. Changes in land-use, even, for example, in the time of mowing a meadow, may have profound effects on the flora and invertebrate fauna. Thus, the increasing historical and archæological evidence accumulating in North Wales about early human settlement also offers considerable scope for developing knowledge of the influence of former land-use on existing vegetation and wild-life. This is a field of research which is scarcely possible elsewhere in highland Britain because of the scarcity of information about the past.

The basic researches which are thus developing owe much to the pioneer work on soils of the late Prof. G. W. Robinson, as well as to the more recent inspiration of Prof. Alun Roberts. They have also profited much from the existence in the University College of North Wales of strong Departments of Agriculture, Botany, Forestry and Zoology, the continued co-operation of which augurs well for the future.

While, in the present stage of investigation, much of the work centres around the general problems of upland and moorland vegetation and soils, there are other centres of developing research in the nature reserves, notably the special mountain floras and faunas, the dune vegetation and invertebrates at Newborough, and the problems presented by the woodland reserves now becoming available. These are likely to offer much scope for development into other fields of investigation as the primary researches mature.

THE DAVID NORTH PLANT RESEARCH CENTRE

THE Colonial Sugar Refining Co. is to build a plant research centre in Brisbane to conduct basic research on the sugar cane plant. The laboratory, costing £300,000, is to be completed by June 1961.

The Company has been well aware that, over the past twenty years, there has been a very considerable increase (more than 50 per cent) in the yield of agricultural productivity per acre. For example, in the United States, that of corn has risen about 80 per cent, milk by 40 per cent and beet sugar by 50 per cent. In contrast to this, the increase in yield per acre of cane sugar in Australia, and probably elsewhere, has risen only by 25 per cent. This suggests ample room for improving the yields of sugar. However, the scope for increasing the yields of sugar by conventional methods may be somewhat restricted as many of the clones which make up the present-day breeding material are the result of perhaps thousands of years of selection for sweetness and low fibre during cultivation by primitive communities and, secondly, the more obvious improvements, mainly associated with disease resistance, have been effected. Future important advances are only likely to be achieved through a background of thorough understanding of sugar cane physiology and genetics.

The laboratory will be known as the "David North Plant Research Centre", after Mr. David Shepherd North, who, as early as 1904, was investigating plant diseases in sugar cane. Later, he became interested in seed germination and breeding of cane. His pioneering work on both diseases and breeding in Australia did much to ensure the success and the stability of the industry.

In 1958, plans for the new laboratory were initiated in collaboration with Dr. H. R. Highkin, Dr. D. Koller and Mr. P. Keyes, of the Earhart Plant Research Laboratories at the California Institute of Technology. The basic plan of the new laboratory is very similar to that of the Earhart Laboratory, which was constructed in 1947–48, under the direction of Prof. F. W. Went. Five air-conditioned greenhouses, each of 240 sq. ft., are to be held at temperatures of the range 10–40° C. These are connected by an atrium to a group of eight constant-temperature rooms occupying 1,500 sq. ft. The rooms encompass a range of temperatures from 40° C. to frost conditions at $-10°$ C.

The constant-temperature rooms are each subdivided into four compartments which are artificially illuminated and provide opportunity to study the interaction of temperature, light intensity and light quality in growth and flowering. Means will also be available to control root temperatures independently of other environmental conditions. Because cane plants grow to considerable height, 20-ft. head-room has been allowed in all of the growing areas.

The remainder of the building is broken into two sections. The entrance to the whole structure is secured through air locks ; change rooms are provided, and visitors and staff alike are required to wear sterile clothing. The main laboratory area, 1,800 sq. ft., provides facilities for biochemical investigations with particular emphasis on tracer techniques.

Studies on the physiology and biochemistry of sugar cane were commenced in 1955 as a joint venture between the Botany Department of the University of Sydney, the Plant Physiology Unit, Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization and the Colonial Sugar Refining Co. The initial work covered studies on the respiration of sugar cane stalks and the germination of sugar cane sets. At the same time, basic studies were undertaken on the mechanism of auxin action in plants. This work showed that the adsorption of pectin methylesterase to the tissues of cell walls could be altered by the addition of auxin and synthetic auxins. Experiments with tissue slices demonstrated that pectin methylesterase could be extracted with dilute salt solutions and that the enzyme was partitioned between the tissue and the extracting solution. The equilibrium concentration of pectin methylesterase in solution was altered by the addition of auxin. Presumably the growth of the plant requires that pectin methylesterase be attached to the wall tissue, and the major action of the auxin is that it should be able to reach the appropriate tissue and cause adsorption of pectin methylesterase and perhaps other enzymes.

The group also investigated the movement of sugars into the storage tissues of cane. The uptake was shown to consist of two processes. The first process was that of diffusion into the outer space of the tissue volume, and was governed by the concentration gradient, equilibrium being attained in about half an hour. The second process continued at a constant rate for about 60 hr. and sugar moved against a considerable concentration gradient. The movement was prevented by anaerobic conditions and a number of metabolic inhibitors. This active uptake of sugar into the inner space is analogous to the accumulation of salts by other plant tissues. It was shown that only sucrose—and not reducing sugars—could be taken into the inner space, but that loss from this space was mainly glucose or fructose formed by hydrolysis, particularly in immature tissue. The turnover time for the sucrose pool for young tissue was about 9 hr.

To make use of these observations and other fundamental data, detailed studies are required of the effects of the environment on growth and the translocation and accumulation of sugars. Comparative studies will be made on different species and varieties within species of the genus *Saccharum*. The central interest will be the ability to store carbohydrate as sucrose.

The genetic make-up of commercial varieties of sugar cane is derived from *S. officinarum*, but virtually all varieties now cultivated carry genes from other species, usually with very low sugar content. Hybridization was carried out to increase vigour, resistance to disease, and to widen the range of climatic conditions in which cane can be cultivated successfully. It is anticipated that the comparative studies on sugar accumulation will provide knowledge of the mechanisms by which canes do or do not store sucrose, and this information can be used as a basis for studies on the physiological and biochemical genetics of sugar production.

The work at the David North Plant Research Centre will also include a comprehensive investigation on flowering in the genus *Saccharum* and several related genera and on problems associated with sterility and with the germination of its seeds. Complementing this programme, more general studies will be undertaken in the field of phytohormonal and chemical control of plant growth.

The research staff will consist of five graduates and assistants. Space will be made available for two or three guest research workers from other institutions to work with the Colonial Sugar Refining Co.'s group.

Other laboratories situated in Brisbane which carry out research on plants are located in several departments of the University of Queensland, at the Cunningham Laboratory of the Commonwealth Scientific and Industrial Research Organization and the laboratories of the Queensland Sugar Bureau. This concentration of research groups should establish Brisbane as a leading centre for research on tropical plants in the southern hemisphere.

K. T. Glasziou

SOME ASPECTS OF AUTOXIDATION

An informal symposium on the "Physico-chemical, Biological and Applied Aspects of Autoxidation" was held during April 4–5 in the Department of Inorganic and Physical Chemistry of the University of Liverpool. The meeting was organized by Dr. N. Uri (Ministry of Agriculture, Fisheries and Food Research Establishment, Aberdeen) on behalf of the Colloid and Biophysics Committee of the Faraday Society, and its host, Prof. C. E. H. Bawn, was its chairman.

On the afternoon of the first day four papers, dealing mainly with physico-chemical aspects, were presented to the meeting. Prof. J. C. Robb (University of Birmingham) spoke about a new method in work on autoxidation of hydrocarbons in the liquid phase. He explained the considerable experimental difficulties that are encountered when the rates of diffusion of oxygen from the gaseous into the liquid phase must be taken into account. A method has been developed in which the oxygen already dissolved is used up during kinetic measurements without the necessity for replenishment. The rate of reaction is followed by the measurement of rise in temperature by means of a thermocouple and a sensitive amplifier. A rise of 10^{-}[illegible] deg. C./sec. can be determined with a time response of about 10^{-}[illegible] sec. The sensitivity of the method enables one to study non-stationary build-up of radical concentration and to obtain quantitative information on rate constants of propagation and termination as well as reactivity of free radicals towards retarders. Autoxidation of *cyclo*hexene and methyl *cyclo*hexene have been studied at temperatures of 40–80° C.

The second paper, which dealt with the initiation phase in the aerobic oxidation of linoleic acid and its esters, was presented by Dr. N. Uri. Evidence was presented suggesting that metal catalysts are important even in the apparently uncatalysed autoxidation. A survey of the effects of heavy-metal stearates and porphyrins indicated that there must be a complex system of initiation involving oxygen–metal complex formation and subsequent formation of free radicals. A reaction scheme was proposed which involved reactions of the metal compound with oxygen, hydroperoxide and substrate and included an inhibitory reaction between metal and free radicals; the latter feature explained an anomalous curve obtained when the rate of reaction was plotted against metal catalyst concentration. Some experiments relating to the effects of environment and chelating on the catalytic activity of the initiaton were described. A brief survey of the effects or various novel free radical acceptors and their theoretical interpretation concluded the paper. If the discussion Dr. Ford (British Petroleum, Sunbury) directed attention to the fact that anomalous initiation curves were observed by him when hæm pigments were used as autoxidation catalysts.

Prof. C. E. H. Bawn introduced his paper on the metal-catalysed oxidation of alkyl aromatics by emphasizing the practical significance of this work in the synthesis of new products and in the deleterious effect causing break-up and degradation of oils and plastics. The oxidation of *iso*propylbenzene to phenol and of *p*-xylene to terephthalic acid are important examples. Recent discoveries have shown that the first stage of the oxidation of *p*-xylene, that is to say, to *p*-toluic acid, proceeds satisfactorily with the conventional cobalt and manganese catalysts, but the second stage requires the presence of bromide. Detailed kinetic results were presented, and a satisfactory mechanism involving initiation by the bromine atom in conjunction with the cobaltous–cobaltic cycle was proposed. Inhibition of the second oxidation reaction in the absence of added bromine was shown to be associated with the formation of phenolic inhibitors which are destroyed by bromine. In the discussion, Dr. Uri pointed out that metal-catalysed initiation in the oxidation of poly-unsaturated fatty acids is more closely related to that generally proposed by Prof. Bawn for aldehydes rather than that proposed for hydrocarbons. In reply to Prof. H. S. Olcott (University of California, Berkeley), Prof. Bawn explained that iodide could not replace bromide. Dr. C. H. Lea directed attention to various salt effects in the oxidative rancidity of fats which are not yet fully explained.

The fourth paper, by Dr. L. Bateman (British Rubber Producers' Research Association, Welwyn), dealt with the oxidation and antioxidant activity of organic sulphur compounds related to rubber vulcanizates. He emphasized that the response of these complex organic sulphides to atmospheric oxidation was not yet fully understood although it was apparent that it differed considerably from that of the parent hydrocarbon polymer. There are some distinctive features: the reaction is catalysed photolytically, by free-radical generators such as azo*iso*butyronitrile, but not by peroxides; α-hydroperoxysulphide initially formed is converted rapidly into sulphoxide and α-hydrosulphide and the reaction is subject to autoretardation. It was shown that sulphoxides formed from monosulphides and thiosulphinates formed from disulphides were efficient inhibitors of olefin oxidation. The effects of substituents on the efficiency of these inhibitors were discussed in detail, and stress was laid on the practical significance of these results in the interpretation of the oxidation characteristics associated with different vulcanizates.

On the second day of the meeting, Dr. J. Friend (Low Temperature Research Station, Cambridge) spoke about some aspects of the biologically catalysed aerobic oxidation of carotenoids. The nature of the enzyme systems responsible for the carotenoid destruction in plant tissue was discussed. These include lipoxidase and lipoperoxidase (recently studied by Dr. Blain) in seedlings and different enzyme systems in chloroplasts and mitochondria prepared from sugar beet leaves; the latter do not require the presence of linoleic acid or diene hydroperoxide. A comparison of the degradation products by enzymic oxidation and non-enzymic oxidation catalysed by linoleate and ferrous phthalocyanine revealed close similarity.

In a paper on the aerobic oxidation of plant phenols and its biological implications, Dr. D. E. Hathway (British Leather Manufacturers Research Association, Egham), exemplified the synthesis of larger molecules from simple phenols by dimerization of semiquinones and polymerization through quinones. Thus, autoxidation of alkyl gallates in alkaline medium leads to ellagate, whereas quinone polymerization occurs during the autoxidation of (+)-catechin. A similar polymer was isolated from *Acacia catechu* heartwood, and it was suggested that it arises as a result of aerobic oxidation in the heartwood tissue. Some further examples of natural phenolic polymers were presented. It was pointed out that aerobic oxidation of catechins and other flavan-3-ols appears to account for the origin of some of the condensed tannins, particularly in tan barks. Brief mention was made of the anti-fungal and anti-viral protective properties of tannin, which, especially in stembark, may have contributed to the successful evolution of existing forest trees.

Prof. H. S. Olcott (University of California, Berkeley) spoke about the effects of tocopherols in autoxidizing systems. He also directed attention to the vitamin E activity of selenium compounds and wondered whether their antioxidant activity is based on the formation of oxides similar to those described by Dr. Bateman in the case of sulphur compounds. The antagonizing effect of free fatty acids on the activity of phenolic antioxidants was contrasted with the synergistic effect of simple amines. With bases such as tri-*iso*-octylamine, more effective synergism was demonstrable with phenolic antioxidants that possess a hydrogen atom adjacent to the phenolic group (γ-tocopherol, butylated hydroxy anisole) than with those in which these positions are substituted (α-tocopherol, butylated hydroxy toluene). Relatively large amounts of aliphatic amines (in the order of 1–2 per cent) act themselves as antioxidants in lard and exhibit an anomalous dependence on temperature in their efficiency. In the discussion of this paper Dr. Barnard (British Rubber Producers' Research Association, Welwyn) confirmed that selenium compounds were found to be more efficient antioxidants than the corresponding sulphur compounds. Dr. E. M. Learmonth (British Soya Products, Puckeridge) directed attention to the instability of purified soybean oil and the synergistic effects of phospholipids. Dr. Uri said that some of the anomalous concentration effects could be explained by the disappearance of the antioxidant by the 'forbidden route' of a chain reaction, and some of the anomalous temperature effects could conceivably be due to chelating of amines with traces of metal porphyrins. Dr. Bateman proposed that certain synergistic effects should be ascribed to a high reactivity of one antioxidant towards $RO_2\cdot$ radicals and a high reactivity of the other towards $R\cdot$ radicals.

Presenting his paper on autoxidation in relation to food, Dr. C. H. Lea distinguished between the major autoxidizible constituent, that is, unsaturated fatty acids, and a wide variety of minor but almost equally important substances; their oxidation is frequently coupled with that of the fats. Dr. Lea went on to survey the main primary and secondary products as well as their effects on flavour, nutritive value and possible toxicity. Finally, a number of factors which influence autoxidative reactions were discussed, including both pro-oxidant and anti-oxidant effects in general, the action of hæm protein catalysts and lipoxidase, and finally the variable effects of ascorbic acid which, depending on the environment, acts either as pro-oxidant or as anti-oxidant.

The last paper of the meeting was that of Dr. L. A. O'Neill (Paint Research Station, Teddington) on problems of autoxidation in the paint industry. He pointed out that paints which depend on the autoxidation of a drying oil or a polymeric derivative thereof, such as an oil-modified alkyd resin, are still the most widely used class. The oxidation involves the formation of —C—C— polymers via conjugated peroxides. Emphasis was placed on the interesting distinction between the catalytic action of cobalt compounds with oxidation spreading from the surface into the body of the medium and that of lead compounds with uniform oxidation of the bulk of the oil. Oximes are used as temporary antioxidants for storage in containers and afterwards lost from the surface film. Mercaptans prevent the oxidation from proceeding towards degradation. The nature of 'yellowing' on prolonged ageing, which is accelerated by ammonia and other bases in the atmosphere, is not yet fully understood.

N. URI

AVERAGE WATER VAPOUR CONTENT OF THE AIR

IN a recent memoir issued by the Meteorological Office, J. K. Bannon and L. P. Steele outline the first use of humidity observations made with radiosondes to describe, on a nearly world scale, the variation with height of the mean water vapour content of the atmosphere (Air Ministry: Meteorological Office. Geophysical Memoirs No. 102: Average Water-Vapour Content of the Air. Pp. ii+38. (M.O. 631*b*). London: H.M. Stationery Office, 1960. 8*s*. 6*d*. net). Previous work of this nature was necessarily carried out by extrapolating from surface values with empirical formulæ, deduced from mountain observations, for the rate of decrease with height.

The data, which are for the period 1951–1955, are presented in the form of charts for January, April, July and October of isopleths of the average weight of water vapour in decigrams above 1 square centimetre at the Earth's surface and the isobaric surfaces for 850 mb. (about 1·5 km. height), 700 mb. (about 3 km.) and 500 mb. (about 5·5 km.). Surface pressure is about 1,000 mb.

The authors necessarily devote much space to a detailed discussion of the observations and of the difficult problems involved in reconciling observations made with different types of radiosonde and allowing for instrumental defects such as lag.

The most obvious feature of the charts at any on level is that water content is highest over the equatorial rain forests and India in the summer monsoon, and least over the polar regions. Values are notably low for the latitude over the Sahara, where they are about the same as over Europe, but the other great desert areas are not very prominent in the run of the isopleths. Comparing the charts at different levels, it is clear that at all seasons, and over all areas on the average, half the water vapour content of the atmosphere is below 850 mb., far below the corresponding level for air at 500 mb. The highest value is over India in the summer monsoon, when the atmosphere holds 64 decigrams of precipitable water. Above the equatorial belt there is about 50 decigrams. Over the British Isles in winter the amount is about 11 decigrams and in summer 24 decigrams.

The charts permit rough calculations to be made of the ratio of precipitation to storage of water vapour in the atmosphere. Over the Earth as a whole the store is equivalent to nine days rainfall, but over wet cool regions such as the British Isles in winter the average store is equivalent to only about three days rainfall. Such differences in the storage ratio reflect differences in the manner of production of rain, which is mainly by convection of 'local' water vapour over the hot regions and by advection from over the oceans in cool ones.

FREEZING AND DRYING OF BIOLOGICAL MATERIALS

IN recent years much has been said about the rift between science and the humanities. Nevertheless, the majority of scientists are interested in history or literature, music, drama or art, while most students of the humanities use products of science and notice the impact of others on the world at large. The widening gap between different scientific disciplines may be more serious. A stage is approaching when biologists and physicists will no longer understand one another whether they try to communicate orally or by writing. Several attempts to bridge this gap have already been made by those who investigate the effects of low temperatures and of desiccation on living cells and tissues and on their products.

The publication "Freezing and Drying of Biological Materials" is based on a conference held at the New York Academy of Sciences in October 1959[*]. It forms a valuable sequel to two colloquia organized by the Institute of Biology in 1951 and 1958, to the discussion at the Royal Society in 1957, and to Prof. D. Keilin's Leeuwenhoek Lecture in 1958. This is not a book for beginners. Dr. H. T. Meryman is over-optimistic in saying that a stage of simplification has been reached in cryobiology. Prof. B. Luyet is nearer the truth in thinking that the biologist who works at low temperatures is in "a chaos of disequilibrium and disorder". Dr. Luyet has, himself, thrown further light on the phase transition in gelatin gels and in solutions of glycerol, sugars and other biological media at low temperatures. Dr. J. L. Stephenson has continued his mathematical analysis of the process of crystallization in model biological specimens during rapid freezing. Prof. L. Rey admits that it is almost impossible to measure the eutectic temperatures of natural substances; nevertheless, he assesses the 'eutectic requirements' of biological materials in order to reduce damage after thawing or reconstitution from the dry state. Dr. C. V. Lusena finds that rates of formation, dissolution and redistribution of ice are very slow in solutions of glycerol below −40° C. Dr. A. C. Taylor reports that few cells from human conjunctiva or avian skin survive rapid cooling in one stage to −78° or to −120° C. or when the formation of ice is accelerated by use of hydrostatic pressure. Dr. P. Mazur thinks that when certain micro-organisms are cooled rapidly in the range below −15° C. ice crystals in the frozen medium could seed the supercooled interior of the cells by passing through minute pores in the cell membrane; damage, which occurs when slow thawing follows rapid cooling, might be due to migratory recrystallization of the intracellular crystals.

---

[*] *Annals of the New York Academy of Sciences*. Vol. 85, Article 2: Freezing and Drying of Biological Materials. By Harold T. Meryman and 12 other authors. Pp. 501–734. (New York: New York Academy of Sciences, 1960.)

Contributions from authors absent from previous conferences are particularly welcome. Dr. J. Levitt describes freezing injury in plants; but his attempt to produce a single theory to explain the cause of damage in cells of animals and plants is less successful. Dr. A. P. Rinfret has studied factors affecting the erythrocyte during rapid freezing and thawing in the absence and the presence of glycerol and other protective substances. Dr. A. L. Hopkins has used radio-frequency spectroscopy to study biological media, human erythrocytes and frog ventricles at temperatures between 0° and −100° C. In a striking paper, Dr. H. Fernández-Morán describes the properties of liquid helium II and its use for preparing specimens of mammalian tissue for electron microscopy. He claims that his technique gives superior preservation of macro-molecular structures. Cytologists will need considerably more evidence and illustrations to convince them that freezing at −272° C. is necessary when subsequent staining is carried out at −150° C.

Dr. T. W. G. Rowe, in an excellent account of the theory and practice of freeze-drying, employs two useful terms: the 'Torr', a measure of vacuum equivalent to a pressure of 1 mm. mercury, and the 'Lusec', the rate of leakage under a pressure difference of 1 atmosphere of 1 litre/sec. at a pressure of 1μ. Principles of freeze-drying are also elucidated by Dr. H. T. Meryman and Dr. R. I. N. Greaves. Dr. Greaves discusses factors involved when viability of bacteria and other living cells is to be preserved by desiccation and stresses the importance of the composition of the medium surrounding them. Dr. Meryman and Dr. E. Kafig are the first to have successfully preserved mammalian cells by freeze-drying. Rat erythrocytes were intact and bull spermatozoa resumed motility after drying and reconstitution under the special conditions of their experiments. It is hoped that this interesting result with bull spermatozoa will be confirmed in other laboratories.

A number of typographical errors have been noted; the figure legend on p. 523 is incorrect. Verbal efflorescences such as "organoleptic properties" (p. 527) to describe meat, "operational complementarity" and "sequentially arrested states" (p. 690) will do little to bring physicists and biologists together and would drive Mr. Thurber to his psychosemanticist. The editors are, however, to be congratulated on the speed with which they have published the report of this important conference.

AUDREY U. SMITH

U.S. NATIONAL ACADEMY OF SCIENCES–NATIONAL RESEARCH COUNCIL

ANNUAL REPORT FOR 1958–1959

THE annual report for 1958–59 of the National Academy of Sciences–National Research Council includes the review of the president, Dr. Detlev Bronk, reports on the autumn meeting, 1958, and annual meeting, 1959, of the National Academy, the Treasurer's report, list of publications and reports on the activities of the Academy and the Research Council, including those of the several Divisions, those not assigned to a Division, of the Office of International Relations, of the Office of Scientific Personnel, and of the United States National Committee for the International Geophysical Year (pp. viii+224. Washington, D.C.: Government Printing Office, 1960. 70 cents). The president in his review stresses the increasing concern of the Academy–Research Council with international scientific activities. The new Committee on Oceanography, an outgrowth of the International Geophysical Year, completed a report on the status and needs of all phases of oceanography and its opportunities, which has already stimulated greater interest in oceanography and support for oceanographic research, including provision by the National Science Foundation of a new research vessel. As a result of a conference held under the auspices of the Academy and the President's Science Advisory Committee to consider how science and technology can be used more effectively by the International Co-operation Administration in its programmes of foreign assistance, the Academy was requested to study the possibilities for such assistance to the regions of Africa south of the Sahara and north of the Union of South Africa.

During this first formative year of the National Aeronautics and Space Administration, the Space Science Board, established in June 1958, after securing programme recommendations from a broad cross-section of the scientific community, sought to develop a short-range space science programme.

Physics, chemistry, mathematics, astronomy, geology, geophysics, psychology and biology are all represented on the Board. Many biologists are planning for research undertakings in outer space and to provide a forum for their discussions and planning an Armed Forces–National Research Council Committee on Bio-astronautics has been established.

The Committee on Fire Research has recently broadened the scope of its interests to include consideration of the causes and control of all unwanted fires, such as forest fires, and publication of *Fire Research Abstracts and Reviews* as a periodical was commenced. A Research Correlation Conference on "Noise Control in Buildings" was sponsored by the Building Research Institute and a committee set up for the study of agricultural pests and their control. Two temporary committees were appointed to supplement the work of the Materials Advisory Board, one to consider and define the more promising areas of research in solid-state physics and metallurgy, and the other to deal with the organization and support of materials research in the universities, industry and government.

The Division of Medical Sciences commenced a survey of needs in tropical medicine, and its Committee on the Cardiovascular System is seeking to stimulate interest in research into the central nervous control of circulation, but the Committee on Infectious Diseases and Chemotherapy is being dissolved to make way for a more fundamentally oriented group. The activities of the Division of Chemistry and Chemical Technology markedly increased, particularly in the international field; the Division of Engineering and Industrial Research was also much occupied, and its Committee on Ship Steel and Ship Structural Design continued to assist the research programme of the inter-agency Ship Structure Committee by formulating research programmes in these fields. These include a study of the influence of metallurgical structure on the brittle behaviour of ship steel, a comparison of the influence of manganese, carbon and other elements on notch-impact properties, and efforts to increase knowledge of the response by ships to ocean waves and of brittle fracture mechanics.

The Office of International Relations has worked vigorously to foster exchanges of scientists between the United States and the U.S.S.R. and to facilitate travel there of United States scientists. A programme of reciprocal exchanges was negotiated between the Academy and the Academy of Sciences of the U.S.S.R. and arrangements were made for the participation of United States scientists in more than thirty international scientific meetings.

RECRUITS TO TEACHING IN GREAT BRITAIN

An inquiry by F. W. Land, of the University of Liverpool, was undertaken primarily in order to investigate the factors which were restricting the recruitment of a sufficient number of students in training colleges who were able and willing to teach mathematics and science*. This problem must be looked at as a facet of the larger problem of producing the whole body of teachers who should have, between them, a proper balance of subject interests. Although smaller in number, the trained graduates from universities take a role in this balance which, in many respects, is crucial, since they provide the greater part of the staffs of grammar schools from which are recruited the majority of the training college students.

The problem of university teacher-training departments is that mathematics and science graduates are not coming forward for training as teachers, whereas the training college problem is that those who are electing to train as teachers are reluctant to study mathematics and science. The Association of Teachers in Colleges and Departments of Education report of 1956 made it clear that this can only be brought about by a manifold increase in the number of mathematics and science graduates coming forward to train for service in both grammar schools and training colleges. This, in turn, depends on the ability of the universities to recruit more mathematics and science students and upon the willingness of industry to curb its seemingly insatiable demand for mathematics and science graduates.

Any future increase in the number of science undergraduates will depend on the ability of schools to supply further recruits able to undertake university courses, and this, in turn, is dependent upon a supply of science teachers. For the time being, until the critical supply of teachers has been rectified, industrialists should be asked how many of the posts now being filled by graduates could be filled with less highly qualified persons without substantially reducing industrial efficiency.

Mathematics and science pose problems for the training colleges which are of a different nature. Throughout the infant and junior schools almost all teachers are called upon to teach arithmetic. In secondary schools there is no possibility for years of having enough properly qualified teachers to provide specialist mathematics teachers for all children, and it is a debatable point whether studies such as English and mathematics, which are basic to all other studies, should be taught by specialists throughout the secondary schools. Most secondary teachers must expect to teach some arithmetic at least, even if the more specialized parts of the mathematics syllabus are in the hands of specialists. For this reason the arithmetical competence of all training college students is a matter of direct and intimate importance to their teaching.

Science teaching will be much more in the hands of the specialists. In secondary schools, specialists with responsibilities for laboratories must teach the greater part of science. In many junior schools in Britain almost no science is taught at all. Although it is highly desirable that more science be introduced into junior schools, it will not be highly specialized science calling for special qualifications, and any well-educated teacher ought to be able to cope with junior school science as he is expected to cope with junior school geography, history or handwork. The demands of schools are for an *adequate* proportion of students to be well qualified to serve as science specialists, and, in addition, it is desirable that *all* teachers should be informed about the basic nature of the scientific developments which are such a common feature of the environment in this second half of the twentieth century.

---

* Recruits to Teaching: a Study of the Attainments, Qualifications and Attitudes of Students entering Training Colleges. By F. W. Land. Pp. 83. (Liverpool: The University Press, 1960.) 7s. 6d. net.

For all students, standards to be desired are: sufficient mastery in both English and mathematics to qualify them as competent to teach the subjects, a generally balanced education which includes a fair knowledge of and interest in all the main subjects of the curriculum, including chemistry and physics as well as history and geography and art and music, together with a more specialized interest in a particular subject which has been studied to the standards for examination at Advanced Level of the General Certificate of Education, and which will be their own individual contribution to the vitality of the teaching in their school. The interests of the schools require that the more specialized main studies should be so distributed among the teachers that the staffs of schools are not unduly biased in their interests and include representatives of all the main intellectual disciplines.

These desirable standards are fulfilled in respect of English. The fact that the outlook for English is so healthy with entrants to training colleges is a reflexion of the fact that five times as many women honours graduates in English are being fed into schools by university departments as correspondingly qualified mathematicians.

In arithmetic and mathematics the position is most unsatisfactory. In mathematics only just over half the students enter training colleges with passes at Ordinary Level of the General Certificate of Education, women students rate it tenth on their lists of interests and 44 per cent say either that they dislike it or they derive no enjoyment from it. The Vernon Test discloses such gross shortcomings in simple arithmetic that many students will have to spend time on basic arithmetic in the course of their training. In Land's investigation only 193 women students out of 1,880 have elected to study mathematics as a main subject.

For the 90 per cent of students who are not taking main mathematics, provision must be made to give them ample opportunity to prepare themselves for whatever arithmetic and mathematics teaching comes their way. Approximately half of these seem to have sufficient competence to begin on a course which should have a two-fold aim. A necessary part of this course should be to interest them in using the mathematical skills they have, so that they begin to value their irreplaceable contribution to the understanding and appreciation of the world around them. This calls for the exercise of considerable imagination and versatility, and, at present, many training colleges do not find sufficient time on their time-tables to enable this task to be attempted with any hope of success. The other part of their course will be more closely pedagogical and devoted to 'methods of teaching'.

For the other half of the students, these two courses need to be preceded and accompanied by a further course in basic arithmetic and mathematics. Such a course should begin with the assumption that there is no confident facility with number work. It must also take into account that achievement and understanding have been limited to arithmetic and that there is no background of appreciation of mathematical ideas to build on. It must start with the acceptance of shortcomings in the powers of visualization of mathematical concepts, and, so far as possible, begin with simple arithmetical processes and build up some picture of mathematical development without much recourse to abstract ideas, formulæ or formal geometry.

The staffing needs of mathematics ought to be reassessed. That about a quarter of the women's colleges have been without full-time mathematics lecturers has always seemed, in Land's words, "to have been scandalous".

ASSOCIATION BETWEEN AURORÆ AND VERY LOW-FREQUENCY HISS OBSERVED AT BYRD STATION, ANTARCTICA

By L. H. MARTIN, Dr. R. A. HELLIWELL
Radioscience Laboratory, Stanford University, Stanford, California
AND
K. R. MARKS
U.S. Antarctic Research Program, Washington 25, D.C.

OBSERVATIONS during 1959 at Byrd Station, Antarctica (lat. 70·5° S. geomagnetic), show a close association to exist between auroræ and certain very low-frequency hiss. The hiss usually occurs in a broad band with a centre-frequency of about 8 kc./s. The intensity and band-width vary with ionospheric absorption and may also vary with the intensity of the auroræ. Under conditions of extreme ionospheric absorption, the intensity of the hiss drops to undetectable levels even in the presence of intense and active auroræ. There are some indications that the centre-frequency of this auroral hiss may be related to the type of aurora; in particular, a centre-frequency of 9·6 kc./s. appears to be associated with red aurora. The average field intensity of the auroral hiss lies between 1 mV./m. and 3 mV./m.

The hiss was received with equipment designed for the study of whistlers and related very low-frequency phenomena. This equipment consists essentially of a large vertical-loop antenna matched to a wide-band (150 c./s.–30 kc./s.) audio amplifier. The signals received were automatically recorded for 2 min. each hour. Auroral data were obtained visually as part of the regular International Geophysical Year programme.

The close association between the occurrence of auroræ and very low-frequency hiss on frequencies greater than 4 kc./s. can be seen from the contingency tables.

Table 1. OCCURRENCE AND ABSENCE OF AURORÆ AND VERY LOW-FREQUENCY HISS ABOVE 4 KC./S.

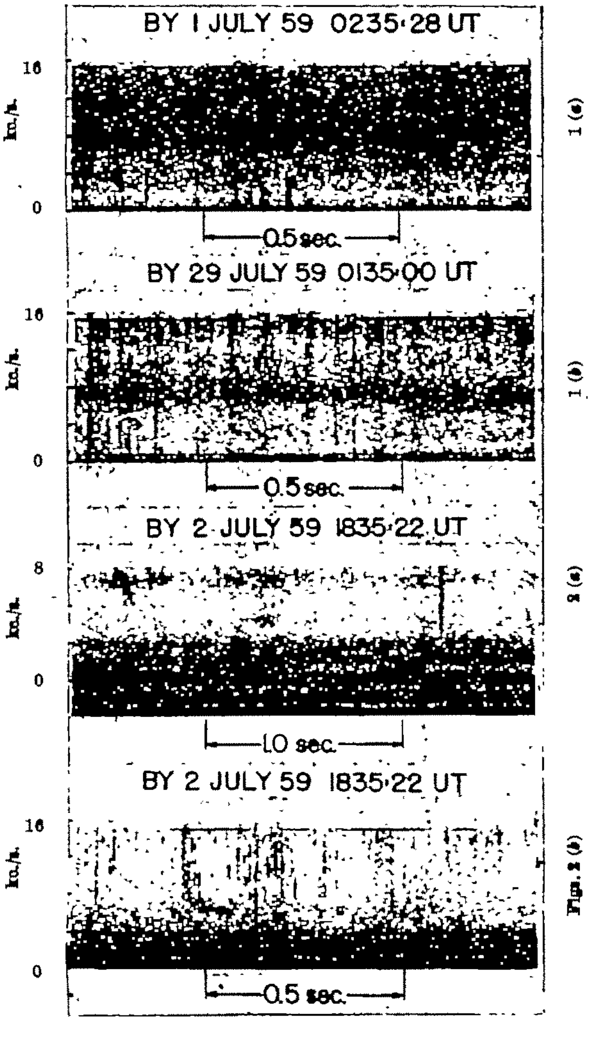
		Hiss above 4 kc./s.	
		Yes	No
Auroræ	Yes	213	18
	No	31	334

The contingency table of actual results (Table 1) may be compared with the equivalent random table (Table 2), which shows the results that would be expected if there were no association whatever between the very low-frequency hiss and auroræ.

Table 2. RANDOM CONTINGENCY TABLE OF OCCURRENCE AND ABSENCE OF AURORÆ AND VERY LOW-FREQUENCY HISS ABOVE 4 KC./S.

		Hiss above 4 kc./s.	
		Yes	No
Auroræ	Yes	93	138
	No	151	214

This comparison shows the significant association between the occurrence of the very low-frequency hiss and auroræ. A statistical (χ^2) test on the above tables gives $\chi^2 = 418$ for three degrees of freedom, thus strongly supporting the inference drawn from an inspection of the 'Yes—Yes' figures.



Figs. 1 and 2

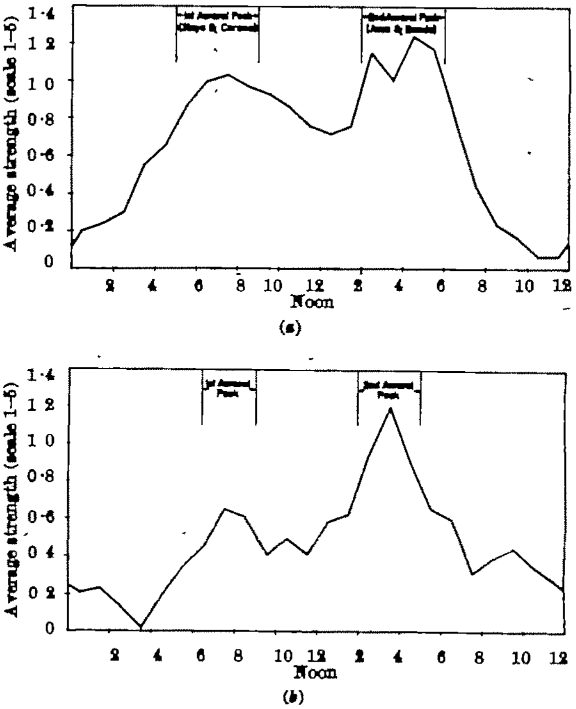


Fig. 3. Diurnal variation of hiss at frequencies greater than 4 kc./s. at Byrd Station. (a) July 1959; (b) August 1959

As Table 1 shows, hiss occurring on a frequency greater than 4 kc./s. cannot always be associated directly with auroræ, nor can visible auroræ always be associated with hiss. The 31 occasions when hiss was observed but no auroræ reported coincide with periods when visual observations were not possible due to cloud cover or bright moonlight conditions; it is probable that auroræ did occur on these occasions and the discrepancy is not regarded as significant. The 18 occasions noted when auroræ were observed without hiss occurring can be attributed to complete absorption of the hiss signal in the lower ionosphere during blackout conditions. During the prolonged ionospheric storm of July 10–16, 1959, which was accompanied by considerable auroral activity, no hiss was observed during the periods of complete ionospheric absorption. The hiss signals returned simultaneously with the return of high-frequency echoes on the vertical-incidence ionosonde.

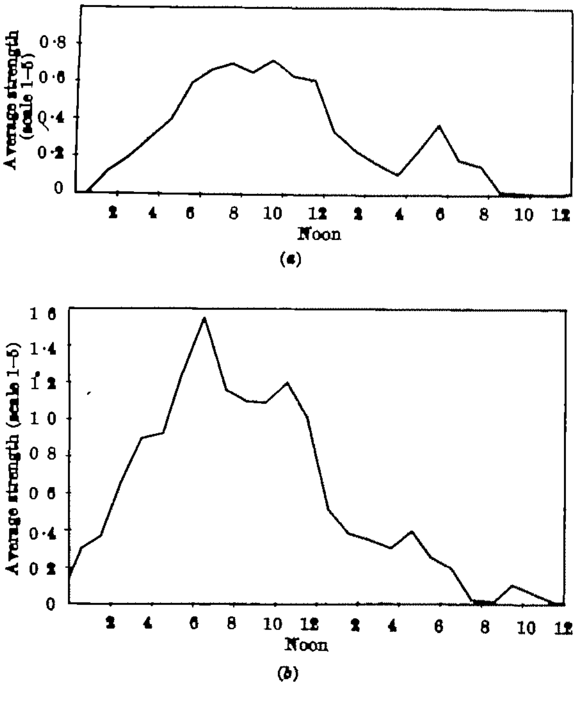
Auroral hiss as observed at Byrd Station is different in character from the usual very low-frequency hiss observed at this Station. The normal hiss band lies at frequencies less than 4 kc./s. and the hiss is usually associated with 'chorus', a mixture of rising and falling tones. Figs. 1*a* and 1*b* show a typical sonagram of the 'auroral' hiss, and it can be seen that the greater part of the energy is concentrated at frequencies greater than 4 kc./s. and that the hiss extends above 16 kc./s. Figs. 2*a* and 2*b* show a typical sample of the normal very low-frequency hiss received at Byrd Station. Here the greater part of the energy is concentrated at frequencies less than 4 kc./s. and the hiss is accompanied by 'chorus'. The lower-frequency limit of the hiss appears to extend below 150 c./s., which is the low-frequency cut-off of the equipment.

The diurnal behaviour of the 'auroral' and the normal very low-frequency hiss are significantly different. The average diurnal variation of the 'auroral' hiss for July and August, 1959, plotted in Figs. 3a and 3b shows two diurnal peaks, each coinciding with periods of maximum auroral activity. The diurnal behaviour of all other hiss for these months is plotted in Figs. 4a and 4b. These curves show one significant peak and closely follow the diurnal pattern of 'chorus' activity as plotted in Figs. 5a and 5b.

Figs. 3a and 3b show two diurnal maxima, each corresponding to different types of auroral activity. It has been suggested[1,2] that these bi-diurnal peaks result from different diurnal distribution and characteristics of auroræ occurring in two distinct auroral zones, an inner zone, about 10° from the geomagnetic pole, and an outer zone, about 20° from the geomagnetic pole. The diurnal peak of auroral activity of the inner zone coincides with the diurnal peak in chorus and very low-frequency activity at frequencies less than 4 kc./s. Further study of this coincidence is required before any great significance can be attached to it.

Very low-frequency noise associated with auroræ has been previously reported by other workers. The simultaneous occurrence of sub-visual aurora, observed with a sky-scanning photometer, and 4·6 kc./s. noise observed on a narrow-band receiver at lat. 42° S. geomagnetic as reported by Duncan and Ellis[3] are not inconsistent with the observations at Byrd Station.

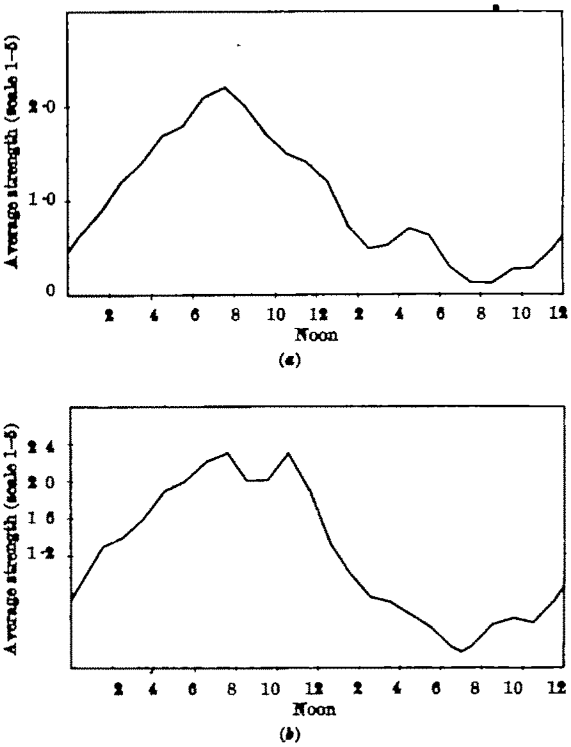
The origin, or origins, of very low-frequency hiss and associated emissions is not yet understood. Hypotheses have been advanced based on: (1) selective travelling-wave amplification in the outer ionosphere[4]; (2) Čerenkov radiation[5]; and (3) proton gyro-resonance[6]. The first two are similar in many respects and do not appear to be inconsistent with the observations reported in this article. However, the proton gyro-resonance hypothesis would seem to be applicable only to hiss occurring at frequencies less than that of proton gyro-resonance as pointed out by Aarons *et al.* Since the dominant hiss associated with auroræ occurs at frequencies greater than 4,000 c./s. and the maximum possible proton gyro-frequency is about 800 c./s., it appears that this hypothesis cannot account for the 'auroral' hiss observed at Byrd Station.



(a)

(b)

Fig. 4. Diurnal variation of hiss at frequencies less than 4 kc./s. at Byrd Station. (a) July 1959; (b) August 1959



(a)

(b)

Fig. 5. Diurnal variation of 'chorus' at Byrd Station. (a) July 1959, (b) August 1959

Further studies of available results are in progress, and it is expected that the occurrence and frequency distribution of the hiss bands throughout one year will be established. Further field observations should seek to determine the detailed relationships between the spectral characteristics of hiss and aurora. In addition, it is important to determine the spatial distribution of hiss with geomagnetic latitude. This might be accomplished using suitable direction-finding techniques or spaced-station studies along a line of geomagnetic longitude.

The very low-frequency observations at Byrd Station were made by K. R. Marks, and subsequent analysis of the recorded tapes was carried out at the Radioscience Laboratory, Stanford University, under National Science Foundation Grant 9511. The auroral data were compiled from observations by Mr. Marks and reports were issued by the U.S. Antarctic Research Program of the National Science Foundation.

---

[1] Lassen, K., *Nature*, **184**, 1375 (1959).

[2] Fel'dshtyn, Ya. I., *Izvest. Akad. Nauk S.S.S.R.*, Ser. Geofiz., No. 1, 170 (1959).

[3] Duncan, R. A., and Ellis, G. R., *Nature*, **183**, 1618 (1959).

[4] Gallet, R. M., and Helliwell, R. A., *J. Res. Nat. Bur. Stand.*, **63D**, 21 (1959).

[5] Ellis, G. R., *J. Atmos. Terr. Phys.*, 10, Nos. 5/6, 302 (1957).

[6] Aarons, J., Gustafsson, G., and Egeland, A., *Nature*, **185**, 148 (1960).

PRECISION INTERCOMPARISONS OF LEAD ISOTOPE RATIOS: BROKEN HILL AND MOUNT ISA

By F. KOLLAR, Prof. R. D. RUSSELL and T. J. ULRYCH
Geophysics Laboratory, Department of Physics, University of British Columbia, Vancouver, 8

VARIATIONS in the isotope ratios of lead as observed in Nature are being used to a steadily increasing extent for such problems as determining the mode of emplacement of sulphide ore bodies, estimating the absolute ages of deposition of certain mineral deposits and as a means of obtaining geochemical information about the distribution of uranium, thorium and lead in the outer parts of the Earth. The precision with which such measurements can be made is variable, and it is difficult to state an overall average, but uncertainties in a single analysis ranging from a few tenths of 1 per cent in the various ratios up to nearly 1 per cent certainly occur. As more and more sophisticated methods for analysing these data are developed the interpretations become more and more dependent on the available precision. We have recently constructed a mass spectrometer and have developed techniques which enable lead isotope ratios to be compared with a precision substantially better than that previously obtained. It is the purpose of this article to show some examples of the precise intercomparison of lead samples and to make a few preliminary interpretations of the results obtained.

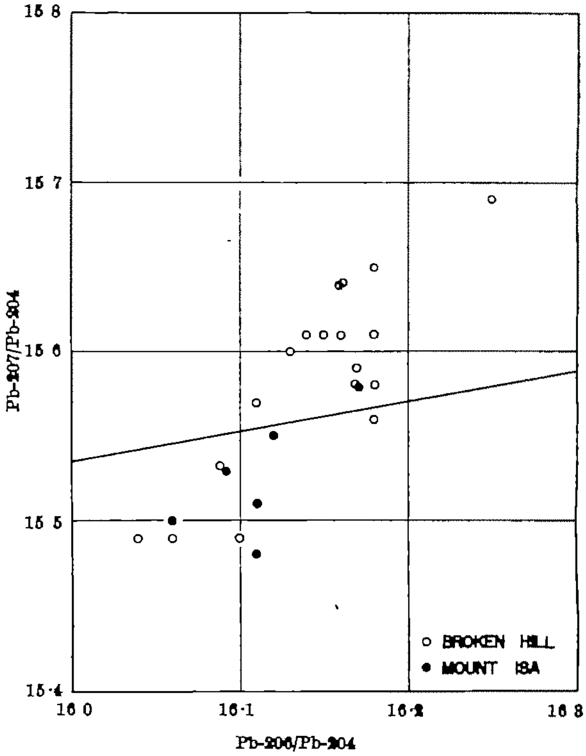


Fig. 1. Measured lead isotope ratios by the University of Toronto. The solid line is the conformable lead curve selected by Russell and Farquhar (in the press)

All the measurements described in this article were made on a 12-in. radius, 90° sector-type, direction-focusing mass spectrometer constructed in our laboratory. Apart from the fact that this instrument makes use of transistor and magnetic amplifiers in the various power supplies[1], it is not substantially different from the usual instruments of its size. Principal differences that contribute towards increased precision are the stability of the filament emission control, which is somewhat better than in many instruments, and the use of a servo voltmeter to measure the ion currents, which enables us to make a peak height measurement with a precision much greater than we could obtain by measuring the record obtained with a chart recorder. Even with this precision and stability we are able to observe small variations in the ratios measured in a single sample from day to day. These variations are about 1/10 of 1 per cent. In order to minimize this effect we have compared each sample with a standard by observing alternatively two pairs of the sample spectra and two pairs of the standard spectra. Our procedure has been to compare the standard with one sample, then to compare this sample with a second, and finally to compare the second sample again with the standard. This gives a closed loop around which the deviations should sum to zero. In the measurements we obtain there is a closure error which is distributed among the measurements in the loop. Thus to obtain values

Table 1. Differences in Measured Lead Isotope Ratios

No.	Description	Deviation from standard in ratio shown					
		204/206	207/206	208/206	206/204	207/204	208/204
	Broken Hill						
1	Main lode, No. 2 lens, No. 15 level	0	0	0	0	0	0
30	Centennial Mine	−0·002	−0·03	$+0\cdot1_{2}$	+0·006	+0·001	$+0\cdot03_{4}$
31	Pinnacles Mine	+0·002	+0·06	$-0\cdot2_{4}$	−0·005	−0·016	$+0\cdot06_{1}$
34	Main lode, No. 2 lens, No. 17 level	+0·003	+0·02	$-0\cdot2_{1}$	−0·007	−0·004	$-0\cdot06_{8}$
44	Little Broken Hill Mine	−0·006	−0·05	$+0\cdot1_{5}$	+0·015	+0·006	$+0\cdot05_{7}$
49	Globe Mine	+0·002	−0·04	$-0\cdot1_{7}$	−0·004	−0·011	$-0\cdot03_{7}$
	Mount Isa						
59	Black Star Orebody	−0·029	−0·21	$-0\cdot3_{2}$	+0·074	+0·037	$+0\cdot11_{3}$
60	Level No. 11, No. 2 Orebody	−0·050	−0·35	$-0\cdot4_{0}$	+0·129	+0·060	$+0\cdot22_{0}$
61	Level No. 12, No. 5 Orebody	−0·040	−0·32	$-0\cdot3_{4}$	+0·104	+0·048	$+0\cdot17_{3}$
62	Level No. 9, No. 7 Orebody	−0·043	−0·22	$-0\cdot4_{7}$	+0·116	+0·072	$+0\cdot17_{3}$
63	Level No. 9	−0·040	−0·21	$-0\cdot2_{9}$	+0·104	+0·061	$+0\cdot18_{7}$

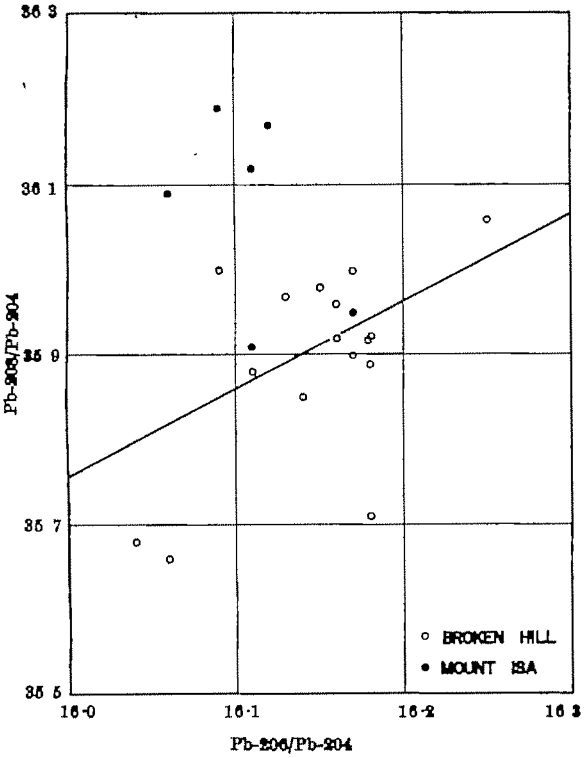


Fig. 2. Measured lead isotope ratios by the University of Toronto. The solid line is the conformable lead curve selected by Russell and Farquhar (in the press)

for two samples we require the equivalent of six separate analyses. However, this additional effort has been well worth while in the increased precision obtained.

It should be remarked that the intercomparison has been made possible by having rather pure samples of lead tetramethyl made by purifying the products of the usual Grignard reagent reaction in a vapour phase chromatographic column. Having pure samples increases the precision in a number of ways. Specifically, we are able to reproduce very closely the pressure and composition of the gas in the mass spectrometer source region and we are able to operate at lower mass spectrometer pressures than we would otherwise be able to do, thereby reducing the effect of pressure scattering. Despite these precautions the tailing due to pressure scattering is still significant and we make a correction for this in our final results. This correction ordinarily amounts to about 0·06 per cent at the adjoining mass.

Measurements made in this way are shown in Table 1 for samples from the conformable layer Broken Hill, New South Wales, Australia, and from Mount Isa, Queensland, Australia. Both these localities have previously been investigated by Russell, Farquhar and Hawley[3] and by Stanton and Russell[4]. The results of the previous analyses are shown in Figs. 1 and 2, where it is clear that it is impossible to observe any convincing relationship between the Mount Isa and the Broken Hill samples, and which show very clearly the magnitude of the spread in the existing measurements on these samples. Figs. 3 and 4 show the results of analyses made at this University with the new instrument and technique. The difference in precision is very striking. In particular, the cluster of points presenting the

Table 2. Replicate Analyses of Sample 1

Date of analysis	100/ratio of 204/206	 207/206	 208/206
February 17*	6·198	96·60	223·77
February 19*	6·197	96·58	224·13
February 24*	6·203	96·40	223·50
February 25*	6·205	96·53	223·90
March 9	6·212	96·43	223·72
March 10	6·213	96·42	223·75
March 14	6·205	96·49	223·96
March 16	6·208	96·33	223·71
March 31	6·200	96·39	223·73
Mean of all analyses with standard deviations	6·205 ± 0·006	96·44 ± 0·09	223·80 ± 0·18
Mean of last five analyses with standard deviations	6·208 ± 0·005	96·42 ± 0·06	223·77 ± 0·08

* Samples indicated were measured from the recorded chart.

Broken Hill analyses in Fig. 3 is just a factor of 10 smaller than that previously reported. Moreover, the distinction between the Mount Isa and the Broken Hill samples is now clear. The Broken Hill samples were calculated from peak heights measured with a Brown chart recorder, and are therefore slightly less precise than the Mount Isa results, which were measured directly from our servo voltmeter.

Table 2 lists the analyses of our comparison sample No. 1, which is identical with Toronto sample No. *T*-1003 and which in turn has been widely circulated as an inter-laboratory standard. It can be seen that even on an absolute basis the reproducibility over a period of several weeks is quite good. It is also apparent that the reproducibility, particularly of the lead-208 value, is better for samples measured with the servo voltmeter.

Although it is not primarily our intention to discuss the interpretations of these analyses in this article,

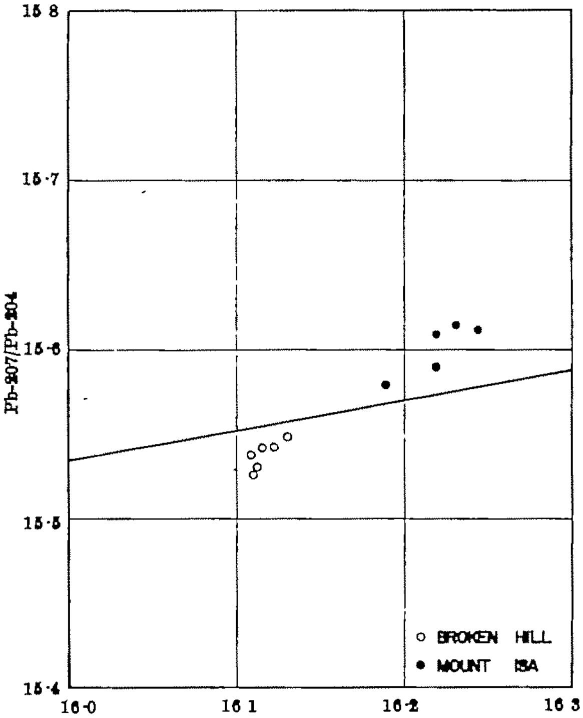


Fig. 3. Measured lead isotope ratios by us. The solid line is the conformable lead curve selected by Russell and Farquhar (in the press)

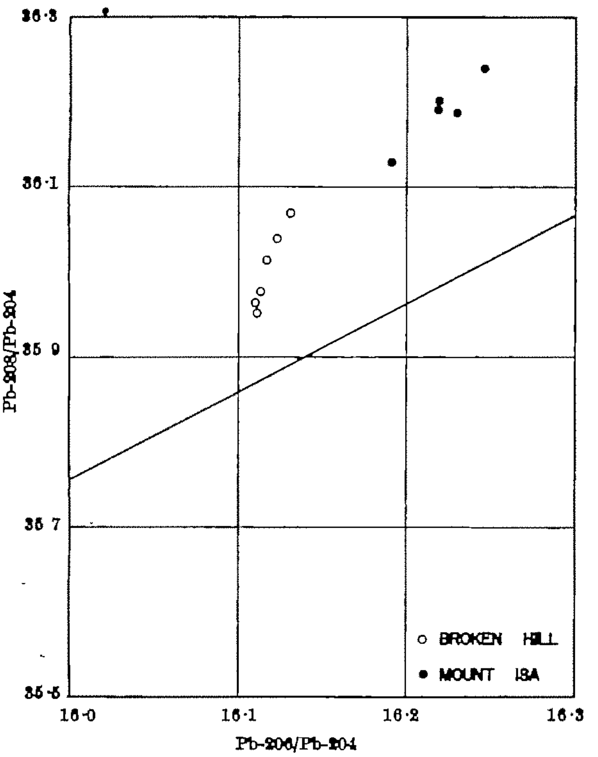


Fig. 4. Measured lead isotope ratios by us. The solid line is the conformable lead curve selected by Russell and Farquhar (in the press)

the following points seem very clear. Stanton and Russell[3], and Cahen *et al.*[4] have suggested uniformity in isotopic composition as one of the criteria for non-anomalous leads. It can be seen that the lead-207/lead-204 and lead-206/lead-204 isotope ratios for the Broken Hill samples differ from their average value by less than 0 07 per cent. These samples are obtained from a 200 square mile area of the conformable lead-bearing deposits at Broken Hill. Such extreme constancy for lead isotope ratios for a region this size has never been demonstrated before.

The ratio lead-208/lead-204 is not nearly so constant, and we feel that the range of variation in this ratio exceeds the experimental error, which, judging from Table 2, should be no worse than for the other ratios. Note that this variation cannot be explained by an uncertainty in the lead-204 abundance. Our tentative interpretation is that the Broken Hill conformable leads have been contaminated by small amounts (0·2 per cent) of radiogenic leads formed from an environment with a uranium/thorium ratio three times the mean crustal or subcrustal value. The largest contamination is observed in samples No. 30 and No. 44, which occur farthest from the north-east–south-west line through Broken Hill parallel to the structural trends of the district. A similar trend is suggested by the measurements by Russell and Farquhar, but is obscured by the larger uncertainties of the measurements.

The Mount Isa samples are less constant, and we are confident that the variation among these samples is significant. Moreover, these samples do not fit on the identical growth curve that would be chosen on the basis of the Broken Hill samples. However, if the less radiogenic samples are considered from each group, they fit a common growth curve to within about 0·15 per cent. These two mining areas are about 800 miles apart and this lends some support to the suggestion that these leads have been derived from depth by relatively simple processes, as has been suggested by Stanton[5]. The relationship among the Mount Isa samples is one that can be explained on the assumption that these are slightly anomalous leads being contaminated by thorium and uranium leads in their crustal environment. It is apparent that the Mount Isa leads are younger than the Broken Hill leads by an amount not exceeding 80 million years and probably not greater than 40 million years if the least radiogenic sample from each location is considered.

We are at present undertaking a series of measurements in an effort to find out whether suites of anomalous leads lie closely on straight lines as suggested by Russell, Farquhar and Hawley in the reference cited above, whether conformable leads as defined by Stanton lie as precisely on a single growth curve as preliminary measurements have suggested and whether samples of the same age do lie on isochrons as postulated originally by Gerling, Holmes and Houtermans.

Technical assistance of J. L. Allard and P. H. Neukirchner is acknowledged with thanks. The samples were supplied through the kindness of Dr. H. F. King, Dr. R. M. Farquhar and Dr. R. M. Thomson. This work has been supported by the National Research Council of Canada and the Geological Survey of Canada.

---

[1] Russell, R. D., and Kollar, F., *Canadian J. Phys.* (In the press).

[2] Russell, R. D., Farquhar, R. M., and Hawley, J. E., *Amer. Geophys. Union Trans.*, 38, 557 (1957).

[3] Stanton, R. L., and Russell, R. D., *Econ. Geol.*, 54, 588 (1959)

[4] Cahen, C., Eberhardt, P., Geiss, J., Houtermans, F. G., Jedwab, J., and Signer, P., *Geochim. Cosmochim. Acta*, 14, 134 (1958)

[5] Stanton, R. L., *Austral. J. Sci.*, 17, No. 5, 173 (1955).

POTENTIOMETRIC STUDY OF PRIMING PAINTS FOR METAL

By DR. N. R. BHARUCHA

Research Association of British Paint, Colour and Varnish Manufacturers, Paint Research Station, Teddington

SINCE corrosion is an electrochemical phenomenon it is reasonable to expect that a study of potentials on the surface of a corroding metal would yield valuable and interesting information concerning the corrosion process. Useful information has already been obtained from the study of changes in the potentials of metal surfaces corroding in an aqueous environment[1–8].

The presence of single coats of oil paints on the metal surface does not interfere with the process of potential measurements as both water and dissolved oxygen permeate sufficiently rapidly through the paint film. The effects of the coating on the corrosion reaction may hence be determined. Potentiometric examinations of painted metal specimens have been carried out by several authors[9–14]. The measurement of such compromise potentials has drawbacks. The potential/time curves of specimens exposed to corrosive environments are generally subjected to random fluctuations. The results obtained are only qualitative, since the interpretation of the curves must in all cases depend not upon the actual values but upon the direction of the drift of such potentials with time. Furthermore, depending on the anodic and cathodic polarization characteristics of the metal, a measured potential may be associated with either a very low or a very high anodic current density. The measurement of such potentials also does not provide any conclusive information on the nature of any corrosion inhibition, that is, whether anodic or cathodic.

A new method has been devised to provide data capable of quantitative interpretation, measuring individually the potential changes of anodic and cathodic areas of a partially painted test specimen. Since painted areas are generally found to be cathodic with respect to unpainted steel areas[15,16], a single specimen half-coated with a paint (primer) may be looked upon as forming a 'contact couple' when immersed in a corroding environment. A schematic representation of such a contact couple is shown in Fig. 1. The current lines are seen to be more concentrated at the painted/unpainted boundary with the different equipotential lines at right angles to current lines.

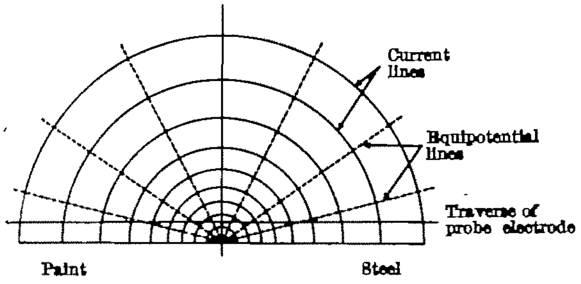


Fig. 1. Schematic representation of a contact couple formed by a half-painted mild steel specimen

The method consists essentially of scanning the surface of a specimen half-coated with a paint and immersed in a suitable electrolyte, noting the potentials recorded at regular distances (1 cm., 2 cm., 3 cm., etc.) from the boundary between the painted (cathodic) and the unpainted (anodic) areas. The scanning is effected by means of a probe calomel electrode with a potassium chloride/agar bridge with a fine capillary tip (0·60 mm. diam.). The reference (calomel) electrode is placed at a fixed distance from the probe electrode and does not traverse the surface of the specimen. The tip of the probe electrode is kept at a distance of approximately 1 mm. from the surface of the specimen. The potential values are recorded on a valve potentiometer.

The theoretical curves of potential against distance near the boundary between the anode and the cathode of a 'contact couple' are shown in Fig. 2; when the resistance of the electrolyte has an appreciably high value an S-shaped curve is normally to be expected[17].

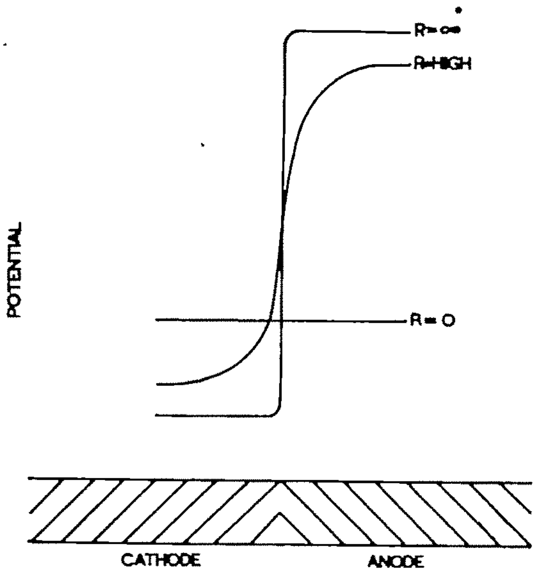


Fig. 2. Theoretical potential/distance curve for the area near the painted/unpainted boundary of a contact couple

Cathode, painted; anode, unpainted

After a number of experiments with various electrolytes, triacetin (glyceryl triacetate), containing approximately 3 per cent water, was chosen, because of its low electrical conductivity ($1 \cdot 1180 \times 10^{-8}$ mhos/cm. at 25° C.), stability, and non-reactivity with the paint film for the duration of the experiment.

A paint film may provide protection by: (1) resistance inhibition; (2) chemical inhibition. Both types of inhibition can be detected by a study of the S-shaped curve. Variations in the dimensions of the S curve may be correlated with different degrees of resistance inhibition, a curve that is small and compressed denoting better resistance inhibition than one that is large and elongated. Changes in the shape of the S curve, showing a decrease in the potential values over either the anodic or cathodic areas or both suggest chemical inhibition. A

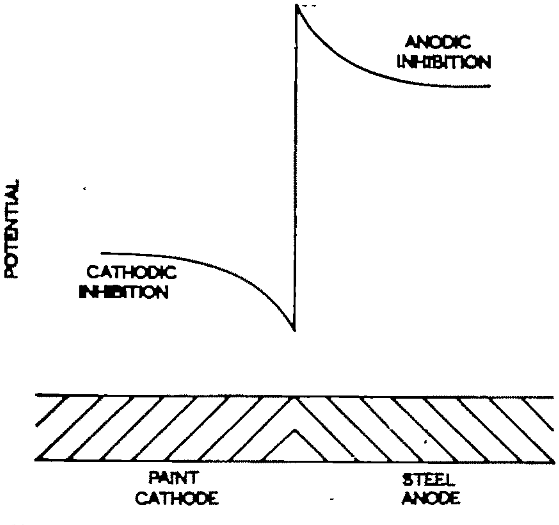


Fig. 3. Schematic representation of deviations from the ideal curve for potential/distance produced by anodic and cathodic inhibition

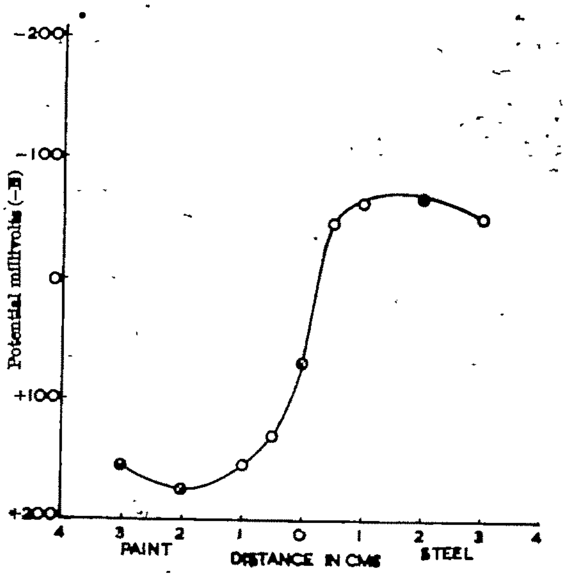


Fig. 4. Potential distribution between steel and red iron oxide

schematic representation of such a deviation from the ideal curve is shown in Fig. 3.

To illustrate the types of curves obtained with films containing red iron oxide or red lead in pale boiled linseed oil are shown in Figs. 4 and 5. Readings were taken every 15 min. until three consecutive sets of readings showed a constant value. A quick scanning was also carried out along two different paths over the panel to check the uniformity of the potential values. These values were then used to plot the potential/distance curves.

The curve obtained for the red iron oxide paint is smooth and S shaped, indicating that the contribution of this pigment specimen to protection against corrosion is likely to be one of improving the structural barrier effect of the paint medium to ingress of moisture as a corrosive agent. The curve obtained from the red lead paint, however, shows distortion over both anodic and cathodic areas, suggesting that this material, in addition to providing resistance inhibition, provides both anodic and cathodic chemical inhibition.

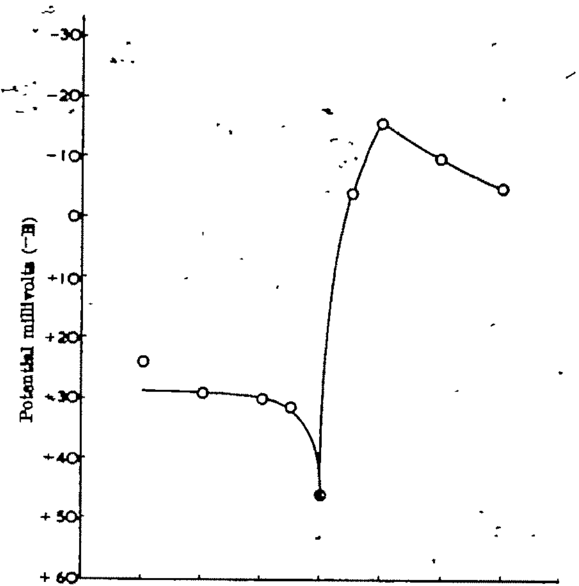


Fig. 5. Potential distribution between steel and red lead

Other priming paints have been studied and found to provide varying degrees of resistance inhibition and, in some cases, chemical inhibition.

[1] Benedicks, C., and Sundberg, R., *J. Iron and Steel Inst.*, 114, 210 (1926).

[2] Callendar, L. H., *Proc. Roy. Soc.*, A, 115, 349 (1927).

[3] May, R., *J. Inst. Metals*, 40, 141 (1928).

[4] Evans, U. R., *J. Chem. Soc.*, 92 (1929).

[5] Bannister, L. C., and Evans, U. R., *J. Chem. Soc.*, 1361 (1930).

[6] Hoar, T. P., and Evans, U. R., *J. Iron and Steel Inst.*, 126, 379 (1932).

[7] Pryor, M. J., and Cohen, M., *J. Electrochem. Soc.*, 98, 263 (1951).

[8] Pryor, M. J., and Cohen, M., *J. Electrochem. Soc.*, 100, 203 (1953).

[9] Burns, R. M., and Haring, H. E., *Trans. Electrochem. Soc.*, 69, 169 (1936).

[10] Schweitzer, A., *Z. Electrochem.*, 42, 624 (1936).

[11] Haring, H. E., and Gibney, R. B., *Trans. Electrochem. Soc.*, 76, 287 (1939).

[12] Jarrett, M. E. D., *J. Oil Col. Chem. Assoc.*, 23, 40 (1940).

[13] Zahn, H., *Paint, Oil and Chem. Rev.*, 106, 6 (1944).

[14] Wormwell, F., and Brasher, D. M., *J. Iron and Steel Inst.*, 162, 129 (1949).

[15] Crennel, J. T., *J. Soc. Chem. Indust.*, 69, 536 (1950).

[16] Mayne, J. E. O., *Chem. and Indust.*, 70, 293 (1951).

[17] Akimov, G. K., *Corrosion*, 11, 515t (1955).

SOME ASPECTS OF THE FIBRINOGEN-FIBRIN TRANSITION

By K. LAKI, JULES A. GLADNER
National Institute of Arthritis and Metabolic Diseases
AND
J. E. FOLK
National Institute of Dental Research, National Institutes of Health, Bethesda, Maryland

THE thrombin-catalysed conversion of fibrinogen to the insoluble gel-like polymer, fibrin clot, constitutes the final stage in the complex process of blood coagulation.

The observation that the thrombin-induced conversion of fibrinogen to fibrin clot is a two-phase process[1,2]: (1) an enzyme action modifying fibrinogen to fibrin, followed by (2) the aggregation of fibrin molecules, may be considered as the starting point in a systematic study of this last step in blood coagulation. Our present understanding of many of the chemical and physico-chemical reactions involved in this conversion is a result of the ingenuity and combined efforts of many investigators.

The Enzymatic Phase

The difference in isoelectric points[3] and titration curves of fibrinogen and fibrin[4] suggested that, in the enzymatic process, a small molecule (or molecules), bearing negative charges, was released from fibrinogen[5]. These suggestions were substantiated when non-protein nitrogen[6] and ninhydrin-reacting material[7] were found in the supernatant fluid of fibrin clots. Further studies revealed that the non-protein nitrogen, liberated during clotting, consisted primarily of two acidic peptides, afterwards designated peptides *A* and *B* (ref. 8). These findings indicated that thrombin was a protease. However, the exact nature of the bond or bonds acted upon by thrombin remained unknown. The finding that amino-terminal glutamic acid of fibrinogen is replaced by amino-terminal glycine in fibrin suggested that thrombin-catalysed hydrolysis occurred on the amino-side of specific glycine residues[9]. By the use of carboxypeptidase *B*, recently discovered in this laboratory[10,11], it was possible to demonstrate arginine as the carboxyl-terminal residue of both peptides *A* and *B*[12,13]. Since fibrinogen has no C-terminal arginine residues, it can be concluded that the peptides are bound to fibrinogen through their arginine end. This evidence directly substantiates the previous tentative conclusion that the bonds hydrolysed by thrombin to liberate these peptides are arginylglycine bonds.

The specificity of thrombin for ester or peptide bonds involving the carboxyl group of arginine has been demonstrated by the speed with which thrombin hydrolyses the synthetic substrate, tosyl-1-arginine methyl ester and its amide analogue, while scarcely attacking similar compounds of other amino-acids[14].

The proteolytic nature of thrombin was further demonstrated by the observation that the clotting as well as the esterase activity of thrombin becomes completely inhibited following treatment with di-*iso*propylphosphofluoridate[15,16]. This reagent is a powerful inhibitor of a number of hydrolytic enzymes.

Since thrombin inhibited by di*iso*propylphosphofluoridate can be restored to activity by chemical means, for example, by nucleophilic attack, it may be postulated that the localization of the *iso*propyl phosphate binding involves the active site. The *iso*propyl phosphate is bound so strongly to these enzymes that it survives mild acid hydrolysis. Employing di*iso*propylphosphofluoridate labelled with phosphorus-32 for the inhibition, the peptides containing the radioactive phosphorus following mild hydrolysis can easily be detected and isolated. We have isolated four such peptides of the inhibited thrombin[17].

The composition of these peptides is shown in Table 1. Since serine is the common amino-acid, it is reasonable to assume that the serine hydroxyl group is the site of the *iso*propyl phosphate binding. Furthermore, it was possible to show, by end-group and sequence analysis, that the sequence of amino-acids in the vicinity of this serine is gly.asp.ser.gly. This is the same sequence that was found at the active site of the proteolytic enzymes trypsin and chymotrypsin[18,19].

Table 1. RADIOACTIVE PHOSPHOPEPTIDES ISOLATED FROM THE SYSTEM DIISOPROPYLPHOSPHOFLUORIDATE-THROMBIN

Fraction of peptide	Amino-acid composition
2	(Asp, Ser, Gly)
4	(Asp, Ser)
5	(Ser, Gly)
7	(Asp, Ser, Gly)
8	(Asp, Ser, Gly, Glu, Ala)

These observations, which clearly class thrombin among the proteolytic enzymes, do not explain why the action of thrombin is limited to the hydrolysis of a few arginyl peptide bonds in fibrinogen. There must be many such bonds in this protein. Trypsin, for example, splits many arginyl bonds of several proteins, including fibrinogen, which are not susceptible to the action of thrombin (Mihalyi, E., personal communication). It is conceivable that the unique sequence of amino-acids around or in the vicinity of bonds susceptible to thrombin directs this 'limited proteolysis' in a manner similar to that postulated for the selective bond-cleavage which occurs during the tryptic activation of trypsinogen[20].

In order to explore this theory of 'limited proteolysis' as well as to obtain amino-terminal sequence data on fibrinogen, an amino-acid sequential analysis of peptides *A* and *B* was undertaken. For such investigations, peptides *A* and *B* were separated, isolated and purified by chromatography on an anionic cellulose exchanger. Combined sedimentation and diffusion results with the purified peptides indicated a molecular weight of 2,000 for peptide *A* and 2,400 for peptide *B*. The quantitative amino-acid analysis of these peptides gave minimum molecular weights of 1,890 and 2,460 for peptides *A* and *B*, respectively, in good agreement with the physical measurements[13,21].

Peptide *A*
glu.asp.gly.ser asp.pro.pro.ser.gly asp.phe.leu.thr.glu.gly gly gly.
val.arg.
Peptide *B*
(NH$_2$)
(asp$_4$.glu$_4$.pro$_2$ thr.gly.tyr-SO$_4$.phe.arg.lys.)val.gly.leu.gly.ala arg.

Fig. 1. Summary of the proposed complete amino-acid sequence of peptide *A* and partial amino-acid sequence of peptide *B*

Fig. 1 shows the postulated amino-acid sequence of peptide *A* (ref. 22) and the partial amino-acid sequence of peptide *B*. (A sequence similar to that presented in this article with the exception of the position of one aspartic acid residue in peptide *A* has been reported recently in a short communication[23].) In peptide *A*, the free carboxyls of aspartic and glutamic acids are rather evenly distributed along the peptide chain and are separated from the C-terminal arginine by the gly$_3$.val sequence. The two adjacent proline residues can form a point at which the direction of the peptide chain may be reversed. It should be mentioned that the prolylproline sequence has been found in the melanophore-stimulating hormone from pig anterior pituitary gland[24]. This type of linkage (that is, between two cyclic amino-acids) has been suggested as a recurrent one in gelatin[25]. Although our present knowledge of the structure around the bonds of fibrinogen susceptible to thrombin is limited to the amino-acid sequence of peptide *A* and the partial sequence of peptide *B*, it is, nevertheless, tempting to speculate on the unique and narrow specificity of thrombin in its role of releasing these peptides from fibrinogen. There are in each peptide two proline residues as well as several dicarboxylic amino-acids—gly$_3$.val in the case of the *A* peptide, and val.gly.leu.gly.ala. in peptide *B*. The high density of negative charges, perhaps oriented in some specific manner relative to the remainder of the fibrinogen molecule, may contribute to the selective cleavage by thrombin. This type of structure has been postulated to be involved in the selective bond-splitting which occurs during the tryptic activation of trypsinogen[20]. Other residues or groups of residues in the peptide molecules may exert a further orienting effect, as suggested by the prolylproline sequence of peptide *A*. In line with this suggestion is the ability of thrombin to hydrolyse gelatin[26].

On the other hand, the structure of the peptides *per se* may play no part in the transition of fibrinogen to fibrin, other than that of masking hydrogen-bond donor or acceptor groups which are afterwards involved in polymerization[27] (see polymerization phase). Residues or groups of residues on the glycine side of the arginine glycine bonds which are attacked by thrombin may be altogether responsible in directing the specificity of this enzyme.

The enzymatic phase of the fibrinogen–fibrin transition may be summarized by the following reaction:

$$\text{fibrinogen} \overset{\text{thrombin}}{\rightleftarrows} \text{fibrin} + \begin{matrix}(\text{peptide } A)\\(\text{peptide } B)\end{matrix}$$

In the next step, fibrin molecules polymerize to form the clot, but the peptides *A* and *B* are left freely dispersed in the clot liquor. In co-operation with E. Leonard (National Heart Institute), we have observed the action of these peptides on the carotis muscle of rabbit. This effect is probably similar to the stimulating effect observed on frog heart by one of us[7]. With an isolated preparation of rabbit carotid artery strip, suspended in such a way that the muscle could be stimulated electrically and tension measured[28], it was found that 250 µgm./ml. of peptide *B* caused a slow rise in the tension exerted by the muscle fibres without electrical stimulation, and that in the presence of 80 µgm./ml. the tension developed in response to electrical stimulation was increased over control values. Although these results are based on experiments with only two preparations of peptide (on four strips of artery) and the specificity of the effects has not yet been adequately studied, it is tempting to speculate that in tissue trauma the cleavage of fibrinogen leads not only to clotting but also to local vasoconstriction through the release of the peptides. The local concentration of peptides *A* and *B*, assuming complete conversion of fibrinogen to fibrin, would be approximately 120 µgm./ml. Although the tissue concentration of peptide might well be less than the 80 µgm./ml. found to affect the contractility of the arterial strip, it is frequently observed that the sensitivity of smooth muscle in the large vessels is much less than that of the arterioles and pre-capillaries, and, therefore, a local constrictor action of the peptides *in vivo* remains a possibility.

The Polymerization Phase

Depending on conditions, *p*H, ionic strength, etc., the fibrin molecules formed in the enzymatic phase quickly aggregate to form a network-like structure, the fibrin clot. However, the aggregation is not completely random. For example, electron micrographs reveal interesting regularities in these clots[29]. In addition, various physicochemical measurements indicate that the fibrin molecules are held together in the clot by about ten hydrogen bonds[27]. Such a great number of bonds might be indicative of large areas of complementariness between these fibrin molecules, further suggesting that the molecules actually aggregate into a highly ordered network. The pattern and properties of this network are 'coded' into the fibrin molecules. In order to understand more fully the clotting process, this 'coded' pattern must be elucidated in terms of chemical bonds, bond patterns, and bond forces. For details, the reader is referred to a recent review by Scheraga and Laskowski[27].

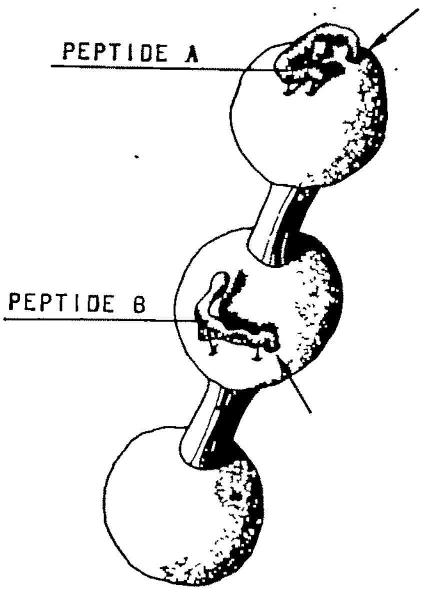


Fig. 2. Schematic representation of the fibrinogen molecules (ref. 33). The arrows indicate the location of the arg.gly. bonds, the site of thrombin action. The 'legs' on which the peptides stand indicate hydrogen bonds (ref. 27)

Recently the formation of four N-terminal glycine residues on fibrin, replacing the two N-terminal glutamic acid residues removed with peptides *A* in fibrinogen, was reported[30]. This is indicative of the rupture of four peptide bonds. This observation, coupled with the reported release of about 3 per cent of the fibrinogen nitrogen, can be satisfied by postulating the release of two each of the acidic peptides per 320,000 gm. of fibrinogen. One each of the peptides would be released from 160,000 gm. of fibrinogen, suggesting this value as the molecular weight for monomeric bovine fibrinogen.

Undoubtedly the removal of these peptides is a prerequisite for the subsequent polymerization of the fibrin molecules. These highly charged peptides could conceivably prevent the association of fibrinogen molecules (for example, by masking binding sites). It is of interest to speculate whether the removal of both these peptides is necessary for clotting, since it is possible to obtain a clot by snake venom enzyme with the removal of only peptide *A* from fibrinogen[31]. However, under conditions where only peptide *A* is released, the subsequent aggregation of fibrin molecules is almost exclusively end-to-end. Normally, both peptide *A* and *B* are released and the fibrin molecules aggregated end-to-end as well as side-by-side. It is thus possible to have essentially all fibrin molecules incorporated into a clot while the clotting process is still going on. Unless the end-point of the clotting is properly ascertained, one may conclude that the removal of only one of the peptides, peptide *A*, is necessary for normal clotting. The termination of the clotting process is clearly recognizable when the clotting is followed in a calorimeter; the cessation of heat evolution marks the end of clotting[32]. When the clot liquor is examined at this point, it is found that it contains both peptides *A* and *B*.

When the clotting is followed in a *p*H-stat, the uptake of base stops after the cleavage of two peptide bonds per 160,000 gm. (Mihalyi, E., personal communication). Again the clot liquor contains both the two peptides.

Since the release of peptide *A* favours end-to-end aggregation, one may conclude that peptide *A* is located at the end of the fibrinogen molecule and peptide *B* on the side of the molecule.

In electron microscopic examinations, the fibrinogen molecule appears to resemble a string of three beads with a total length of about 475 Å. (ref. 33). Accepting the localization of peptide *A* on the end, and *B* on the side, the fibrinogen molecule may be pictured as shown in Fig. 2. In this illustration the peptides are in their unfolded state. The lack of any helical structure in these peptides is inferred from optical rotation measurements we have made on the isolated peptides in purified form (unpublished results). There is also indication that these peptides have no helical structure when bound to the fibrinogen molecule, since no change in the optical rotation of fibrinogen is observed when the peptides are split off by thrombin[34].

The picture of fibrinogen–fibrin transformation is not complete without mentioning that the clot formed in normal plasma differs from that formed in the purified fibrinogen–thrombin system. While the clot formed in the purified system is soluble in 8 *M* urea, the normal plasma clot is not, indicating that in plasma some factor causes the formation of strong bonds between fibrin molecules. The existence of such a factor can easily be demonstrated[35].

The addition of calcium ions and serum to a purified fibrinogen–thrombin system results in a fibrin clot which is insoluble in 8 *M* urea. (This factor has been called *L-L* factor[36] or fibrin serum factor[37].) Recently this factor has been isolated and purified 8,000 fold[38] from human plasma and has been found to contain a number of easily oxidizable SH groups which are necessary for its activity. It is a protein with a molecular weight of about 1/2 million[38]. The mode of action of converting urea-soluble fibrin clot into urea-insoluble clot has not yet been fully elucidated, but the fact that very small amounts of the pure factor are enough to convert the clot into its insoluble form suggests that its action on fibrin is enzymatic. The factor apparently is manufactured in the blood-forming organs. In certain diseases, especially with serious disturbance in the metabolism of bone marrow, this factor is missing, only the defective urea-soluble clot being formed[39]. The problem of why bone marrow is involved in formation of blood clots is intriguing and remains to be investigated.

It is hoped that the few experiments discussed in this short review illustrate the extent to which the molecular aspects of the fibrinogen–fibrin conversion have been clarified by the efforts of scientists of varying disciplines. The realization is also emerging that the last phase of blood clotting is intimately inter-related to other physiological processes such as the normal functioning of the bone marrow and the contractility of the capillary bed.

[1] Laki, K., and Mommaerts, W. F. H. M., *Nature*, 156, 664 (1945).
[2] Laki, K., *Arch. Biochem. Biophys.*, **32**, 317 (1951).
[3] Laki, K., and Mihalyi, E., *Nature*, 163, 66 (1954).
[4] Chaudhuri, D. R., *Hung. Acta Physiol.*, 1, 238 (1948).
[5] Laki, K., *Fed. Proc.*, 8, 90 (1949).
[6] Lorand, L., *Nature*, 167, 992 (1951).
[7] Laki, K., *Science*, 114, 435 (1951).
[8] Bettelheim, F. R., and Bailey, K., *Biochim. Biophys. Acta*, **9**, 578 (1952).
[9] Lorand, L., and Middlebrook, W. R., *Biochem. J.*, **52**, 196 (1952).
[10] Folk, J. E., Gladner, J. A., and Laki, K., *Fed. Proc.*, 16, 181 (1957).
[11] Folk, J. E., and Gladner, J. A., *J. Biol. Chem.*, **231**, 379 (1958).
[12] Gladner, J. A., Folk, J. E., and Laki, K., *Fed. Proc.*, 17, 299 (1958).
[13] Folk, J. E., Gladner, J. A., and Laki, K., *J. Biol. Chem.*, **234**, 67 (1959).
[14] Sherry, S., and Troll, W., *J. Biol. Chem.*, **208**, 95 (1954).
[15] Gladner, J. A., and Laki, K., *Arch. Biochem. Biophys.*, **62**, 501 (1956).
[16] Miller, K. D., and van Vunakis, H., *J. Biol. Chem.*, **223**, 227 (1956).
[17] Gladner, J. A., and Laki, K., *J. Amer. Chem. Soc.*, **80**, 1263 (1958).
[18] Schaffer, N. K., Simet, L., Harshman, S., Engle, R. R., and Drisko, R. W., *J. Biol. Chem.*, **225**, 197 (1957).
[19] Schaffer, N. K., Lang, R. P., Simet, L., and Drisko, R. W., *J. Biol. Chem.*, **230**, 185 (1958).
[20] Davie, E. W., and Neurath, H., *J. Biol. Chem.*, **212**, 515 (1955).
[21] Gladner, J. A., Folk, J. E., Laki, K., and Carroll, W. R., *J. Biol. Chem.*, **234**, 62 (1959).
[22] Folk, J. E., Gladner, J. A., and Levin, Y., *J. Biol. Chem.*, **234**, 2317 (1959).
[23] Blombäck, B., Wallen, P., and Sjoquist, J., *Acta Chim. Scand.*, 13, 819 (1959).
[24] Harris, J. L., and Roos, P., *Biochem. J.*, 71, 434 (1959)
[25] Schroeder, W. A., Kay, L. M., LeGette, J., Honnen, L., and Green, F. C., *J. Amer. Chem. Soc.*, 76, 3556 (1954).
[26] Miller, K. D., New York State Department of Health, Annual Report, Division of Laboratories and Research, 44 (1957).
[27] Scheraga, H. A., and Laskowski, jun., M., "Adv. in Protein Chem.", **12**, 1 (1957).
[28] Leonard, E., *Amer. J. Physiol.*, 189, 185 (1957).
[29] Hawn, C. V. Z., and Porter, K. R., *J. Exp. Med.*, **86**, 285 (1947).
[30] Blombäck, B., and Yamashina, I., *Arkiv Kem.*, **12**, 173 (1958).
[31] Laurent, T. C., and Blombäck, B., *Acta Chim. Scand.*, **12**, 1875 (1958).
[32] Laki, K., and Kitzinger, C., *Nature*, 178, 985 (1956).
[33] Hall, C. A., and Slayter, H. S., *J. Biophys. Biochem. Cytology*, **5**, 11 (1959).
[34] Mihalyi, E., Abst. of Papers, 135th Meeting, American Chemical Soc. (1959).
[35] Laki, K., and Lorand, L., *Science*, 108, 280 (1948).
[36] Loewy, A. G., and Edsall, J. T., *J. Biol. Chem.*, **211**, 829 (1954).
[37] Shulman, S., *Nature*, 171, 606 (1953).
[38] Loewy, A. G., Dunathan, K., Gallant, J., Kriel, R. L., and Walfinger, jun., H. L., Abst. of Papers, 135th Meeting, American Chemical Society (1959)
[39] Lorand, L., and Dickenman, R. C., *Proc. Soc. Exp. Biol. Med.*, 89, 45 (1955).

POSSIBLE OCCURRENCE OF INTERFERENCE SYSTEMS IN VIRUS-INFECTED PLANTS

By A. D. THOMSON*

Agricultural Research Council Virus Research Unit, Huntingdon Road, Cambridge

INTERFERENCE between plant viruses was first demonstrated in plants infected with tobacco mosaic virus[1] and has since been demonstrated between serologically related strains of many plant viruses[2] and between some apparently unrelated viruses[3]. Although several theories have been proposed to explain interference[2], the most recent by Best[4], there is little evidence on the mechanisms involved. In the experiments described below interference was measured by the ability of an inoculum that does not produce local lesions (interfering strain) to affect the local lesions produced by

---

* Present address: Plant Diseases Division, Department of Scientific and Industrial Research, Christchurch, New Zealand.

another strain when the two are inoculated simultaneously to susceptible leaves. Inhibition of infections by lesion-forming strains in these conditions was first described by Sadasivan[5]. The present results suggest that sap from virus-infected plants contain, in addition to infective particles, another factor that inhibits infection.

Table 1 shows the extent to which unfractionated sap from leaves infected with tobacco mosaic virus, potato virus *X* and potato virus *Y* decreased the number of lesions produced by lesion-forming strains of these viruses. Reduction in lesion numbers was accompanied by reduction in recoverable infectious virus. In addition to fewer lesions being formed, those produced by the mixed inocula were smaller than those produced by the single strain.

Interference during simultaneous infection occurred with serologically related viruses (Table 1). Thus unfractionated extracts of 3 strains of tobacco mosaic virus inhibited the ribgrass and aucuba strains and extracts of 5 strains of virus *X* inhibited 3*XE*–1. Extracts of unrelated viruses did not inhibit tobacco mosaic virus or virus *X*. However, extracts from plants infected with severe etch virus, virus *Y* and tobacco mosaic virus inhibited infection by cabbage black ringspot virus (Table 1).

Virus preparations of apparent equal infectivity differed significantly in their ability to interfere with infection by lesion-forming strains. For example, with tobacco mosaic virus, interfering activity was greatly reduced by heating expressed sap at 55° or 60° C. for 10 minutes and by dialysing expressed sap against distilled water for 48 hours (Table 2). Loss of interfering activity also occurred during purification of the virus by precipitation with ammonium sulphate (Table 2) and after 5 cycles of high- and low-speed centrifugation.

In the case of virus *X*, freezing leaves before extracting sap resulted in elimination of interfering activity (Table 2) although this treatment did not reduce the interfering activity of tobacco mosaic virus.

Preparations of tobacco mosaic virus which showed little interference with infection did interfere with the size of lesions of the lesion-forming strain (Table 2). This suggests that two factors responsible for interference occur in unfractionated sap; one is more unstable than the virus and inhibits infection and another which is always associated with infectivity and inhibits virus synthesis or movement after infection. However, with all infectious preparations the interfering system would be formed after infection and the same factor may be responsible for both phenomena.

Table 1. INHIBITION OF LESION-FORMING BY NON-LESION-FORMING VIRUSES

Inoculum*		Mean lesions per half-leaf	
Interfering virus	Lesion-forming virus	Treated	Control
'Type' strain tobacco mosaic virus	Aucuba strain tobacco mosaic virus	9	108
'Type' strain tobacco mosaic virus	Cabbage black ring-spot virus	3	38
'Masked' strain tobacco mosaic virus	Ribgrass strain tobacco mosaic virus	16	135
AST4 strain potato virus *X*	3*XE*-1 strain potato virus *X*	20	92
TVNV strain potato virus *Y*	'Type' strain potato virus *Y*	19	64
'Type' strain potato virus *Y*	Cabbage black ring-spot virus	2	38
Severe etch virus	Cabbage black ring-spot virus	9	38

* Equal volumes interfering and lesion-forming viruses (treated) or healthy sap and lesion-forming viruses (control) rubbed on twelve tobacco (tobacco mosaic virus, virus *X* and cabbage black ringspot virus) or *Physalis floridana* (virus *Y*) half-leaves. Interfering preparations were unfractionated sap from infected leaves. The concentration of lesion-forming strains of tobacco mosaic virus was 0 02 mgm./ml. 3*XE*-1 was infective sap diluted 1/100, and virus *Y* and cabbage black ringspot virus were infective saps diluted 1/10.

Table 2. EFFECT OF TREATMENTS ON INTERFERING ACTIVITY OF TOBACCO MOSAIC VIRUS AND VIRUS *X*

Interfering preparation*	Mean No. lesions per half-leaf	
	Interfering prep. + lesion-forming strain	Healthy sap + lesion-forming strain
'Type' strain tobacco mosaic virus		
heated 60°/10 min.	84‡	109
unheated	16‡	128
dialysed	53‡	70
undialysed	4‡	70
precipitated once†	24‡	54
precipitated three times	60‡	54
unfractionated	14‡	58
inactivated by ultra-violet light	101	100
unirradiated	35‡	100
AST4 strain potato virus *X*		
from frozen leaves	45	40
from unfrozen leaves	4	64

* Equal volumes interfering preparation (expressed sap except where indicated otherwise) and lesion-forming strains (aucuba or 3*XE*-1) rubbed on twelve tobacco half-leaves with similarly treated sap from healthy plants on opposite halves.

† Virus precipitated with ammonium sulphate and concentration adjusted with distilled water to give preparations of infectivity equal to unfractionated virus.

‡ Lesions of lesion-forming strain restricted in size.

Except possibly for homologous antisera[6] and irradiated virus preparations[7] there is little evidence for specificity in the action of plant virus inhibitors. The present phenomenon appears to differ from that described by Bawden and Kleczkowski[7], since preparations of tobacco mosaic virus which inhibited infection were not inhibitory when inactivated by ultra-violet light (Table 2). Virus protein prepared by fission of tobacco mosaic virus with alkali is also an inhibitor of infection[8], but there is no evidence that it is specific. Expressed sap from leaves infected with tobacco mosaic virus was centrifuged at 36,000 r.p.m. for 60 min. in rotor 40 of the Spinco model *L* ultracentrifuge. Interfering activity was not present in the supernatant fluid. This suggests that certain anomalous proteins associated with virus infection are not involved with interference. Density-gradient centrifugation of tobacco mosaic virus and virus *X* in sucrose showed that infectivity and interfering activity occurred in the same zone in the gradient. If interference systems occur, then these appear to be in some way associated with virus particles. Virus multiplication also results in the appearance of other products in extracts from virus-infected plants, and of particular interest here is a virus-inactivating system present in plants infected with Rothamsted tobacco necrosis virus and tobacco ringspot virus[8]. This inactivating system seems to differ from interference; for example, the inactivating system does not occur in tobacco plants infected with tobacco mosaic virus[9].

[1] McKinney, H. H., *J. Agric. Res.*, 39, 557 (1929).
[2] Bennett, C. W., "Ann. Rev. Microbiol.", 5, 295 (1951).
[3] Thomson, A. D., *Nature*, 181, 1547 (1958).
[4] Best, R. J., *Aust. J. Biol. Sci.*, 7, 415 (1954).
[5] Sadasivan, T. S., *Ann. App. Biol.*, 27, 359 (1940).
[6] Bawden, F. C., "Adv. Virus Res.", 2, 31 (1954).
[7] Bawden, F. C., and Kleczkowski, A., *J. Gen. Microbiol.*, 8, 145 (1953).
[8] Bawden, F. C., and Pirie, N. W., *J. Gen. Microbiol.*, 17, 80 (1957).
[9] Bawden, F. C., and Pirie, N. W., *J. Gen. Microbiol.*, 16, 696 (1957).

HISTOCHEMICAL LOCALIZATION OF HUMAN, TERM PLACENTAL 17β-ŒSTRADIOL DEHYDROGENASES: IMPLICATIONS FOR THE TRANSHYDROGENASE REACTION

By DR. DONALD A. KELLOGG and DR. GEORGE G. GLENNER

National Institutes of Health, Bethesda, Maryland

THREE 17β-œstradiol-sensitive enzyme systems have been described in human, term placental homogenates: a diphosphopyridine nucleotide (DPN)-linked dehydrogenase, a triphosphopyridine nucleotide (TPN)-linked dehydrogenase, and a TPNH–DPN transhydrogenase[1-4]. Although previous work suggested that these reactions were mediated by a single enzyme which, because of its dual nucleotide specificity, could function as a transhydrogenase[2-4], Hagerman and Villee recently isolated separate and distinct protein fractions for each system[5]. The presence of di- and tri-phosphopyridine nucleotide as co-factors in these reactions suggested that histochemical experiments might give further insight into the problem. If only one protein exists, or if the function of the two dehydrogenases is to mediate transhydrogenation, one would expect similar cellular localization of the two dehydrogenases. On the other hand, dissimilar histochemical localization of the two nucleotide-linked dehydrogenases would be consistent with the existence of more than one protein system catalysing the dehydrogenation of 17β-œstradiol. The validity of demonstrating histochemically a specific nucleotide-linked dehydrogenase by means of tetrazolium salts had been discussed by Cascarano and Zweifach[6]. Using histochemical techniques, Pearson and Grose demonstrated a 17β-œstradiol diphosphopyridine nucleotide-linked dehydrogenase in rat liver and small intestine[7]; and Wattenberg studied a diphosphopyridine nucleotide-linked 3β-ol steroid dehydrogenase in rat ovary, adrenal cortex, testis, and liver and human corpus luteum, adrenal cortex, and the syncytiotrophoblast of term placenta[8]. In these experiments, no attempt was made to demonstrate a triphosphopyridine nucleotide-linked reaction; however, Wattenberg suggested that the presence of a 3β-ol steroid dehydrogenase implied the existence of a steroid synthesizing mechanism.

The present histochemical observations show that the two 17β-œstradiol dehydrogenase reactions of human, term placenta have characteristically different cellular localizations.

Ten term placentas were frozen within 30 min. of delivery; fresh frozen sections, 10μ thick, were cut on a freezing microtome, mounted on slides, and immediately incubated in appropriate media for 1–3 hr. at 37° C. Other specimens were fixed for 4 hr. in neutral, 10 per cent formalin, washed, and carried through identical sectioning and incubation procedures. The incubation medium for demonstration of dehydrogenase activity consisted of 2 moles of pH 7·4 *tris* buffer, 2 μmoles of steroid substrate, 50 μmoles of oxidized nucleotide, 50 mgm. of crystalline bovine albumin, and 10 mgm. of nitro-blue tetrazolium salt in a final volume of 20 ml. The addition of 1 μmole of Mg^{++} or 0·2 μmole of Zn^{++} to the medium did not alter the staining characteristics. For histochemical localization of tri- or di-phosphopyridine nucleotide diaphorase, 50 μmoles of reduced nucleotide replaced steroid substrate and oxidized nucleotide in the incubating medium.

Tri- and di-phosphopyridine nucleotide diaphorase were demonstrated in cells of the trophoblast, stroma and decidua. There was no difference in the distribution or intensity of the two diaphorase reactions. Staining in the presence of 17β-œstradiol and diphosphopyridine nucleotide was most prominent in cells of the trophoblast and decidua and less intense in the stroma (Fig. 1*a*). Incubation with 17β-œstradiol and triphosphopyridine nucleotide produced intense staining of the perivascular stroma; but there was no detectable reaction in the cells of the trophoblast or decidua following 1 hr. incubation (Fig. 1*b*). Although a 3-hr. incubation in the presence of 17β-œstradiol and triphosphopyridine nucleotide produced a minimal reaction in the trophoblast, the staining differences described above were accentuated.

Either oxidized nucleotide incubated with 17α-œstradiol, stilbœstrol or œstrone produced no staining. Both dehydrogenase reactions were inhibited by 50 μmoles of mercuric chloride in the incubating medium. Raising the *p*H to 8·6 did not appreciably affect the reaction although lowering it to 6·4 lessened the intensity of staining. These data are in general agreement with known biochemical findings[2-4].

Because of the recognized limitations of the histochemical technique, it cannot be stated unequivocally that the differences demonstrated here are not due to such factors as differences in binding of tetrazolium salt, the existence of a diffusable enzyme, differences in reaction-rates with the two nucleotides, interaction of steroid with diaphorase or oxidase, or coupling of enzyme to diaphorase.

To investigate the possibility that the marked staining of the trophoblast and decidua in the diphosphopyridine nucleotide-linked reaction was due to preferential binding of tetrazolium salt, placental slices were incubated in the usual medium containing all constituents except nucleotide and steroid substrate. Following the washing of these sections and the reduction of the tetrazolium salt with 0·1 per cent ammonium polysulphide solution[9], no preferential decidual or trophoblastic binding was noted.

To determine if enzyme diffusion occurred, placental slices were overlaid on inactivated rat kidney slices and incubated in appropriate media. Moderate staining of the kidney in the presence of 17β-œstradiol and diphosphopyridine nucleotide was obtained, but there was no detectable staining of the kidney in the presence of 17β-œstradiol and triphosphopyridine

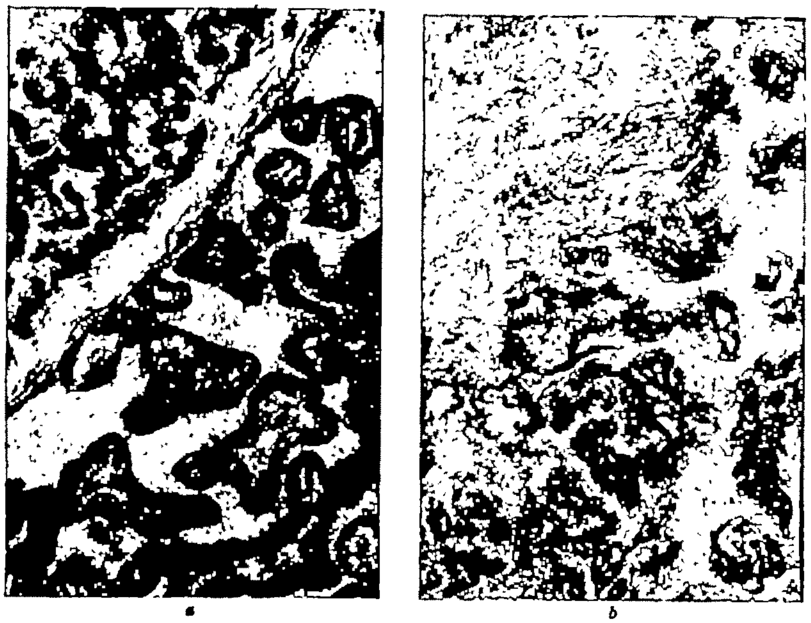


Fig. 1. *a*, Localization of 17β-œstradiol diphosphopyridine nucleotide-linked dehydrogenase. *b*, Localization of 17β-œstradiol triphosphopyridine nucleotide-linked dehydrogenase

nucleotide following 1 hr. incubation. Formalin fixation for 4 hr. did not alter these phenomena. Either reduced nucleotide incubated without steroid substrate in overlay experiments produced no staining of the inactivated rat kidney. Incubation of placental sections in buffer alone for 15–30 min. followed by transfer to a medium containing substrate and oxidized nucleotide revealed a decrease rather than an increase in trophoblastic and decidual staining.

Although these differences in staining of the overlaid kidney may be partly or wholly explained by the fact that placental homogenates reduce triphosphopyridine nucleotide in the presence of excess 17β-œstradiol approximately one-half as rapidly as diphosphopyridine nucleotide[4,5], the total lack of triphosphopyridine nucleotide-linked reaction in the inactivated rat kidney militates against it. Further, this cannot explain the characteristically different staining patterns observed in the placental slices with the two nucleotides and the fact that these differences are accentuated by prolonged incubation.

The possibility that 17β-œstradiol is affecting the diaphorase differentially or inhibiting reduced diphosphopyridine nucleotide oxidase, as shown biochemically by Yielding and Tomkins[10], and thereby diverting electrons to diaphorase, was examined by incubating placental slices with reduced di- or triphosphopyridine nucleotide and steroid. No significant differences resulted when compared with identical incubations without steroid.

That these results are explained by the existence of one enzyme coupled predominantly to triphosphopyridine nucleotide diaphorase in the stromal cell and only to diphosphopyridine nucleotide diaphorase in the trophoblastic cell appears unlikely in view of the intense reaction in the trophoblastic cell in the presence of reduced triphosphopyridine nucleotide.

In placental homogenates the diphosphopyridine nucleotide-linked reaction can be inhibited by small quantities of triphosphopyridine nucleotide[6]. Attempts were made to demonstrate this histochemically by pre-incubation of a placental slice for 5–15 min. in a medium containing triphosphopyridine nucleotide followed by incubation with 17β-œstradiol and diphosphopyridine nucleotide for 1 hr. There was no significant difference between the resulting staining pattern when compared with controls preincubated in buffer and albumin. The same findings resulted when slices were preincubated in diphosphopyridine nucleotide and transferred to a medium containing 17β-œstradiol and triphosphopyridine nucleotide for 1 hr. Incubation in a medium containing 17β-œstradiol and both oxidized nucleotides resulted in a summation of the staining patterns which resulted upon incubation with either nucleotide individually.

The observations in this histochemical system for the two dehydrogenase reactions strongly suggest that at least two distinct 17β-œstradiol-sensitive enzymes are being demonstrated. If the function of these two enzymes is to perform transhydrogenation, or if there is only one enzyme which because of its dual nucleotide specificity can perform transhydrogenation, one might expect the staining reactions to be similar. In these experiments such was found to be the case only in the stromal cell. The apparent absence of significant 17β-œstradiol triphosphopyridine nucleotide-linked dehydrogenase activity in the cells of the trophoblast and decidua where the 17β-œstradiol diphosphopyridine nucleotide-linked dehydrogenase activity is most prominent makes it unlikely that the two dehydrogenases function together in these cells principally as mediators of TPNH–DPN transhydrogenation. It is suggested that the different distributions of the two dehydrogenase reactions in these two cell-types reflects a different qualitative function for 17β-œstradiol in each cell. It is noteworthy that the diphosphopyridine nucleotide-linked reaction resides in the syncytiotrophoblast, the site of a diphosphopyridine nucleotide-linked 3β-ol steroid dehydrogenase presumably associated with a steroid synthesizing apparatus, and predominantly in those tissues directly associated with implantation, that is, trophoblast and decidua—tissues which have no significant triphosphopyridine nucleotide-linked activity.

We wish to express our thanks to the physicians of the Obstetrical Unit of the National Naval Medical Center for their generous assistance, and to Dr. Roy Hertz for his helpful advice and criticism.

[1] Villee, C. A., and Hagerman, D. D., *J. Biol. Chem.*, **205**, 873 (1953).

[2] Langer, L. J., and Engel, L. L., *J. Biol. Chem.*, **233**, 583 (1958).

[3] Talalay, P., Hurlock, B., and Williams-Ashman, H. G., *Proc. U.S. Nat. Acad. Sci.*, **44**, 862 (1958).

[4] Hollander, V. P., Hollander, N., and Brown, J. D., *J. Biol. Chem.* **234**, 1678 (1958).

[5] Hagerman, D. D., and Villee, C. A., *J. Biol. Chem.*, **234**, 2031 (1959).

[6] Cascarano, J., and Zweifach, B. W., *J. Biophys. Biochem. Cytol.*, **5**, 309 (1959).

[7] Pearson, B., and Grose, F., *Proc. Soc. Exp. Biol. Med.*, 100, 636 (1959).

[8] Wattenberg, L. W., *J. Histochem. Cytochem.*, 6, **225** (1958).

[9] Farber, E., Sternberg, W. H., and Dunlap C. E., *J. Histochem. Cytochem.*, **4**, 254 (1956).

[10] Yielding, K. L., and Tomkins, G. M., *Proc. U.S. Nat. Acad. Sci.*, **45**, 1730 (1959).

LETTERS TO THE EDITORS

CRYSTALLOGRAPHY

Mimetic Twinning in Urea–Ammonium Bromide

DURING an investigation of the crystal structure of the 1 : 1 complex formed by urea and ammonium bromide it was found that certain of the crystals obtained from solution exhibited orthorhombic symmetry whereas the remainder appeared to belong to the lower monoclinic system. Examination of these under the polarizing microscope did not reveal any obvious macrotwinning.

Structure determination afterwards revealed the true symmetry to be monoclinic and the pseudo-symmetry shown by some of the crystals appears to be a result of twinning by crystallites of small dimensions.

The pseudo-orthorhombic cell may be satisfactorily accounted for on the grounds of equal numbers of crystallites twinned as a result of a 180° rotation about the *c* axis as shown below. The symmetry of the monoclinic cell projection is *p*2 and the resulting symmetry of the orthorhombic cell *cmm* (shown in dotted outline).

In order for it to be possible for an orthorhombic cell of this symmetry to result from this type of twinning, the geometrical relation $a \cos \beta = \frac{c}{4}$ must hold within the monoclinic cell. This is satisfied by the complex with $a = 8{\cdot}9$ Å., $c = 7{\cdot}1$ Å. and $\beta = 102°$. (The relationship mentioned above is similar to that which results in twinning according to the Carlsbad law as evidenced in felspar when $a \cos \beta = \frac{c}{2}$.)

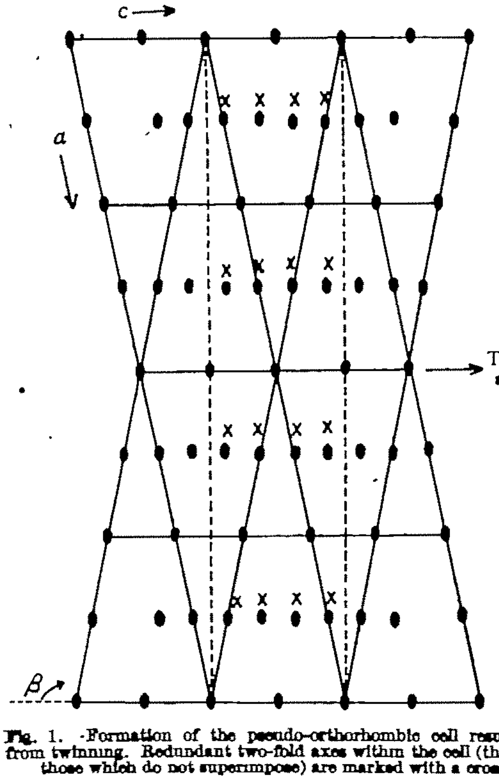


Fig. 1. Formation of the pseudo-orthorhombic cell resulting from twinning. Redundant two-fold axes within the cell (that is, those which do not superimpose) are marked with a cross

A further feature resulting from this twinning is that only half the urea molecules and bromide ions are directly superimposed in projection along with *b* axis, and consequently the Fourier map for this projection of the pseudo-orthorhombic cell shows a set of peaks for these having only half the expected electron density.

Further work on the structure is in progress and full details will be published later.

Thanks are due to African Explosives and Chemical Industries, Ltd., for permission to publish this work, and to Drs. J. W. Menary and W. H. Aarts for their valuable help.

C. G. C. CATESBY

Research Department,
African Explosives and
Chemical Industries, Ltd.,
P.O. Northrand,
Transvaal.

PHYSICS

Pure Rotational Association of Ozone in the Region 125–500 Microns

PURE rotation spectra of gaseous ozone have been recorded in the laboratory for the wave-length range 125–500μ. This extends the region observed by Danti and Lord (125–200μ) to longer wave-lengths, but has a useful overlap with their results[1]. It also covers part of the observed far infra-red solar spectrum where some unidentified features were attributed to absorption by ozone in the upper atmosphere[2].

Ozone was made by passing oxygen through a glass apparatus with an annular region in which there was a silent discharge. A mixture of oxygen and ozone was condensed in a trap surrounded by liquid nitrogen and, by slowly warming up the trap, the oxygen was removed by fractional distillation, leaving liquid ozone. This was then evaporated into an absorption cell which was part of the interferometer arrangement shown in Fig. 1. In this the whole optical path between the source and the detector can be evacuated to a pressure of less than 10^{-3} mm. mercury, and a trap cooled externally with liquid nitrogen further reduces the amount of water vapour to the point where its absorption is negligible. The glass absorption cell was 10 cm. in length and was fitted with crystal quartz windows 2 mm. thick. These were sealed with silicone rubber 'O' rings, and silicone grease was used in stopcocks and joints connecting the cell to the rest of the gas-handling equipment. With this arrangement the stability of the sample was such that the amount, measured by the total absorption, was not less than half the initial amount after 25 min., which was the time taken to complete one run. Interferograms were recorded, and spectra derived from them by Fourier transformation on a digital computer. The methods used for this, as well as a full description of the interferometer, will be given in later publications. Brief descriptions have already been published[3].

Fig. 2 shows typical results from a number of spectra recorded. Each curve was obtained by finding the ratio of ordinates of a pair of spectra, one taken with gas in the cell and one with the cell evacuated. For comparison are also shown the centres of gravity of the *Q* branches of ozone as calculated by Gora[4] (full lines) from microwave observations, and the positions and strengths of the strongest lines of H_2O as given by Benedict in a private communication (dotted lines). No relationship between the intensities of ozone and water lines is implied in the scale of the figure.

It will be seen that the absorption of *Q* branches observed at the positions indicated is well marked, but elsewhere the reproducible features in the spectra largely correspond to the positions of water lines. These are not present in the spectra taken with the cell evacuated and must be caused by water in the ozone sample itself. Since this has been evaporated from a trap at a temperature of about 150° K., it seems certain that the water must have resulted from the reaction of ozone with something in the cell. The only likely material would be the silicone rubber or silicone grease.

The spectral resolution, here defined as the width at half-intensity of a spectral window which is approximately gaussian, is about 0·8 cm.$^{-1}$ for the spectra shown. A number of runs have also been made with the higher resolution of 0·3 cm.$^{-1}$ but have not so far given any new information. The scale of intensity can only be given roughly since there are two sources of uncertainty. The first is the decay of the sample during the run; the second is that the scale depends on the assumption that the continuous background absorption is negligible at some selected point chosen in taking the ratios of the spectra. The values of absorption at the 46-cm.$^{-1}$ minima in the spectra *A*, *B* and *C* were, respectively, 34, 29 and 40 per cent.

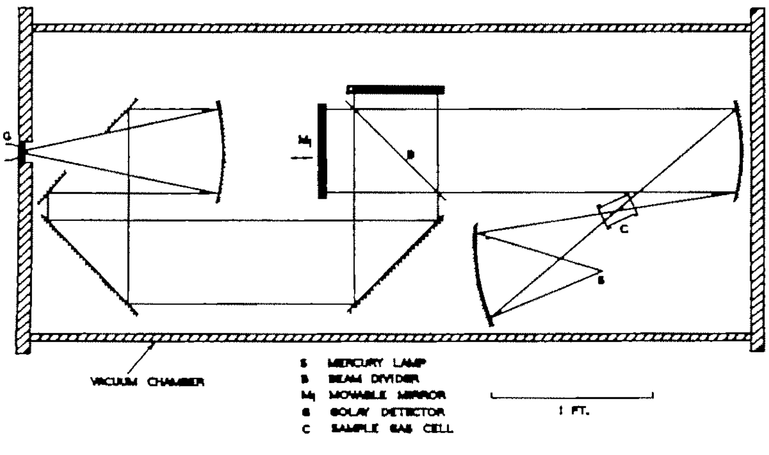


Fig. 1

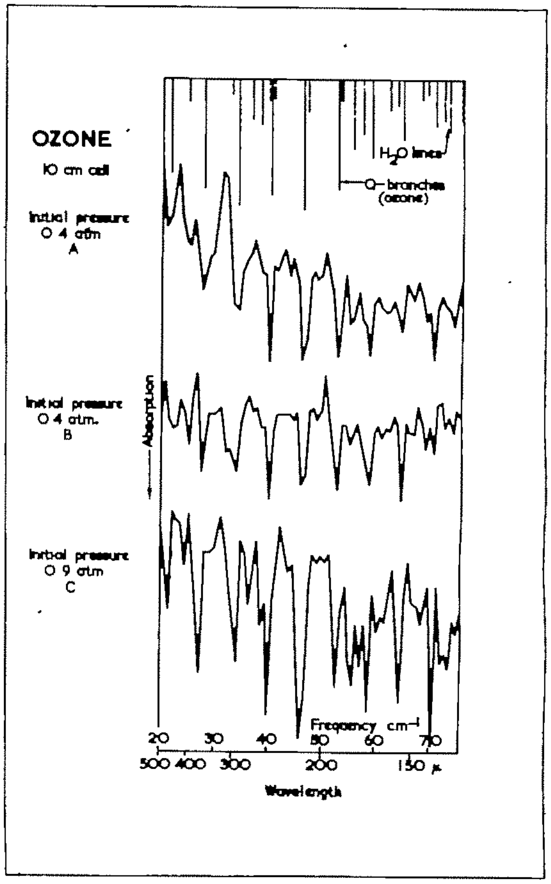


Fig. 2

These results extend the range in wave-length where there is agreement between the positions of observed minima and Gora's prediction of the centres of gravity of *Q* branches of ozone. In the region where the present results overlap with those of Danti and Lord, there is agreement and their conclusions are supported. In particular, the claim is also made here that much valuable data on the structure of molecules can easily be obtained from far infra-red spectra that can be derived only by considerable labour from microwave observations. The reason is that although the spectral resolution obtainable in the far infra-red is orders of magnitude smaller than in the microwave region, the range that can be studied is very much greater. In this way the two techniques may be complementary.

The confirmation that *Q* branches are observed near 22 cm.$^{-1}$ and 28 cm.$^{-1}$ in the laboratory spectra makes plausible the suggestion that unidentified features in the solar spectrum could be attributed to ozone in the upper atmosphere. There still appear to be problems, however, in reconciling the intensities of the laboratory and solar spectra, and further work will be required on both.

The work described above has been carried out as part of the research programme of the National

Physical Laboratory, and this communication is submitted by permission of the Director of the Laboratory.

H. A. GEBBIE
N. W. B. STONE

National Physical Laboratory,
Teddington, Middlesex.

C. D. WALSHAW

Cavendish Laboratory,
Cambridge.

[1] Danti, A., and Lord, R. C., *J. Chem. Phys.*, **30**, 1310 (1959).
[2] Gebbie, H. A., *Phys. Rev.*, 107, 1194 (1957).
[3] Basic Physics Division, N.P.L., Report No. 1 (1960). Proc. Symposium on Interferometry, N.P.L., June 1959, Paper No. 5-4.
[4] Gora, E. K., *J. Mol. Spectroscopy*, **3**, 78 (1959).

Equations for determining Diffusion Coefficients in Liquid Systems by the Diaphragm Cell Technique

THE diaphragm-cell technique, first introduced by Northrop and Anson[1], has been widely used as an experimental method of utilizing Fick's first law to obtain diffusion coefficients in liquids. The procedure is a simple one whereby diffusion takes place through a porous diaphragm separating two cells in which the respective liquid concentrations, initially different to provide a driving force or potential for diffusion, are maintained uniform. It is made clear by Gordon[2] in his classical review of the experimental and theoretical basis of the method that certain simplifying assumptions must be made in its utilization. These assumptions include constant solution volumes and constant fluxes throughout the porous diaphragm at any given moment. In measurements involving dilute solutions of electrolytes, the errors introduced by these assumptions have been analysed[2,3] and found to be unimportant. In the present work the magnitude of the error introduced by the second assumption was assessed for typical diaphragm diffusion cell conditions (including consideration of a binary non-electrolyte system). Dropping this assumption, the resulting system of differential equations was solved by a numerical method. Comparison of the times required to produce a given concentration change with and without the above assumption showed a difference of not more than 0·02 per cent. The first assumption of constant solution volumes, however, may introduce significant error whenever the system is one that displays volume change on mixing. The importance of accurate liquid diffusion coefficients has led us to replace, with a more general expression, the simple logarithmic equation, given by Gordon[2], that applies admittedly only if there is no change in volume on mixing:

$$\ln\frac{(c'-c'')_f}{(c'-c'')_i} = -\left[\left(\frac{1}{v'}+\frac{1}{v''}\right)\frac{A}{l}\right]D\,.\,t = -\beta\,.\,D\,.\,t \qquad (1)$$

where c' and c'' are concentrations, and v' and v'' are volumes of the half-cells, f and i refer to final and initial states respectively, A and l are the effective path area and length respectively, and β is the 'cell factor'.

The general approach proposed utilizes the expressions for diffusion coefficients obtained by de Groot[4] by using the methods of the thermodynamics of irreversible processes with the mass flux given in terms of chemical potential as a driving force. The assumption that the system is close enough to equilibrium for the flux to be proportional to the first power of the chemical potential gradient is made. Bird[5] has tabulated the various types of notation used for binary systems. The following fundamental equation may then be taken (at constant temperature and pressure):

$$n_A = -\rho\,.\,D_{AB}'\,.\left(\frac{\partial\omega_A}{\partial x}\right) + \omega_A\,.\,(n_A+n_B) \qquad (2)$$

$$\text{with } D_{AB}' = D_{AB}\,.\left(\frac{\partial\ln a_A}{\partial\ln\omega_A}\right) \qquad (3)$$

where n_A and n_B are the fluxes of components A and B in gm. cm.$^{-2}$ sec.$^{-1}$, with respect to the apparatus as a frame of reference; ρ is mass density (overall concentration) in gm. cm.$^{-3}$; ω_A is concentration of A as mass fraction; a_A is thermodynamic activity of component A; x is positional co-ordinate for unidirectional diffusion; D_{AB} is diffusion coefficient; and D_{AB}' is modified diffusion coefficient incorporating the activity correction. In this equation the fluxes are considered with respect to stationary axes but the diffusion coefficient is the so-called barycentric diffusion coefficient, that is, taken with respect to the mass average velocity. Comparable equations result for other terms of reference.

For the 'steady state' assumption involved in this application of irreversible thermodynamics, we propose substituting the concept of 'space constant material transport across the diaphragm'. Using this premise and with rigorous application of the above equation to the diaphragm-cell experiment, the following equation has been derived for the integral diffusion coefficient, $\overline{D}_{AB}'$:

$$\overline{D}_{AB}' = \frac{\ln R + I}{\beta\,.\,t}\,(\overline{\omega}_A{}^*\,.\,\overline{\gamma}_{BA} + \overline{\omega}_B{}^*)\left(\frac{2}{1+\overline{K}}\right) \qquad (4)$$

$$\text{where } R = \frac{(\rho_A'-\rho_A'')_i}{(\rho_A'-\rho_A'')_f} = \frac{(\Delta\rho_A)_i}{(\Delta\rho_A)_f};$$

$$I = \int_{v_i''}^{v_f''}\frac{\rho_A''}{\Delta\rho_A\,.\,V''}\,.\,\mathrm{d}V'';$$

$$\gamma_{BA} = \frac{\overline{n}_B}{\overline{n}_A};$$

$$K = \frac{\rho''\,.\,\omega_A' - \rho'\,.\,\omega_A''}{\Delta\rho_A};$$

$\rho = \rho_A + \rho_B$ is mass density (overall concentration) in gm. cm.$^{-3}$; ρ_A is concentration of A in gm. cm.$^{-3}$; v is volume (cm.^{3}); ω_A is concentration of A as mass fraction; n_A is flux of component A in gm. cm.$^{-2}$ sec.$^{-1}$; t is diffusion time, sec.; superscript $'$ is closed half-cell; superscript $''$ is open half-cell; $-$ is mean of initial and final values; $*$ is mean of the values at the bottom and the top of the diaphragm; subscript i is initial value at time $t = 0$; subscript f is final value at time t; and subscripts A,B are components A,B ($A \neq B$).

The integral diffusion coefficient $\overline{D}_{AB}'$ is related to the true differential value D_{AB}' by the following rigorous equation:

$$\overline{D}_{AB}' = \frac{(\ln R + I)\,(\overline{\omega}_A{}^*\,.\,\overline{\gamma}_{BA} + \overline{\omega}_B{}^*)\left(\dfrac{2}{1+\overline{K}}\right)}{\displaystyle\int_0^t\frac{\rho_A''}{F(\omega_A',\omega_A'')}\,.\,\mathrm{d}\ln v'' - \int_0^t\frac{\mathrm{d}\Delta\rho_A}{F(\omega_A',\omega_A'')}} \qquad (5)$$

where
$$F(\omega_A' \cdot \omega_A'') = \int_{\omega_A''}^{\omega_A'} \frac{\rho \cdot D_{AB}'}{(\omega_A \cdot \gamma_{BA} + \omega_B)}\, d\omega_A \qquad (6)$$

For an excellent approximation:

$$\bar{D}_{AB}' = \frac{(\bar{\omega}_A^* \cdot \bar{\gamma}_{BA} + \bar{\omega}_B^*)}{\bar{\rho}^*} \cdot \frac{1}{\bar{\omega}_A' - \bar{\omega}_A''} \cdot \int_{\bar{\omega}_A''}^{\bar{\omega}_A'} \frac{\rho \cdot D_{AB}'}{(\omega_A \cdot \gamma_{BA} + \omega_B)} \cdot d\omega_A \qquad (7)$$

It mey be noted that all the terms can be evaluated from overall density-composition data, to give a diffusion coefficient which has the same value regardless of whether the concentrations of component A or of component B are used, and regardless of whether the half-cell containing the more- or the less-concentrated solution is open.

It can be shown when ρ is constant, or ρ is $a + b\rho_A$ (that is, no volume change on mixing), that equation (3) reduces to equation (1), and equation (7) becomes:

$$\bar{D}_{AB}' = \frac{1}{\bar{c}_A' - \bar{c}_A''} \cdot \int_{\bar{c}_A''}^{\bar{c}_A'} D_{AB}' \cdot dc_A \qquad (8)$$

Extensive precision measurements on the ethanol–water system have been made. The calculated diffusion coefficients, based on these equations, and the complete derivation of these equations will be reported later.

The use of the equations presented here will now allow the use of large concentration differences in diaphragm cell experiments, and permits the calculation of accurate differential coefficients, D_{AB}', from a series of values of $\bar{D}_{AB}'$ the integral coefficients. The precision of the experimental determination of the latter is, of course, enhanced greatly by utilizing conditions of large concentration differences. The conversion of the values of D_{AB}' to the corresponding D_{AB} values can be done whenever the activity is known as a function of composition.

We thank the National Research Council of Canada for a grant-in-aid, and the Eldorado Mining and Refining Co., and Canadian Industries, Ltd., for the grants of fellowships (to F. A. L. D.) and financial support.

F. A. L. DULLIEN
Department of Chemical Engineering,
University of British Columbia.

L. W. SHEMILT*
University College, London, W.C.1.

---

* Honorary research associate on leave from the Department of Chemical Engineering, University of British Columbia.

[1] Northrop, J. H., and Anson, M. L., *J. Gen. Physiol.*, 12, 543 (1929).
[2] Gordon, A. R., *Ann. N.Y. Acad. Sci.*, 46, 285 (1945).
[3] Barnes, C., *Physics*, 5, 4 (1934).
[4] De Groot, S. R., "Thermodynamics of Irreversible Processes" (Interscience Pub., New York, 1951).
[5] Bird, R. B., in "Advances in Chemical Engineering", 1 (Academic Press, New York, 1956).

CHEMISTRY

Energies of Activation for Self-diffusion of Alkali Metal Ions in Analcite

THE self-diffusion coefficients and energies of activation for migration of alkali metal cations in analcite have recently been measured[1]. We now find that when these energies are plotted against α_1, the polarizabilities of the cations, the linear graph shown in Fig. 1 is obtained. This line can be represented by the equation:

$$E = 10{\cdot}5 + 6{\cdot}6 \times \alpha_1 \times 10^{24} \qquad (1)$$

where E is expressed in kcal./gm. ion and α_1 in cm.^{3}/ion.

Diffusion of a cation along a channel, the walls of which are, as in analcite, lined with negatively charged oxygens, must involve coulombic, polarization, dispersion and repulsion energies. The variation in coulombic energy as the ions diffused was calculated in ref. 1 for an idealized system approximating to that existing in analcite. This periodic variation of coulombic energy for a univalent cation diffusing along the channel resulted in a contribution, ΔE_c, of approximately 10 kcal./gm. ion to the overall energy of activation. This coulombic energy is independent of the polarizability of the cation, thus accounting for the term in equation 1 which is independent of polarizability, although the good agreement between experimental and calculated values is no doubt fortuitous considering the simplifications made in the calculations referred to[1].

The polarization energy of a cation of polarizability α_1 in a field of strength, F, is, to a first approximation:

$$E_P = -\tfrac{1}{2}\alpha_1 F^2 \qquad (2)$$

and therefore the activation energy for diffusion of the cation due to polarization would be:

$$\Delta E_P = -\tfrac{1}{2}\alpha_1 (F_T^2 - F_B^2) \qquad (3)$$

where F_B and F_T are the fields existing at an equilibrium cation site and at the point in the channel corresponding to the top of the energy barrier respectively. Thus $\Delta E_P = \alpha_1 B$, where B is a constant.

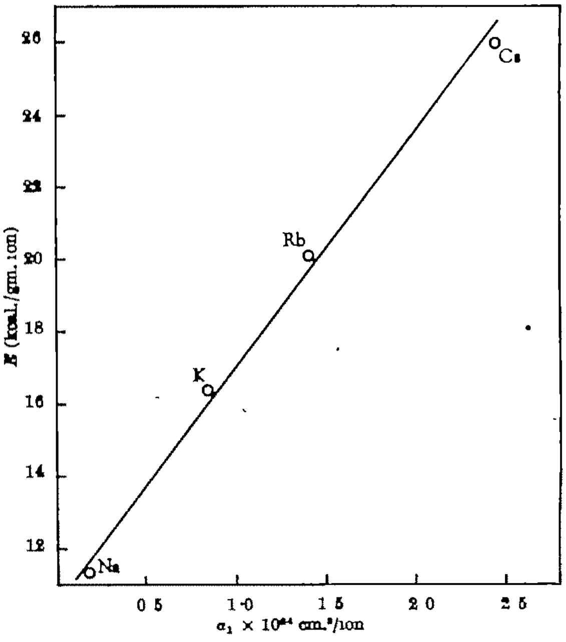


Fig. 1. Relationship between energy of activation for self-diffusion of alkali metal cations in analcite and the polarizability of the cations

The dispersion repulsion energy can be evaluated from the relation:

$$E_{D+R} = -6Nmc^2 \frac{\alpha_1\alpha_2}{\alpha_1\chi/_1 + \alpha_2/\chi_2} \sum_{r's} \left(\frac{1}{r^6} - \frac{r_e^6}{2r^{12}}\right) \quad (4)$$

where α_1, α_2 and χ_1, χ_2 are the polarizabilities and diamagnetic susceptibilities of the cation and of oxygen respectively, m is the mass of the electron, N is the Avogadro number and c the velocity of light; r denotes the distance between the oxygen and cation centres, and r_e is the equilibrium oxygen : cation separation. α_1/χ_1 is approximately constant for the four cations considered here, and thus equation 4 can be written:

$$E_{D+R} \simeq -\alpha_1 \times \text{constant} \sum_{r's} \left(\frac{1}{r^6} - \frac{r_e^6}{2r^{12}}\right) \quad (5)$$

and, as in the case of the polarization energy:

$$\Delta E_{D+R} \simeq -\alpha_1 \times \text{constant} \sum_{r's} \left\{ \left(\frac{1}{r_1^6} - \frac{r_e^6}{2r_1^{12}}\right)_T - \left(\frac{1}{r_2^6} - \frac{r_e^6}{2r_2^{12}}\right)_B \right\} \quad (6)$$

where r_1's and r_2's are the distances between cation centres and the centres of framework oxygens when the cations are on equilibrium sites and at the top of the energy barriers respectively. Accordingly, all r_1's and r_2's are constant for all ions so long as the equilibrium positions and those of the tops of the energy barriers are the same. The r_e's will differ among the ions, so the terms in $1/r^6$ are constant for all ions but not those in $1/r^{12}$. If the latter are small, we may write:

$$\Delta E_{D+R} = \alpha_1 C \quad (7)$$

where C is a coefficient which does not vary greatly among the ions. The total energy of activation, E, can then be represented by an equation of the same form as equation 1, since, according to the above treatment:

$$E = \Delta E_C + \Delta E_P + \Delta E_{D+R} = 10 + (B + C)\alpha_1 \quad (8)$$

In general, polarizability is proportional to ionic volume for similar ions of the same valence, and a linear relation was observed also between E and the volumes of the cations.

R. M. Barrer
L. V. C. Rees

Chemistry Department,
Imperial College of Science and Technology,
London, S.W.7.

---

[1] Barrer and Rees, *Trans. Farad. Soc.*, 56, 709 (1960).

Differential Thermal Analysis of Some Transition Metal Ethylenediamine Tetraacetic Acid Chelates

One of the least-studied aspects of co-ordination chemistry is the thermal properties of metal complexes with organic chelating agents. With such easily available instruments as the automatic recording thermobalance and differential thermal analysis apparatus, physical parameters such as minimum and maximum temperature limits for dehydration and pyrolysis reactions, rate-studies of thermal decomposition reactions[1], and detection of intermediate compounds formed during pyrolysis are easily attainable. Such information is needed in order to understand more fully the nature of certain types of thermal rearrangements and in synthesis work.

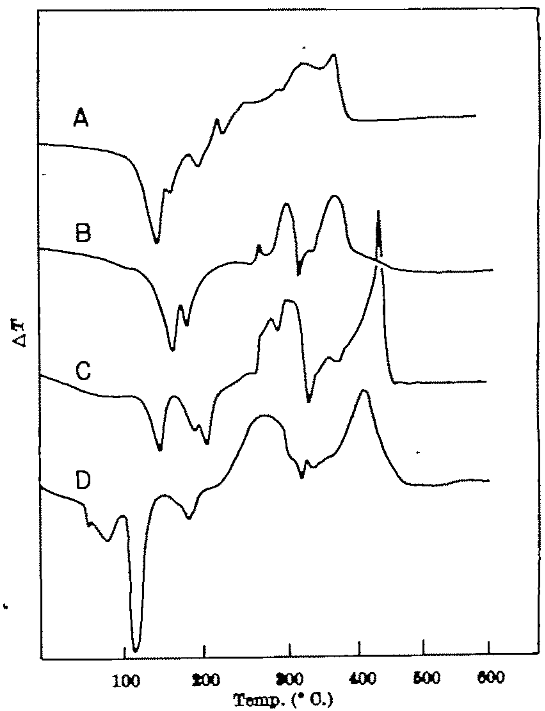


Fig. 1. Differential thermal analysis curves for metal ethylenediamine tetraacetic acid compounds. *A*, $Na_2CuEDTA\cdot3H_2O$; *B*, $Na_2ZnEDTA$ $3H_2O$; *C*, $Na_2CoEDTA$ $4H_2O$; *D*, $Na_2MnEDTA$ $5-6H_2O$

Although the thermal stability of a number of complexes is known[2], little information can be obtained concerning the thermal decomposition of transition metal ethylenediamine tetraacetic acid (EDTA) chelates. Previous work has been limited to the determination of the optimum drying temperatures for the salts, $Na_2EDTA\cdot2H_2O$ (refs. 3–5) and $Na_2CaEDTA\cdot2-3H_2O$ (ref. 5). It was found that the former could be converted to the anhydrous compound by heating to 120° C., but that temperatures above 150° C. resulted in decomposition of the salt. Similarly, the latter complex was dehydrated in the 37–180° C. temperature-range, with decomposition beginning at 337° C. In order to study further the thermal decomposition of the ethylenediamine tetraacetic acid metal complexes, the compounds $Na_2M\text{EDTA}\cdot n\text{H}_2O$, where M is cobalt(II), copper(II), manganese(II), and zinc(II), were examined by differential thermal analysis.

The apparatus for differential thermal analysis consisted of a furnace, similar in design to that previously described[6], and a microvolt strip-chart recorder and furnace temperature controller[7]. Sample sizes ranged in weight from 125 to 140 mgm. with calcined alumina being used as the reference material. A heating-rate of 8·0 deg. C. per min. was employed with a chart speed of 6 in. per hr.

The metal ethylenediamine tetraacetic acid complexes were obtained from the Geigy Chemical Co. (we are indebted to Dr. W. H. Zussman for providing these compounds), and were recrystallized from water–alcohol mixtures before pyrolysis. Thermobalance analysis[8] established the amount of hydrate water present in the complex and also the composition of the residual thermal decomposition product.

The resulting thermograms of the differential thermal analyses are given in Fig. 1. All the complexes gave pronounced endothermic (downward direction) peaks below 200° C. which were due to the evolution of hydrate-bound water. Immediately following the dehydration reactions, a series of exothermic (upward direction) peaks were observed which were due to the pyrolysis of the anhydrous salts. The pyrolysis of the complexes appears to proceed stepwise, as evidenced by the number of peaks observed. Since the reactions were carried out in air, the decomposition products were probably gaseous carbon dioxide, nitrogen, water and ammonia, and residues consisting of mixtures of sodium carbonate and metal oxide.

The thermal stability of the hydrates, as shown by the endothermic peak minima, was: manganese (80°) 110° < copper, 140° < cobalt, 145° < zinc, 160° C. Some idea as to the heat of hydration can be obtained by comparing the areas under the dehydration peaks. All the complexes were 3-hydrates except manganese, which appeared to have the composition, 5–6 hydrate. Naturally, with the larger number of molecules of water of hydration on the manganese it would have the largest peak area; however, a rough comparison can be made with the other complexes.

Some difficulty was experienced in obtaining reproducible exothermic peaks beyond 250° C. This was due to the tendency of the complexes to swell to voluminous proportions in the sample chamber during the pyrolysis, which resulted in pockets of air and erratic thermal conductivity of the samples. Hence, the differential response of the thermocouple was affected by this behaviour.

It is planned to continue this work with other metal complexes of ethylenediamine tetraacetic acid.

Wesley W. Wendlandt
G. Robert Horton

Department of Chemistry,
Texas Technological College,
Lubbock,
Texas.

---

[1] Freeman, E. S., and Carroll, B., *J. Phys. Chem.*, 62, 394 (1958).

[2] Duval, C., "Inorganic Thermogravimetric Analysis" (Elsevier, Amsterdam, 1953).

[3] Blaedel, W. J., and Knight, H. T., *Anal. Chem.*, 26, 741 (1954).

[4] Duval, C., *Anal. Chim. Acta*, 16, 545 (1957).

[5] Wendlandt, W. W., *Anal. Chem.*, 32, 848 (1960).

[6] Lodding, W., and Hammell, L., *Rev. Sci. Instr.*, 30, 885 (1959).

[7] Wendlandt, W. W., *J. Chem. Educ.*, 37, 94 (1960).

[8] Wendlandt, W. W., *Anal. Chem.*, 30, 56 (1958).

A New Technique for following Rapid Rates of Crystallization

TECHNIQUES for measuring rates of crystallization have been the subject of recent reviews[1,2]. Most of the methods described are not applicable to fast rates. A microscope-ciné camera technique[3] can be used when the species crystallizes in visibly discernible forms; but interpretation of results is sometimes complicated by impingement of boundaries between the crystalline entities. A method independent of the texture of the crystallizing species but requiring birefringence in the crystallized specimen has been developed in these laboratories. This consists, essentially, of following the increase in depolarization of plane-polarized light by the crystallizing specimen. Birefringence and crystallinity do not occur concurrently under all conditions of crystallization[4], but it is believed that when crystallization takes place from a melt under no external stress, measurement of rate of depolarization of light by the crystallizing sample parallels the development of crystallinity.

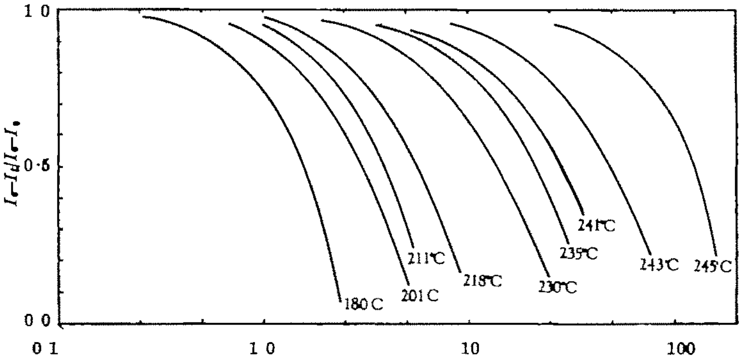


Fig. 1

Sections of dry polyhexamethylene adipamide (nylon 66) were melted in silicone oil between coverslips and then transferred rapidly to a thermostatted hot-stage mounted between crossed nicols on a microscope. Depolarization of the plane-polarized light was followed by a photomultiplier connected to a cathode-ray oscilloscope and recorded by a camera fitted to the cathode-ray oscillograph. A time-base superimposed on the photographic trace facilitated calibration and measurement. The instrument was calibrated using standardized neutral density optical filters; over the range of outputs studied, photomultiplier response was stable and linear. After the polymer melt specimen was transferred to the hot-stage a finite induction time, τ, elapsed during which no depolarization occurred. With the onset of crystallization, the photomultiplier output increased exponentially to a maximum rate and then the rate decreased as a pseudo-equilibrium crystallinity was attained. Characteristic sigmoidal isotherms were obtained for each crystallizing temperature. Both the induction period and the crystallization time decreased with decrease in crystallizing temperature in the range 170–255° C., but a minimum is expected in the region 160–170° C. where nylon 66 is believed to crystallize most rapidly.

Normalized plots of $\frac{I_e - I_t}{I_e - I_o}$ against t for each isotherm are superimposable and fit the Avrami equation[5]:

$$\ln\left(\frac{I_e - I_t}{I_e - I_o}\right) = -kt^n$$

where I_o = initial photomultiplier output; I_e = final photomultiplier output; I_t = photomultiplier output after time t(sec.); k = constant; n is a constant characteristic of the type of nucleation.

This technique does not provide information on the relative contributions of the nucleation and growth processes involved, but corresponding information may be obtained from spherulitic growth studies at low degrees of supercooling[1–3].

Fig. 1 shows normalized plots of $\frac{I_e - I_t}{I_c - I_e}$ versus t for various crystallization temperatures. The majority of these isotherms are coincident on displacement of the time axis, in agreement with specific volume/time curves, and are typical of rate measurements[4].

Fig. 2 shows plots of $\log\left(\frac{1}{t_{\frac{1}{2}}}\right)$ against $\frac{1}{T°\text{K.}}$ for the light transmission method superimposed on $\log G$ versus $\frac{1}{T°\text{K.}}$ for spherulitic growth-rate measurements[3] ($t_{\frac{1}{2}}$ = time when $\frac{I_c - I_t}{I_c - I_0} = 0{\cdot}5$; G = growth-rate in μ/min.). Results indicate that the apparent activation energies involved in both cases are similar, and this substantiates the similarity between the measurements.

This technique has been applied to other homopolymers under conditions where no visible spherulitic crystallization was apparent. It has also been shown to be an accurate method for melting-point determinations.

A more detailed account of the apparatus and analysis of results will be published later.

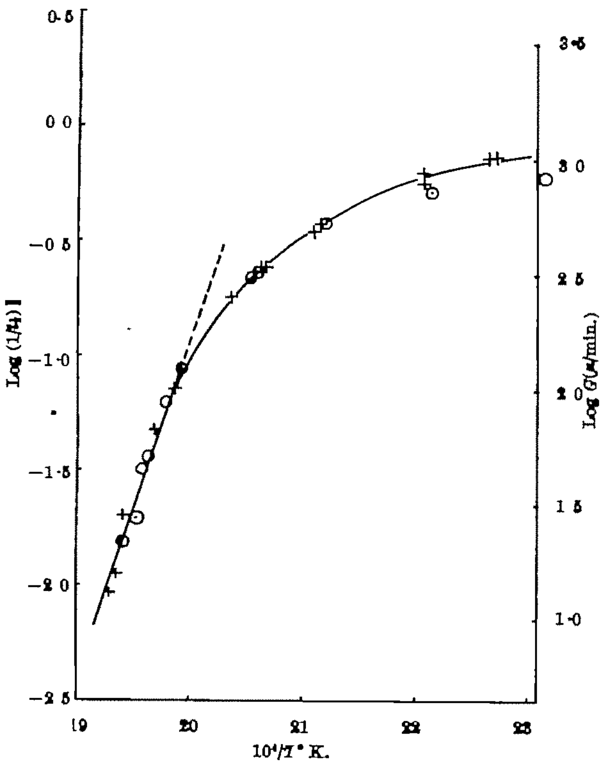


Fig. 2. ○, Burnett and McDevit (ref. 3); +, this work

Thanks are due to British Nylon Spinners, Ltd., for permission to publish this communication.

J. H. Magill

Research Department,
British Nylon Spinners, Ltd.,
Pontypool,
Monmouthshire.

[1] Mandelkern, L., in "Growth and Perfection of Crystals", edit. by Doremus, R. H., Roberts, B. W., and Turnbull, D., 467 (Wiley, New York, 1958).

[2] Mandelkern, L., *Soc. Plastics Eng. J.*, **15**, No. 1 (1959); *Rubber Chem. and Tech.*, **32**, 1392 (1959).

[3] Burnett, B. B., and McDevit, W. F., *J. App. Phys.*, **28**, 1101 (1957).

[4] Bunn, C. W., "Fibres from Synthetic Polymers", Chap. 10 (R. Hill, Elsevier, 1953).

[5] Avrami, M., *J. Chem. Phys.*, **7**, 1103 (1939); **8**, 212 (1940); **9**, 177 (1941).

[6] McLaren, J. V. (unpublished work).

[7] Flory, P. J., and McIntyre, A. D., *J. Polymer Sci.*, **90**, 592 (1955).

[8] McIntyre, A. D., Ph.D. thesis, Cornell University (1956). Univ. Microfilm No. 16256.

[9] Mandelkern, L., Quinn, F. A., and Flory, P. J., *J. App. Phys.*, **25**, 830 (1954).

Use of Azo Dyestuffs for the Polarographic Determination of the Lanthanides

The polarographic behaviour of some 2,2′-dihydroxy azo dyes in the presence of the lanthanides has recently been a subject of study in this laboratory. The lanthanides were found to form coloured chelates in alkaline solution with eriochrome violet *B* (5-sulpho-2-hydroxy benzene-azo-2-naphthol, *C.I.* No. 169), eriochrome black *PV* (5-sulpho-2-hydroxy benzene-azo-1,5-dihydroxy naphthalene, *C.I.* No. 170) and mordant blue 31 (5-sulpho-2-hydroxy benzene-azo-1,8-dihydroxy naphthalene 3,6-disulphonic acid, *C.I.* No. 16675). These dyes all exhibit well-defined single polarographic reduction waves. In ammonia, diethanolamine and piperidine buffers, the lanthanides cause a decrease in height of the dye step, and a second wave appears at a more negative potential. The height of the second wave is proportional to the concentration of lanthanide.

Eriochrome violet *B* has previously been used for the polarographic determination of aluminium[1,2], thorium and zirconium[3]. This dye was also found the most suitable of those investigated for the present purpose, and was studied in detail using d.c. and a.c. pen polarography and linear-sweep cathode-ray polarography. The lanthanides combine with eriochrome violet *B* in a 1 : 2 ratio, with apparent stability constants in the range 10^9 for neodymium to 10^{12} for ytterbium at *p*H 9. The azo group is believed to be involved in the co-ordination, this accounting for the difference in reduction potential of the free dye and dye-lanthanide complex. In an ammonia buffer of *p*H 9, the difference in the half-wave potentials of the free dye and complex was found to increase with increasing atomic number of the lanthanide, being 45 mV. for lanthanum, and 234 mV. for lutetium. This permits simultaneous determination of the lighter and heavier lanthanides in admixture. In piperidine buffer (*p*H 11) the half-wave potentials of the complexes are all very similar, being separated from the dye wave by about 180 mV.

The development of an analytical method necessitated a fundamental study of the polarographic behaviour of 2,2′-dihydroxy azo dyes at the dropping-mercury electrode. The behaviour of both the dye and the lanthanide complex is greatly influenced by adsorption of one or more forms at the mercury interface. These adsorption phenomena were investigated in some detail by a.c. polarography; tensammetric waves being observed for the dye, the reduced dye, and the dye-lanthanide complex.

A complete account of this work will be published elsewhere in due course.

T. M. Florence
L. E. Smythe

Australian Atomic Energy Commission
Research Establishment,
Lucas Heights,
New South Wales.

---

[1] Willard, H. H., and Dean, J. A., *Anal. Chem.*, **22**, 1264 (1950).
[2] Perkins, M., and Reynolds, G. F., *Anal. Chim. Acta*, **18**, 616 (1958).
[3] Patzak, R., and Zaki, M. R., *Mikrochim. Acta*, **274** (1959).

Structure of $AgSCN.P(n\text{-}C_3H_7)_3$

Complexes of silver iodide with *n*-alkyl trisubstituted phosphines are tetrahedrally co-ordinated[1]. Complexes with trico-ordinated silver can be prepared with substituted alkyl–aryl phosphines[2]. Electronic effects due to alkyl substitution cannot be neglected, as factors which could influence the change in co-ordination[3]; however, their importance must not be over-emphasized[3]. In fact, silver(I) very easily changes its co-ordination according to the nature of co-ordinating groups, and the factors which affect the changes of stereochemistry are not at all clear[4].

Earlier work[5] on complexes of silver thiocyanate and silver iodide with tri*cyclo*hexylphosphine has shown that silver is tri-co-ordinated in AgSCN.2PCy_3 (the situation being more complicated for the silver iodide derivative). X-ray preliminary results have shown that the silver atoms are not bonded by —SCN— bridges. In agreement with the structure in the solid state, the compound was found to be monomeric in freezing benzene.

On the other hand, it is known that silver thiocyanate has a polymeric structure, the silver atoms being bound to nitrogen and sulphur atoms by two covalent bonds. The non-linearity of this co-ordination is a very interesting feature of the structure[6].

The crystal structure of $AgSCN.NH_4SCN$ is built up by silver thiocyanate molecules, and silver forms only one 'true' covalent Ag—S bond (2·47 Å.). However, the nature of three further 'long' Ag—S bonds (2·63, 2·65, 2·74 Å.)[7] must also be taken into consideration before any definite conclusions on the real stereochemistry of silver in this compound can be drawn.

With these results in mind we found it of interest to investigate the compounds with general formula AgSCN.PR_3, extending our earlier study on AgSCN.2PCy_3 to a larger number of aliphatic phosphines.

The following previously unknown compounds were prepared by reaction of silver thiocyanate dissolved in ammonium thiocyanate water solution, and the corresponding phosphines: AgSCN.PEt_3 (m.p. 121° C.), AgSCN.PPr_3^n (m.p. 66° C.), AgSCN.PPr_3^i (m.p. 99° C.). The compound AgI.PPr_3^i (m.p. 205° C.) was also prepared in a similar way. These compounds are all non-electrolytes ($\Lambda_M \approx 10^{-2}$ in 10^{-3} molar nitrobenzene solution). The degree of association of AgSCN.PPr_3^i, determined cryoscopically in benzene, is 2·0, whereas that of the AgSCN.PPr_3^n is between 2·2 and 3·0. A dimeric structure (in solution) seems likely for the former compound, and interaction between the dimeric molecules is probably very weak also in the solid state. The degree of association of AgI.PPr_3^i is 3·5 in benzene. This compound clearly belongs to the class of four-covalent complexes of the type $[AgI.PR_3]_4$ (R = *n*-alkyl)[1].

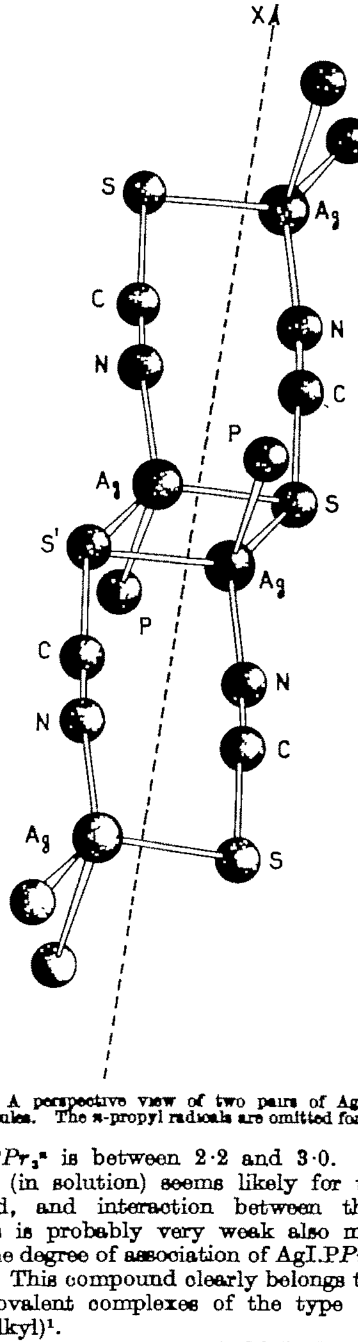


Fig. 1. A perspective view of two pairs of AgSCN.PPr_3^n molecules. The *n*-propyl radicals are omitted for clarity

The crystal structure of AgSCN.PPr_3^n has been determined from two-dimensional X-ray data. There is still some question about the exact positions of the light atoms but the general picture of the structure is well established. Determination of the parameters by means of precession photographs gave the following data: AgSCN.PPr_3^n. *M*, 326·2. Monoclinic. *a* =

Table 1. Bond-Lengths and -Angles

Bond	*d* (Å.)	Angle	θ (deg.)
Ag—S	2·79	P—Ag—N	137
Ag—S'	2·74	S—Ag—N	104
Ag—P	2·52	S'—Ag—P	111
		S—Ag—P	107
Ag—N	1·96	S'—Ag—N	108
N—C	1·28	S—Ag—S'	94
		Ag—S'—C	98
C—S	1·76	Ag—S—C	103

$6{\cdot}32 \pm 0{\cdot}02$, $b = 14 \pm 0{\cdot}04$, $c = 18{\cdot}24 \pm 0{\cdot}05$ Å. $\beta = 114 \pm 20'$. Absent spectra, $h0l$ when l is odd, $0k0$ when k is odd. Space group $C^5_{2h} - P2_1/c$. Four molecules per unit cell. Volume of unit cell = 1482 Å. (ref. 3), d, calc. 1·45, measured 1·41.

The structure has been resolved by means of the usual two-dimensional methods. Intensities were estimated photometrically from several series of Weissenberg photographs by using copper K_α radiation. At the present stage of refinement the reliability factors are $R = 0{\cdot}15$ on the projection (100) and $R = 0{\cdot}13$ on the projection on (010). Bond-lengths and -angles are given in Table 1. The mean probable error of the atomic co-ordinates, calculated with Luzzati's method[8], is 0·06 Å. Owing to the differences in weight of the atoms it is reasonable to assume that the error in the bond-lengths of the heavy atoms is 0·04 Å., and of the light atoms is 0·15 Å.

The molecular configuration is shown in Fig. 1. The silver atoms are linked by two —SCN— groups forming 8-membered quasi-planar rings. This type of bridging of two metal atoms by two —SCN— groups has been found previously in two complexes of cadmium[9,10], and in the platinum compound $[Pt_2(SCN)_2Cl_2(PPr_3^n)_2]$ (ref. 11). The planar units are linked by Ag—S bonds, forming an endless chain arranged along the X-axis as shown in Fig. 1. Alternatively the structural arrangement can be described as zigzag . . . —Ag—SCN—Ag—SCN— . . . polymeric chains bound in couples by Ag—S cross-linking. The steric arrangement of the ligands about the silver atom is that of a very distorted tetrahedron. The Ag—P bond is of normal length (2·52 Å.), but the Ag—S bond-length is considerably greater (2·74–2·79 Å.) than the distance of 2·43 Å. reported in silver thiocyanate[6].

There are two possible causes of the ionic character of the Ag—S bonds, and their relative importance cannot at present be decided. The first is the possible conjugation of the π electrons of the —SCN— group with the σ electrons of the Ag—S bond. The second is the electro-neutrality requirement on the silver atom. The former effect is probably more important in $[Pt_2(SCN)_2Cl_2(PPr_3^n)_2]$, where the length of the Pt—S bonds (2·44 Å.) is greater than expected for a Pt—SCN bond (2·27–2·30 Å.)[11]. In the present case the ionic character of the Ag—S bond is presumably attributable to the effect of charge distribution. In this respect the apparent absence of double-bonding character of the Ag—P bond becomes significant, indicating that negative charge has not been transferred from filled d orbitals of the silver to empty orbitals of the phosphorus atom. The different situation of the —SCN— group is consistent with the shift of the —CN— stretching frequency from 2,150 cm.⁻¹ observed for AgSCN (ref. 12) to 2,090 cm.⁻¹ found in the present case[13].

A full account of this work will be given after further refinement of the structure has been completed.

A. Turco

Istituto Chimica Generale,
University of Padua.

C. Panattoni
E. Frasson

Centro Strutturistica Chimica CNR,
Padua.

[1] Mann, G. F., Wells, A. F., and Purdie, D., J. *Chem. Soc.*, 1829 (1937).

[2] Cass, R. C., Coates, G. E., and Hayter, R. G., *J. Chem. Soc.*, 4007 (1955).

[3] Ahrland, S., and Chatt, J., *Chem. and Indust.*, 96 (1956).

[4] Ahrland, S., Chatt, J., Davies, N. R., and Williams, A. A., *J. Chem. Soc.*, 276 (1958).

[5] Turco, A., Panattoni, C., and Frasson, E., *Ricerca Sci.*, 29, 545 (1959).

[6] Lindqvist, I., *Acta Cryst.*, 10, 29 (1957).

[7] Lindqvist, I., and Strandberg, B., *Acta Cryst.*, 10, 173 (1957).

[8] Luzzati, V., *Acta Cryst.*, 5, 802 (1952).

[9] Zhdanov, G. S., and Zvonkova, Z. V., *Uspekhi Khimi*, 22 (1), 3 (1953).

[10] Cavalca, L., Nardelli, M., and Fava, G., *Proc. Chem. Soc.*, 159 (1959).

[11] Owston, P. G., and Rowe, J. M., *Acta Cryst.*, 13, 253 (1960).

[12] Chatt, J., Duncanson, L. A., Hart, L. A., and Owston, F. A., *Nature*, 181, 43 (1958).

[13] Pecile, C., Giacometti, G., and Turco, A., *Atti Accad. Lincei*, 28, 189 (1960).

BIOCHEMISTRY

Synthesis and Biological Properties of L-Arginyl-L-Prolyl-L-Prolyl-Glycyl-L-Phenylalanyl-L-Seryl-L-Phenylalanyl-L-Arginine, an Octapeptide related to Bradykinin

A structure has recently been proposed[1] for bradykinin, a plasma peptide obtained from or blood. The isolation, purification and amino-acid composition of this substance were reported earlier by the same workers[2]. The apparent importance of this peptide and its small size have prompted us to undertake its synthesis and a more detailed study of its biological action. Our first preparation of this octapeptide showed little bradykinin-like activity in several biological tests. While our synthesis and biological work were therefore being rechecked, workers[3,4] in two other laboratories reported the synthesis of this peptide and its lack of expected activity on the guinea pig's ileum. In the present communication we describe its synthesis and biological examination, which confirm and extend this recently published work.

The synthetic approach adopted made extensive use of the p-nitrophenyl ester method of peptide synthesis[5], which has recently proved itself in a synthesis of oxytocin[6]. N-Carbobenzoxy-L-phenylalanine-p-nitrophenyl ester was condensed with nitro-L-arginine methyl ester, giving the dipeptide in 95 per cent yield, m.p. 154–155° (reported[7] m.p. 160–161°).

N-Carbobenzoxy-L-phenylalanyl-nitro-L-arginine methyl ester was treated with hydrogen bromide in acetic acid, giving the dipeptide ester hydrobromide, m.p. 169–171°. Found: C, 41·55; H, 5·42; N, 18·00. Calc. for $C_{16}H_{25}N_6O_5Br$: C, 41·47; H, 5·44; N, 18·14. The dipeptide was allowed to react with N-CBZ-L-seryl azide, which yielded N-CBZ-L-Ser-L-Phe-NO_2-L-Arg methyl ester as colourless needles, m.p. 180–181°, $[\alpha]_D^{24} - 30{\cdot}2°$ (c 2, methanol). Found: C, 54·14; H, 5·88; N, 16·31. Calc. for $C_{27}H_{35}N_7O_9$: C, 53·90; H, 5·86; N, 16·29. After removal of the carbobenzoxy group with hydrogen bromide in acetic acid, the tripeptide ester was condensed with N-CBZ-L-phenylalanine-p-nitrophenyl ester, giving an 87 per cent yield of the crystalline tetrapeptide, m.p. 159–161°, $[\alpha]_D^{24} - 23{\cdot}8°$ (c 2, methanol). Found: C, 57·53; H, 6·17; N, 14·75. Calc. for $C_{36}H_{44}N_8O_{10}$: C, 57·84; H, 5·92; N, 14·96. Treatment with hydrogen bromide in acetic acid removed the amine protection and the resulting tetrapeptide ester and N-CBZ-glycyl-p-nitrophenyl ester gave small colourless needles of N-CBZ-Gly-L-Phe-L-Ser-L-Phe-NO_2-L-Arg methyl ester in 83 per cent yield, m.p. 180–181° (a different sample melted at 165–166° with identical rotation and analysis), $[\alpha]^{24}_{D}$ – 13·7° (*c* 2, dimethylformamide). Found: C, 56·62; H, 5·97; N, 15·20. Calc. for $C_{38}H_{47}N_9O_{11}$: C, 56·63; H, 5·88; N, 15·64. Removal of the carbobenzoxy group was again accomplished with hydrogen bromide in acetic acid, the hydrogen bromide removed from the peptide with '*IRA*-410 (OH^-)' resin and subsequent reaction with N-CBZ-L-proline-*p*-nitrophenyl ester gave N-CBZ-L-Pro-Gly-L-Phe-L-Ser-L-Phe-NO_2-L-Arg methyl ester as microneedles, m.p. 175–176°, $[\alpha]^{24}_{D}$ – 31° (*c* 1, dimethylformamide). Found: C, 57·31; H, 6·27; N, 15·11. Calc. for $C_{43}H_{54}N_{10}O_{12}$: C, 57·18; H, 6·02; N, 15·51. The heptapeptide N-CBZ-L-Pro-L-Pro-Gly-L-Phe-L-Ser-L-Phe-NO_2-L-Arg methyl ester was prepared in the same manner as the hexapeptide and it was found to be rather low melting (125–130°), which was attributed to the two proline residues. The protected heptapeptide was obtained as colourless rosettes from methanol, $[\alpha]^{24}_{D}$ – 35·2° (*c* 1, dimethylformamide). Found: C, 57·31; H, 6·16; N, 15·10. Calc. for $C_{48}H_{61}N_{11}O_{13}$: C, 57·63; H, 6·14; N, 15·40. Reaction of the decarbobenzoxylated heptapeptide (hydrogen bromide in acetic) with the *p*-nitrophenyl ester of tricarbobenzoxy-L-arginine[8] (m.p. 126–127°). Found: C, 62·02; H, 5·20; N, 10·25. Calc. for $C_{36}H_{35}N_5O_{10}$: C, 61·97; H, 5·06; N, 10·04) gave the fully protected octapeptide, m.p. 130–135°, $[\alpha]^{24}_{D}$ – 32·4° (*c* 1, dimethylformamide). Found: C, 58·72; H, 6·08; N, 14·47. Calc. for $C_{70}H_{85}N_{15}O_{18}$: C, 59·02; H, 6·16; N, 14·75. Hydrolysis of the methyl ester and one carbobenzoxy group with 1 *N* sodium hydroxide in methanol followed by hydrogenation in acetic acid/methanol using palladium black catalyst gave the triacetate salt of L-Arg-L-Pro-L-Pro-Gly-L-Phe-L-Ser-L-Phe-L-Arg. Found: C, 50·86; H, 7·31; N, 16·91. Calc. for $C_{51}H_{78}N_{14}O_{16}.3H_2O$: C, 51·16; H, 7·07; N, 16·38. Titration with perchloric acid in acetic acid gave an equivalent weight of 401, which is in agreement with a molecular weight of 1,197. Paper chromatography of the octapeptide using two different solvent systems (*iso*propyl alcohol : ammonia : water; *tert*-butyl alcohol : acetic acid : water) gave R_F values of 0·26 and 0·43 respectively with no impurities being indicated (Sakaguchi and bromphenol blue; the ninhydrin test was negative).

The synthetic octapeptide was compared with partially purified bradykinin, prepared by the action of crystalline trypsin on heated beef globulin, standardized against pure bradykinin obtained from similar starting materials[9]. The synthetic peptide (133 μgm./ml.) did not cause contraction of the guinea pig's ileum *in vitro*; but in its presence bradykinin was slightly potentiated. Like bradykinin[9], the peptide relaxed rat's duodenum *in vitro*, but its potency was very roughly 1/6,000 that of pure bradykinin. Unlike bradykinin[10], the peptide (4–16 mgm./kgm.) did not cause broncho-constriction in guinea pigs *in vivo*, but it slightly potentiated this effect of bradykinin. Like bradykinin[11], intradermal doses of the peptide increased the permeability of the skin capillaries of guinea pigs blued with pontamine blue 6*BX*. Its potency was about 1/1,000 that of pure bradykinin.

When given in high doses to four biological preparations, L-Arg-L-Pro-L-Pro-Gly-L-Phe-L-Ser-L-Phe-L-Arg. failed to show two biological properties of bradykinin, and showed another two very weakly.

We wish to thank Dr. D. F. Elliott, Dr. G. P. Lewis and Dr. E. W. Horton for a specimen of pure bradykinin and Dr. I. M. Lockhart and Mr. W. A. Jones for supplies of partially purified bradykinin.

E. D. NICOLAIDES
H. A. DEWALD

Research Department,
Parke, Davis and Co.,
Ann Arbor,
Michigan.

PATRICIA G. SHORLEY
H. O. J. COLLIER

Department of Pharmacological Research,
Parke, Davis and Co.,
Hounslow,
Middlesex.

---

[1] Elliott, D. F., Lewis, G. P., and Horton, E. W., *Biochem. J.*, 76, 16*P* (1960).

[2] Elliott, D. F., Lewis, G. P., and Horton, E. W., *Biochem. J.*, 74, 15*P* (1960).

[3] Schwyzer, R., Rittel, W., Sieber, P., Kappeler, H., and Zuber, H., *Helv. Chim. Acta*, 43, 1130 (1960).

[4] Boissonnas, R. A., Guttmann, St., Jaquenoud, P.-A., Konzett, H., and Sturmer, E., *Experientia*, 16, 326 (1960).

[5] Bodanszky, M., *Nature*, 175, 685 1955).

[6] Bodanszky, M., and DuVigneaud, V., *J. Amer. Chem. Soc.*, 81, 5688 (1959).

[7] Hofmann, K., Peckham, W. D, and Rheiner, A., *J. Amer. Chem Soc.*, 78, 238 (1956).

[8] Zervas, L., Winitz, M., and Greenstein, J. P., *J. Org. Chem.*, 22, 1515 (1957).

[9] Gaddum, J H., and Horton, E. W., *Brit. J. Pharmacol.*, 14, 117 (1959).

[10] Collier, H. O. J., Holgate, J. A., Schachter, M., and Shorley, P. G., *Brit. J. Pharmacol.*, 15, 290 (1960).

[11] Holdstock, D. J., Mathias, A. P., and Schachter, M., *Brit. J. Pharmacol.*, 12, 149 (1957).

Homotransplant Antigens: Preparation of Active Cellular Fractions

WE have reported recently a method for the measurement of the antigenicity of whole splenic cells using highly inbred strains of mice in a homotransplant system[1]. Using this method of assay, we have tested fractions of mouse splenic cells for antigenic activity. Below are described the preparation and properties of tissue fractions active as antigens in a homotransplant system. Other methods of preparation of antigenic fractions from tissues have been described by Billingham, Brent and Medawar[2], by Berrian and Brent[3], by Hašková and Hrubešová[4], by Castermans and Oth[5], and Lejeune-Ledant and Albert[6].

A plunger-type homogenizer, similar to one described by Philpot and Stanier, was used[7]. It consists of accurately drawn heavy-walled glass tubing 10 in. long and 1 in. internal diameter (Fischer and Porter Co., Hatboro, Penn.) and two stainless steel plungers with clearances of 0·0015 and 0·0005 in. A centrifuge, maintained in a cold room at 3–5° C., and capable of 20,000*g* acceleration, was employed for sedimentation. A 'Vir-tis' (Mod. 23) homogenizer was used for high-speed blending. *C57/Bl* 6 male mice, weighing 20 gm. or more, were the recipients and *C3H* or *A/He* male mice weighing 20 gm. or more, were the donors (obtained from the Roscoe B. Jackson Memorial Laboratories, Bar Harbor, Maine).

All preparative steps were carried out at 3–5° C. Mice of donor strains (*C3H* or *A/He*) were killed by cervical luxation. The spleens were excised, chilled in cold 0·15 *M* saline and processed without delay. Groups of 3 or 4 spleens, placed upon a piece of 40-mesh stainless steel screen which was supported on a funnel, were sliced longitudinally, and the pulps were pressed gently through the screen by means of a flat spatula. A fine stream of cold balanced salt solution was directed intermittently on to the tissue in order to wash cells from the screen and the funnel. Calcium ion concentration was kept at 0·0015 *M*; in its absence agglutination occurred. The suspended cells were drawn gently back and forth through a pipette with a wide orifice, and were diluted to a volume of 10–20 ml. per spleen (cell concentrations of 20 to 10 × 10⁶ cells/ml.). After standing about 10 min., the cell suspension was separated from the larger clumps by decanting into a beaker. Aliquots (1 ml.) of the cell suspension were removed after thorough mixing and diluted with 3 per cent acetic acid, and cell counts were performed in a hæmacytometer.

The decanted cell suspension was then sedimented at 4,000*g* for 10 min. The supernatant solution was discarded. The packed cells were resuspended gently, using the plunger with the 0·0015-in. clearance; the suspending medium (2–5 ml. per spleen) was buffered saline (0·13 *M* sodium chloride and 0·01 *M* phosphate, '0·15 *M*', *p*H 7·2–7·3; calcium was absent). Some cell agglutination usually occurred. After sedimentation at 4,000*g* for 10 min. the supernate was decanted and examined microscopically for cells. No cells were found, and the supernate was sedimented at 20,000*g* for 30 min.

The sediment recovered after 4,000*g* centrifugation was recycled four times, using the above sequence of steps with the following modifications: homogenization was effected (rather than resuspension) by vigorous use of the plunger with 0·0005-in. clearance (but production of foam was avoided), and the suspending media (2–5 ml. per spleen), each used twice in succession, were buffered saline diluted with one and four volumes of water ('0·075 *M*' and '0·03 *M*' saline respectively). As above, all supernates were reserved for subsequent 20,000*g* centrifugation.

The sediment obtained after the last homogenization in 0·03 *M* buffered saline was swirled gently in 0·015 *M* saline (about 1 ml. per spleen) in order to lower the ionic strength of the residual saline solution in the sediment without gelling the nucleoprotein. The suspension was then sedimented at 4,000*g*, and the sediment was dispersed by high-speed blending in distilled water (2–3 ml. per spleen). An initial increase of viscosity was evident in about 30 sec., followed by a rapid decrease. After about 2 min. blending, the solution had a low viscosity. The sediment obtained after centrifugation at 4,000*g* was discarded. This supernate, like the others, was opalescent and was centrifuged at 20,000*g*.

Centrifugation of the supernates at 20,000*g* for 30 min. resulted in recovery of a small amount of greenish-tan sediment. Although the supernatant solutions were clear, protein could be precipitated from all by lowering the *p*H to 5 with 0·1 *N* acetic acid.

The greenish-tan sediments recovered after 20,000*g* were resuspended in isotonic saline, either separately or admixed, and these were assayed for antigenic activity. The volumes of these suspensions were adjusted so that 1 ml. contained the greenish-tan sediment extracted from 50 × 10⁶ cells (hereafter referred to as the 'test sediment').

In our test system the test sediment was injected intraperitoneally in 2 ml. of 0·15 *M* saline. Four days later a 1-cm.² full thickness test skin graft, freed of all panniculus, was placed on the intact panniculus carnosus of the recipient strain. The test grafts were excised on the sixth day and were examined histologically. The percentages of surviving epithelium were scored as 0, 10, 25, 50, 75, 90 and 100 per cent, and these values were converted to integers 0–6 respectively for statistical convenience[1].

Table 1. COMPARISON OF ANTIGENIC ACTIVITY OF FRACTIONATED MOUSE SPLEEN CELLS DETERMINED BY SCORES OF TEST SKIN HOMOGRAFTS

Test sediment from	Score*
0·15 *M* fraction	3, 3, 2, 1, 0, 0, 0†
0·075 *M* fraction	4, 3, 3, 3, 2, 1, 1†
0·03 *M* fraction	4, 4, 3, 3, 3, 3, 2†
Water dispersed	5, 5, 5, 4, 4, 4, 4
Control	6, 5, 5, 5, 5, 4, 4

* Maximum antigenicity is indicated by the figure 0.
† Statistically distinguishable from control on $P = 0·05$ level or better (Student '*t*' test).

The antigenic activity of the test sediments from one experiment are shown in Table 1. When considerable antigenic activity was recovered from the 0·15 *M* and 0·075 *M* saline fractions, antigenic activity in the 0·03 *M* saline fraction and the water-dispersed fraction was either feeble or absent. This distribution of antigenicity among the fractions appears to reflect the vigour with which the homogenizer was used to disrupt cells. In other experiments, when homogenization was less vigorous, there was a more even distribution of antigenicity among the fractions. However, when high-speed mechanical blending was substituted for manual homogenization, there was a diminution of observed antigenic activities. The precipitate obtained by addition of acetic acid to the supernates decanted from the test sediments was inactive in our test system.

The test sediments retained activity after suspension in 2 *M* sodium chloride. Appreciable activity remained after rapid freezing to 'dry ice'/acetone temperatures, followed by rapid thawing in a 37° C. water bath. Activity was greatly reduced by suspension in acetate buffered saline, *p*H 5, for about 10 min. The test sediments became inactive after storage overnight at 3° C. in either distilled water or in cold balanced salt solution.

The test sediments were not appreciably soluble in acid solution (up to 18 *N* sulphuric acid), in buffered saline, in 2 *M* sodium chloride, or in distilled water but were dissolved by 0·01 *N* sodium hydroxide and by 6 *M* urea.

The test sediments gave a strong biuret reaction for protein and contained 5–10 per cent of nitrogen by micro-Kjeldahl (dry-weight basis). Alcohol/ether extracts of the sediments contained approximately 1–2 mgm. of chromate-oxidizable material (lipid) per 200–400 μgm. of nitrogen[8] and the residue after extraction contained up to 100 μgm. deoxyribonucleic acid per 200–400 μgm. nitrogen. Hexosamine, N-acetyl-hexosamine, reducing sugars and ribonucleic acid were detectable in small amounts.

We wish to acknowledge the technical assistance of Gertrude Lustig, Edwina Czajkowski and Frances Hall. This work was supported by a grant from the U.S. Public Health Service (*H*-1771) and contracts

with the U.S. Army Medical Research and Development Command (*MD* 645 and 2061).

L. T. Mann, Jun.
J. M. Corson
G. J. Dammin

Departments of Pathology,
Harvard Medical School and
The Peter Bent Brigham Hospital,
Boston, 15, Massachusetts.
June 22.

[1] Mann, Jun., L. T., Corson, J. M., and Dammin, G. J., *Science*, 130, 1707 (1959).
[2] Billingham, R. E., Brent, L., and Medawar, P. B., *Nature*, 178, 514 (1956); *Transplant. Bull.*, 5, 377 (1958).
[3] Berrian, J. H., and Brent, L., *Ann. N.Y. Acad. Sci.*, 73, 654 (1958).
[4] Hašková, V., and Hrubešová, M., *Nature*, 182, 61 (1958).
[5] Castermans, A., and Oth, A., *Nature*, 184, 1224 (1959).
[6] Lejeune-Ledant, G. N., and Albert, F. H., *Ann. N.Y. Acad. Sci.*, 87, 808 (1960).
[7] Philpot, J. St. L., and Stanier, J. E., *Biochem. J.*, 63, 214 (1956).
[8] Paul, J., *The Analyst*, 83, 37 (1958).

The Plasma Proteins in Normal Urine

THE first electrophoretic study of the proteins in concentrated normal urine was published in 1951 by Rigas and Heller[1]. With the aid of the moving-boundary technique, they demonstrated components with mobilities corresponding to those of the main protein fractions in serum. The albumin/globulin ratio was, however, reversed, and there was a poor separation in the globulin range. Other investigators, using moving-boundary or paper electrophoresis, have reported similar results. I have recently subjected the high molecular substances of normal urine to preparative zone electrophoresis[2]. It was found that all urine protein fractions, including the albumin, contained large amounts of carbohydrate, thus differing in composition from the corresponding plasma fractions. Electrophoretic fractionation, therefore, does not give satisfactory information as to the types and amounts of plasma proteins present in normal urine. Immunochemical methods offer better possibilities for identifying individual plasma proteins in urine. Work on the excretion of plasma proteins in normal human urine by immuno-electrophoresis has been published by Grant[3], Patte *et al.*[4], and others. The excretion of about eight different plasma proteins has been demonstrated.

The present work was undertaken in order to identify as many as possible of the plasma proteins excreted in the urines from healthy individuals, and to find out whether immunochemical differences occurred between the urine proteins and the corresponding plasma proteins.

Specimens of filtered 24-hr. urine from 6 male and 6 female healthy students and laboratory workers were concentrated 1,000–1,500 times, using low-pressure ultrafiltration. In some experiments, pooled male urine was also used. The ultrafiltration technique was tested with diluted sera. It was found to give good recoveries of total protein and recoveries of individual proteins without other signs of denaturation apart from some alterations of the lipoproteins. The methods used were immuno-electrophoresis, applying the microtechnique of Scheidegger[5], and the double diffusion-in-gel technique of Ouchterlony[6]. Highly purified plasma proteins (obtained as a gift from Prof. H. E. Schultze, Behringwerke A.G., Marburg/L.) were used as reference substances. A sample of the β_{1A}-globulin, recently isolated by Muller-Eberhard *et al.*[7], was kindly supplied by these workers. Most of the experiments were performed with rabbit antisera (Behringwerke A.G., Marburg/L.) against total human serum and against purified plasma proteins. In some experiments an anti-total-human-serum mule serum (a gift from Prof. P. Grabar, Institut Pasteur, Paris) was also used.

In most instances, eleven to thirteen different plasma proteins were found in the pooled urines as well as in the individual urines. Fig. 1 shows the result of an immuno-electrophoretic experiment with concentrated pooled normal urine and anti-total-human-serum rabbit serum. The electrophoresis was performed at pH 8·2. Twelve or thirteen precipitation lines can be distinguished, probably representing the same number of plasma proteins. This urine also contained the pre-albumin of Schultze[8] and fibrinogen, as shown by specific antisera against these proteins, and thus in total about fourteen or fifteen plasma proteins.

Individual plasma proteins were identified by immuno-electrophoresis, using specific antisera against purified plasma proteins and anti-total-human-serum sera adsorbed with purified proteins, and by the Ouchterlony technique, using specific antisera against purified plasma proteins. By these methods it was possible to demonstrate with certainty the presence of the following plasma proteins in the urines of most of the 12 individuals; the pre-albumin of Schultze, albumin, α_1-seromucoid, haptoglobin, ceruloplasmin, transferrin, the β_{1A}-globulin and γ-globulin. The following plasma proteins were further indicated immuno-electrophoretically: two or three α_1-globulins, in some cases one additional α_2-globulin, regularly one more β_1-globulin and a precipitation line with the same shape and electrophoretic mobility as the β_{2A}-globulin in plasma. Fibrinogen was found in pooled urine and in ten of the individual urines, as revealed by an anti-fibrinogen serum. Ceruloplasmin, the β_{1A}-globulin and fibrinogen do not seem to have been identified earlier in normal urine. Patte *et al.*[4] state that transferrin is the only β_1-globulin present in normal urine. With the present technique, it was possible to demonstrate three β_1-globulins in most of the normal urines. Two of them were identified as transferrin and β_{1A}-globulin. The urine albumin usually showed a somewhat higher electrophoretic mobility than serum albumin in the immuno-electrophoretic experiments, which were carried out at pH 8·2. The same observation was made by Patte *et al.*[4] in pathological proteinurias, but not with normal urine. The reason for this phenomenon is

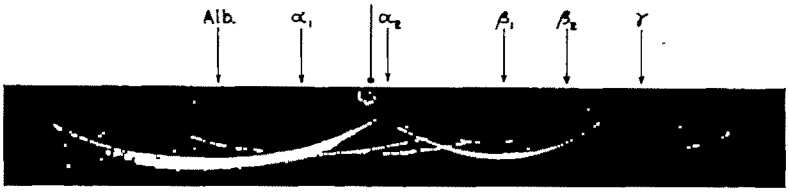


Fig 1

not clear. Experiments with specific antisera against α_2- and β-lipoproteins seem to indicate that these proteins are absent in normal urine. This is in accord with results of earlier investigators. Ouchterlony tests with a specific antiserum against α_2-macroglobulin indicated the presence of traces of this protein in the urines of some of the individuals.

By the use of the Ouchterlony technique and specific antisera against purified proteins, urine was found to contain proteins giving reactions of identity with the plasma proteins pre-albumin, albumin, ceruloplasmin, transferrin, and γ-globulin. Proteins giving reactions of partial identity with plasma globulin seemed also to be present in urine.

A detailed report of this investigation will be published elsewhere.

I. Berggård

Institute of Medical Chemistry,
University of Uppsala.

---

[1] Rigas, D. A., and Heller, C. G., *J. Clin. Invest.*, 30, 853 (1951).

[2] Berggård, I., *Acta Soc. Med. Upsal.*, 64, 156 (1960).

[3] Grant, G. H., *J. Clin. Path.*, 10, 360 (1957).

[4] Patte, J.-C., Baldassaire, G., and Loret, J., *Rev. Franç. Études Clin. Biol.*, 3, 960 (1958).

[5] Scheidegger, J. J., *Int. Arch. Allergy*, 7, 103 (1955).

[6] Ouchterlony, Ö., "Progress in Allergy," edit. Kallós, P., 5, 1 (S. Karger, A. G., Basel, 1958).

[7] Muller-Eberhard, H. J., Nilsson, U., and Aronsson, T., *J. Exp. Med.* (in the press).

[8] Schultze, H. E., Schönenberger, M., and Schwick, G., *Biochem. Z.*, 328, 267 (1956).

Steroid 11β-ol Dehydrogenase in Human Placenta

In the course of work on steroid metabolism in pregnancy, we have observed that adrenal steroids with 11β-ol structure are transformed into 11-keto compounds in homogenates of the human placenta at term. The action and properties of the corresponding enzyme have been investigated.

The homogenates were prepared as follows: 5 gm. of wet placenta were ground in an all-glass Potter mill and suspended in 25 ml. of 0·13 *M* sodium chloride buffered to *p*H 7·4 with 0·02 *N* phosphate.

The activity of the enzyme was measured by estimating the percentage of 11-keto compound formed under standard conditions: 1 μgm. of steroid per 1 gm. of placenta (5 ml. of the homogenate), incubated for 30 min. at 37° C., while shaking in a stream of oxygen.

Tritium-labelled steroids were used throughout[1]. The specific activities of cortisol-1,2-^{3}H, of corticosterone-1,2-^{3}H, and of androst-4-ene-11β-ol-3,17-dione, were respectively 835 mc./m.mole, 412 mc./m.mole and 827 mc./m.mole. Dichloromethane extracts of the homogenates were chromatographed on filter paper using the Bush system *C* and/or *B*1 [2]. The radioactivity on the chromatograms was detected and measured in a windowless flow scanner[3].

The membranes (chorion) are a particularly rich source of the enzyme, which appears strongly bound to connective tissue. In homogenates lysed with 0·2 per cent 'Triton', only 30 per cent of the activity remained in the supernatant after centrifuging for 30 min. at 30,000 r.p.m.

The activity in the supernatant could be precipitated in the cold with neutral ammonium sulphate at half saturation. Precipitation at room temperature and precipitation with non-neutral ammonium sulphate both inactivated the enzyme. The activity also disappeared after freezing the tissues.

Table 1

No.	Steroid	Conditions	% conversion
1.	Cortisol	Supernatant with 0·2% 'Triton'	0
2.	,,	,, 0·2 μ*M* DPN added	11
3.	,,	,, 0·2 μ*M* TPN added	33
4.	,,	As No. 3, 10^{-4} *M* mercuric chloride	0
5.	,,	As No. 3, 100 μgm. of cortisone (reaction product) added	38
6.	,,	As No. 3, *p*H 6·01	32
7.	,,	As No. 3, *p*H 7·01	53
8.	,,	As No. 3, *p*H 8·03	66
9.	,,	As No. 3, *p*H 9·1	65
10.	Cortisone	0·2 μ*M* of TPN and 0·1 m*M* of glucose-6-phosphate added. Percentage conversion calculated for inverse reaction.	7
11.	Corticosterone	0·2 μ*M* of DPN added	19
12.	,,	0·2 μ*M* of TPN added	51
13.	Androst-4-ene-11β-ol-3,17-dione	0·2 μ*M* of DPN added	17
14.	,,	0·2 μ*M* of TPN added	36

DPN, diphosphopyridine nucleotide; TPN, triphosphopyridine nucleotide.

The activity of all fractions was suppressed by dialysis for 24 hr. against saline. The activity could be restored by the addition of triphosphopyridine nucleotide. Diphosphopyridine nucleotide also restored the activity, but to a lesser degree.

In the presence of a triphosphopyridine nucleotide-reducing enzyme system (glucose-6-phosphate dehydrogenase) the keto compounds are reduced to the 11β-ol form, indicating the reversibility of action of steroid dehydrogenase.

The enzyme activity shows a broad maximum between *p*H 8 and *p*H 9.

The results are summarized in Table 1. Percentage conversion has been calculated as keto form/(keto form + hydroxy form) × 100.

Finally, it should be pointed out that the 11β-ol dehydrogenase of human placenta has a low substrate specificity since it transforms both C 19 steroids and C 21 steroids with or without a 17-hydroxy group in the side-chain.

The physiological role of the enzyme is uncertain. The conversion of 11-hydroxy group to 11-keto group is a well-known pathway of extra-hepatic steroid metabolism in the animal and in man[4-7].

The placenta enzyme may be part of the regulatory mechanism of the fœtal–maternal endocrine relations. Its presence in the placenta and in the membranes explains the origins of cortisone in normal human amniotic fluid[8].

The technical assistance of Mrs. M. R. Lacroix and Miss Y. Sonnet is gratefully acknowledged. The placenta were kindly supplied by Prof. Schockaert and Prof. Renaer from the Department of Obstetrics and Gynaecology.

P. A. Osinski

Institut Interuniv. des Sciences Nucléaires,
Hôpital St. Pierre, Louvain.

---

[1] Osinski, P., and Vanderhaeghe, H., *Rec. Trav. Chim. Pays-Bas*, 79, 216 (1960).

[2] Bush, I. E., *Biochem. J.*, 50, 370 (1952).

[3] Osinski, P., *J. App. Rad. and Isotopes*, 7, 306 (1960).

[4] Ganis, F. H., Axelrod, L. R., and Miller, L. L., *J. Biol. Chem.*, 218, 841 (1956).

[5] Hubener, H. J., Fukushima, D. K., and Gallagher, T. F., *J. Biol. Chem.*, 220, 499 (1956).

[6] Grosser, B. I., Berliner, D. L., and Dougherty, T. F., *Fed. Proc.*, 18, 61 (1959).

[7] Bojesen, E., and Egense J., *Acta Endocrin.*, 33, 347 (1960).

[8] Baird, C. W., and Bush, I. E., *Acta Endocrin.*, 34, 97 (1960).

Free Amino-Acids of the Tsetse Fly (*Glossina*)

It was discovered some years ago that there is a substantial decrease in the residual (non-fatty) dry weight of the head and thorax of tsetse flies in the course of starvation[1]. Subsequent analysis of flies (*Glossina swynnertoni* Aust.) collected in the field at different stages of the hunger cycle showed that the thoracic residual dry weight decreases by as much as 0·25 mgm. towards the end of the hunger cycle (unpublished work). The findings suggest the existence of a non-fatty food reserve, and since neither glycogen nor reducing sugars could be demonstrated in amounts sufficient to account for these changes in weight, a study of the free amino-acids was undertaken in an attempt to identify the substances responsible.

Amino-acids were extracted in water after precipitation of proteins with ethanol; to avoid contamination with products of digestion in the gut only the head and thorax were used. The extract was evaporated to dryness and taken up in 10 per cent propanol. Amounts corresponding to 1/20 of a tsetse thorax were spotted on Whatman No. 4 filter paper for two-dimensional development with water-saturated phenol and with 77 per cent ethanol at 23° C.

Fig 1*A* shows the free amino-acids of a well-fed *G. morsitans* Westw. captured in the field; those of a similar fly starved to death at high relative humidity are shown in Fig. 1*B*. The chromatogram of the well-fed fly is dominated by an intense alanine spot; glutamic acid also occurs in substantial concentration, with arginine, taurine and serine present in smaller amounts, and glutamine and aspartic acid just detectable. The chromatogram of the starved fly shows a striking decrease in general ninhydrin positivity; a small amount of ornithine has appeared during starvation, the concentration of taurine and serine is about the same, but the alanine, glutamic acid, glutamine and aspartic acid spots have all but disappeared, and the intensity of the arginine spot is reduced.

Preliminary estimates of the amino-acid contents, using Naftalin's colorimetric technique[2], have shown that the disappearance of the alanine spot alone represents a loss of between 0·1 and 0·2 mgm. In other words, the decrease in ninhydrin positivity is quantitatively commensurate with the recorded decrease in residual dry weight, and there can be little doubt that some of the free amino-acids of the thorax of the tsetse do indeed constitute an expendable reserve of food. Viewed in this light it may not be without significance that the de-amination products of the substances concerned (alanine, glutamic acid, glutamine and aspartic acid) are all members of the citric acid cycle.

A comparison has been made between the amino-acid patterns of fed and starved individuals of a few other insects (*Musca* sp., *Lucilia* sp. and *Apis mellifera*). In all of them there is some change in the relative concentration of different amino-acids during starvation, but none shows the striking decrease in ninhydrin positivity which characterizes the tsetse fly. Other blood-sucking insects are at present under investigation, and details of quantitative and comparative results will be published elsewhere.

I am indebted to the Wellcome Trust for a grant towards equipment used in the present investigation.

E. Bursell

Department of Zoology,
University College of Rhodesia and Nyasaland,
Salisbury.

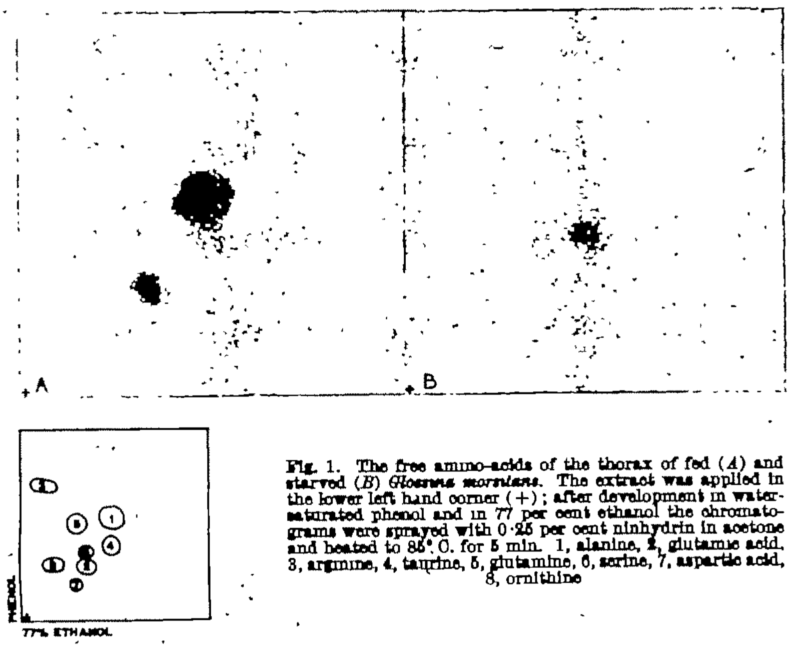


Fig. 1. The free amino-acids of the thorax of fed (*A*) and starved (*B*) *Glossina morsitans*. The extract was applied in the lower left hand corner (+); after development in water-saturated phenol and in 77 per cent ethanol the chromatograms were sprayed with 0·25 per cent ninhydrin in acetone and heated to 85° C. for 5 min. 1, alanine, 2, glutamic acid, 3, arginine, 4, taurine, 5, glutamine, 6, serine, 7, aspartic acid, 8, ornithine

---

[1] Bursell, E., in Ann. Rep. East Afr., Trypanosomiasis Res. Org., Nairobi (1957).

[2] Naftalin, L., *Nature*, 161, 763 (1948).

Sialoadenectomy and the Distribution of Thyrotrophin labelled with Iodium-131

Previous reports from these laboratories[1,2] have indicated the thyroid response to thyrotrophic hormone, as measured by uptake of phosphorus-32 (ref. 3), to be increased in sialoadenectomized animals when compared with intact controls. Hypophysectomy and hypophysectomy plus sialoadenectomy gave identical results as regards iodine trapping by rat thyroid, but the ratio of thyroid organic iodine-131 to inorganic iodine-131 indicated that sialoadenectomy reduced the synthesis of organically bound iodine-131 (ref. 4). To date, our observations have indicated some change in the modus operandi of thyrotrophic hormone in animals whose salivary glands have been removed. To obtain further information regarding the role of thyrotrophic hormone in sialex animals, it was decided to investigate the distribution of labelled hormone therein.

Animal care, feeding, size and preparation were the same as previously described[4]. The thyrotrophic hormone, given by Dr. S. Steelman of the Armour Laboratories, was labelled with iodine-131 by conventional methods[4] with only minor changes. Carrier iodine-127 was kept minimal so that the final iodine to thyrotrophic hormone molecular ratio did not exceed 1 : 100. Under the conditions employed, the radiochemical yield was low (23 per cent) but a high specific activity was obtained. After dialysis, to

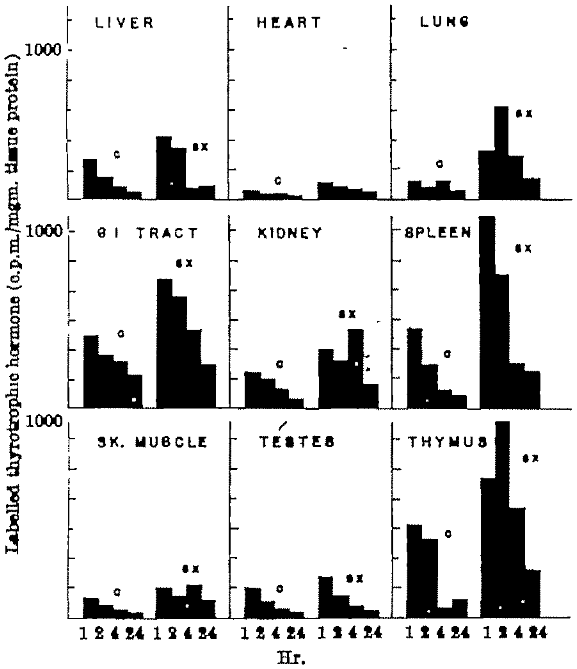


Fig. 1. Distribution of iodine-131 activity following intraperitoneal injection of 5·8 μc./5 μgm. thyrotrophic hormone labelled with iodine-131 to adult male mice. Average results of five animals per group. *C*, intact animals; *SX*, sialoadenectomized animals.

remove free iodide, thyrotrophic hormone content as protein was determined spectrophotometrically by measuring optical density at 280 mμ and comparing with previously calibrated solutions of the original non-labelled thyrotrophic hormone preparation. Radio purity, determined by paper chromatography, was estimated at 98·2 per cent. Bioassay[3] of the labelled thyrotrophic hormone compared most favourably with the original unlabelled hormone, indicating no detectable destruction due to the iodination procedure. The final labelled preparation was diluted with non-radioactive thyrotrophic hormone so that 5·8 μc. of radioactivity corresponded to 5 μgm. of hormone in 0·5 ml. of solution.

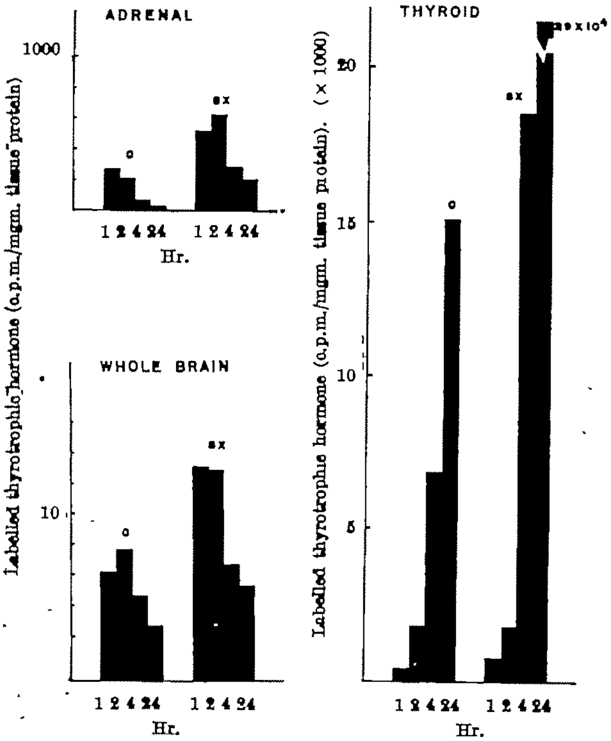


Fig. 2. Distribution of thyrotrophic hormone labelled with iodine-131 in adrenal, brain and thyroid of normal and sialex mice

The thyrotrophic hormone labelled with iodine-131 was administered to adult male mice, intraperitoneally, 5·8 μc. per 5 μgm. per 0·5 ml. Samples of 5 intact animals and 5 sialex animals were taken for analysis at 1, 2, 4 and 24 hr. after injection. Tissue samples, washed free of blood, were homogenized with cold water (1 : 10) and the proteins precipitated with 1 vol. of cold 20 per cent trichloracetic acid. The precipitated proteins were centrifuged, washed with water, alcohol and ether, then resuspended in 3 ml. of saline. The radioactivity of the protein suspensions was measured in a deep-well scintillation counter. The counting was pre-set to give a statistical error no greater than 1 per cent. The protein content of each sample was estimated from the nitrogen content, which was measured by a micro-Kjeldahl procedure. All results are expressed here as counts per minute per mgm. of tissue protein.

The results, indicated in Figs. 1 and 2, show that all the tissues of the sialex mice retained the labelled thyrotrophic hormone (or its degradation products) in higher concentrations than did the intact control animals. After 24 hr., the thyroids of the sialex mice concentrated activity from the thyrotrophic hormone 2·00 times more than did the intact controls, adrenal 5·20, kidney 3·12, heart 3·00, lung 2·73, spleen 2·69, thymus 2·50, liver 2·04, skeletal muscle 1·72, testes 1·69 and brain 1·67. The concentration of activity in the thyroids of both sets of animals exceeded the concentration of all other tissues by factors of at least 9·3 and 7·4 for sialex and intact, respectively. These different tissue concentrations, we feel, can only reflect some profound changes in the metabolism of, and the hormone response by, the sialex host.

The activity appearing in the thyroid is especially interesting, it being the target tissue for thyrotrophic hormone. The very high concentration of labelled thyrotrophic hormone in the sialex animals recalls at once our previous observations[1] regarding the effects of thyrotrophic hormone in these animals. This high uptake in the thyroid is peculiar to labelled hormone since we have not observed any extraordinary uptake when either beef albumin or human albumin labelled with iodine-131 was administered. Decomposition of iodine-131 labelled protein has been shown to be a slow process[6] and should be of little importance in this short-term experiment. We would like to recall the observations of Baker and Abrams[7], which indicated a salivary gland–pituitary relationship to exist. They showed that hypophysectomy resulted in atrophy of the salivary glands and also depressed the enzyme-secreting capacity of zymogenic cells. It is quite probable that sialoadenectomy decreases enzymatic degradation of thyrotrophic hormone, especially in the thyroid as well as in other tissues as the present results seem to indicate. Work by these authors reveals that sialex animals absorb labelled proteins and fats less rapidly than do intact controls, the decreased absorption being related to depressed enzyme activities. On the basis of these observations, our present interpretation is that sialoadenectomy impairs the proteolytic activity of all tissues, especially the thyroid wherein specific proteolytic enzymes exist and which degrade thyrotrophic hormone. The rate of degradation of thyrotrophic hormone would contribute to regulating the rate, and particularly the duration, of action of the hormone. The reduced proteolysis of thyrotrophic hormone in the sialoadenectomized animal results in an extended duration of action. This permits a more pronounced uptake of phosphorus-32, which is due to an increased permeability effect and other phenomena associated with the mechanism of action of the thyrotrophic hormone. Direct measurements of proteolysis in the thyroid of control and sialex animals are needed to confirm this hypothesis.

We wish to acknowledge the technical assistance of Mrs. Nancy Fogel and Robert Sherman.

This work was sponsored in part by a grant from the Office of Naval Research and the English Fund of the Hahnemann Medical College.

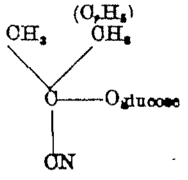
ARTHUR W. WASE
YU SHENG LOUISE FENG

Division of Biological Chemistry,
Hahnemann Medical College,
Philadelphia, Pennsylvania.

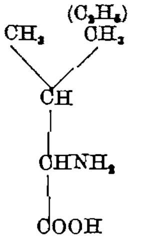
[1] Wase, A. W., and Feng, L., *Nature*, 178, 1395 (1956).
[2] Wase, A. W., and Feng, L., *Nature*, 177, 624 (1956).
[3] Barell, U., and Holmgren, H., *Acta Endocrin.*, 3, 231 (1949).
[4] Wase, A. W., and Feng, Y. S. L., *Acta Endocrin.*, 22, 413 (1956).
[5] Hughes, W. L., *Ann. N.Y. Acad. Sci.*, 70, 3 (1957).
[6] Steinfield, J. L., Paton, R. R., Flick, A. L., Milch, R. A., Beach, F. R., and Tabern, D. L., *Ann. N.Y., Acad. Sci.*, 70, 109 (1957).
[7] Baker, B. L., and Abrams, G. D., International Symposium, Hypophyseal Growth Hormones, Nature and Actions, 107 (McGraw-Hill, 1954).

Biosynthesis of Linamarin and Lotaustralin in White Clover

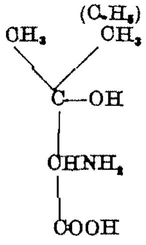
THE strains of white clover (*Trifolium repens* L.) most widely used in New Zealand contain the cyanogenetic glucosides lotaustralin and linamarin (1), which are the glucosides of methylethylketone cyanhydrin and acetone cyanhydrin respectively[1]. Melville and Doak[2] isolated a mixture of the two glucosides from white clover in quantities as high as 1·5 gm. per kgm. fresh material. The pharmacology of these compounds for ruminants grazing on white clover has been studied from the points of view of potential cyanide toxicity[3] and goitrogenic action[4-6].



(1)
linamarin
(lotaustralin)



(2)
valine
(*iso*leucine)



(3)

From structural considerations, and by analogy with the findings of Gander[7,8] on the biosynthesis of *p*-hydroxymandelo-β-glucoside in *Sorghum vulgare*, it was thought likely that the biosynthesis of lotaustralin and linamarin might be related to the metabolism of *iso*leucine and valine (2) respectively. Some preliminary experiments on the biosynthesis of these compounds are reported here.

Four groups of seeds of New Zealand certified white clover were germinated in the dark on moistened filter-papers, to which 10 μc. of one of the following carbon-14 labelled compounds had been added: 1·6 μmole L-*iso*leucine (generally labelled), 2·7 μmole DL-valine-1-^{14}C, 6·5 μmole DL-valine-4-^{14}C and 0·6 μmole glycine-2-^{14}C (obtained from the Radiochemical Centre, Amersham). On the fourth day, the seedlings were transferred to a glasshouse for a further 2 days, after which they were extracted with boiling 80 per cent (v/v) aqueous ethanol for 15 min. The extracts were taken to dryness, shaken with 3 ml. water and clarified by centrifugation. Aliquots of 50 μl. and 150 μl. of each extract were applied in duplicate to Whatman No. 1 filter-papers as adjacent bands and chromatographed in methylethylketone–acetone–water (3 : 1 : 0·6) at 20° C.[9].

Linamarin and lotaustralin in the 50-μl. chromatograms were detected by the following unpublished method, developed by P. Mortimer, Department of Organic Chemistry, University of Adelaide. Each chromatogram was sprayed with linamarase solution (prepared from linseed meal by the method of Coop[10]) and held in a 'Perspex' press adjacent to a similar sheet of paper which had been dipped in picrate reagent[11] and dried in air. A perforated 'Perspex' sheet separated the two papers. The enzyme linamarase hydrolysed both lotaustralin and linamarin with the liberation of hydrogen cyanide and the corresponding ketone. After several hours, orange spots were seen on the picrate papers in areas corresponding to the glucosides. A mean R_F value of 0·59 was observed for linamarin and 0·72 for lotaustralin: glycine, valine and *iso*leucine were found at R_F values of 0·02, 0·10 and 0·18 respectively.

The corresponding areas containing lotaustralin and linamarin on the chromatograms of 150-μl. aliquots were then cut out and eluted with water. The eluates were dried, taken up in 0·5 ml. water and 0·1-ml. aliquots were pipetted on to planchettes. These were dried under an infra-red lamp and counted for radioactivity to 4 per cent error using an end-window Geiger–Muller tube. Aliquots of 0·2 ml. linamarase solution[10] were pipetted on to the planchettes, which were placed in an incubator at 25° for 16 hr. The water and volatile products from linamarase action were evaporated under an infra-red lamp and the planchettes again counted for radioactivity.

The total counts found for the four treatments, expressed in terms of the total plant material, are given in Table 1. Corrections have been made for background counts and for sample geometry; a

Table 1. TOTAL RADIOACTIVITY (COUNTS/MIN. × 10^{-3}, FOR TOTAL PLANT MATERIAL) FOUND IN ELUATES FROM LINAMARIN AND LOTAUSTRALIN REGIONS OF CHROMATOGRAMS BEFORE AND AFTER LINAMARASE ACTION

Amino-acid fed	Before linamarase action		After linamarase action		Radioactivity in aglycone	
	Linamarin	Lotaustralin	Linamarin	Lotaustralin	Linamarin	Lotaustralin
Glycine-2-^{14}C	47	55	41	58	6	−3
L-*iso*Leucine-^{14}C-G	42	270	41	39	1	231
DL-Valine-1-^{14}C	48	20	44	5	4	15
DL-Valine-4-^{14}C	455	61	47	51	408	10

self-absorption correction was not required. The loss in counts after linamarase action corresponded to radioactivity in the aglycone portions of lotaustralin and linamarin respectively; remaining counts could be due to activity in the glucose portions of lotaustralin and linamarin or to activity in other compounds present at these R_F values.

It will be seen that appreciable radioactivity was found in the aglycone portion of lotaustralin when generally labelled *iso*leucine-^{14}C was fed and in the aglycone portion of linamarin when DL-valine-4-^{14}C was fed. Feeding with glycine-2-^{14}C and DL-valine-1-^{14}C resulted in negligible radioactivity in the aglycone portions of both linamarin and lotaustralin.

These findings support the hypothesis that the biosynthesis of lotaustralin and linamarin is related to the metabolism of *iso*leucine and valine, respectively, and that decarboxylation occurs in the process of formation of the cyanide grouping. By analogy with the findings of Gander[7,8], it would appear likely that the corresponding β-OH-amino-acids (3) would be intermediates, but no evidence has so far been obtained for their presence.

This work is continuing and will be reported in detail elsewhere.

G. W. Butler
Beris G. Butler

Plant Chemistry Division,
Department of Scientific and
Industrial Research,
Private Bag,
Palmerston North, New Zealand.

[1] Finnemore, H., and Cooper, Joyce M., *J. Soc. Chem. Indust.*, 57, 162 (1938).

[2] Melville, J., and Doak, B. W., *N.Z. J. Sci. Tech.*, 22, B, 67 (1940).

[3] Coop, I. E., and Blakley, R. L., *N.Z. J. Sci. Tech.*, 30, A, 277 (1949).

[4] Flux, D. S., Butler, G. W., Johnson, June, M., Glenday, A. C., and Petersen, G. B., *N.Z. J. Sci. Tech.*, 38, A, 88 (1956).

[5] Butler, G. W., Flux, D. S., Petersen, G. B., Wright, E. W., Glenday, A. C., and Johnson, J. M., *N.Z. J. Sci. Tech.*, 38, A, 793 (1957).

[6] Flux, D. S., Butler, G. W., Rae, A. L., and Brougham, R. W., *J. Agric. Sci.* (in the press).

[7] Gander, J. E., *Fed. Proc.*, 17, 226 (1958).

[8] Gander, J. E., *Fed. Proc.*, 18, 232 (1959).

[9] Hogstrom, G., *Acta Chem. Scand.*, 11, 743 (1957).

[10] Coop, I. E., *Acta Chem. Scand.*, 22, B, 71 (1940).

[11] "Official and Tentative Methods of Analysis of Association of Official Agricultural Chemists", sixth ed., 416 (1945).

BIOPHYSICS

Evidence for Internal Organization of Nucleic Acid in T_2 Bacteriophage

Pellets of T_2 bacteriophage have been found to be liquid crystalline and to be negatively birefringent when subjected to stresses which cause alignment.

A drop of T_2 bacteriophage suspension placed on a microscope slide and covered with a coverslip, when allowed to dry, reveals birefringence at the edge of the coverslip. When the slow direction of the compensator (Red I plate) is aligned parallel to the edge of the coverslip, and both are placed at 45° to the crossed Nicol prisms of a polarization microscope, the birefringent areas appear orange-red, indicative of negative birefringence. Control experiments with drops of tobacco mosaic virus solution, however, produce positive birefringence, in accordance with studies of a similar nature made by Bernal and Fankuchen[1].

The periphery of pellets of these two viruses also exhibits birefringence. Again, when aligned parallel to the slow axis of the compensator, the T_2 bacteriophage indicates negative birefringence while the tobacco mosaic virus demonstrates positive birefringence.

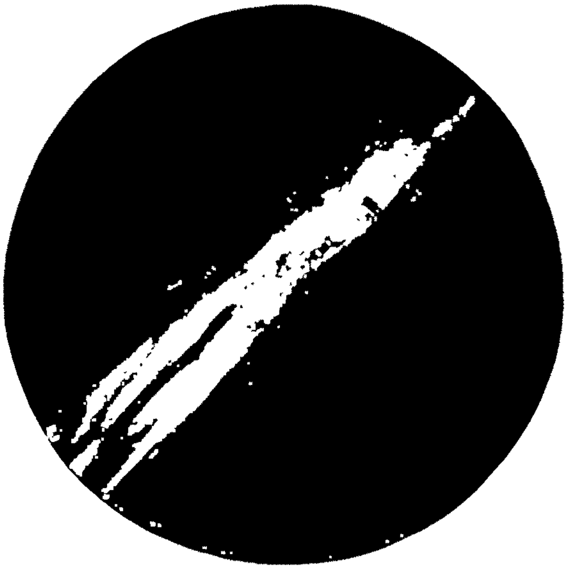


Fig. 1. Photomicrograph of a streak from a T_2 bacteriophage pellet exhibiting birefringence when oriented at 45° to the crossed nicols of a polarization microscope. (× c. 10)

Finally, when material taken from a T_2 bacteriophage pellet is streaked on a microscope slide at 45° to the crossed nicols, it appears orange-red when the slow direction of the compensator is aligned parallel to the streak (Fig. 1). A similarly oriented streak from a pellet of tobacco mosaic virus demonstrates positive birefringence, however, as revealed by a blue colour.

That the birefringence might be the result of extra-particulate deoxyribonucleic acid extruded from the bacteriophage during the manipulative procedures employed prior to the polarization microscopy would appear to be precluded by the following observations. Streaks drawn from pellets of aliquots of a T_2 bacteriophage preparation, one treated and the other untreated with deoxyribonuclease prior to sedimentation in the ultracentrifuge, revealed equally strong negative birefringence. In contrast, streaks from a pellet of an osmotically shocked[2] T_2 bacteriophage preparation, centrifuged sufficiently long to sediment the ghosts but not the nucleic acid, were non-birefringent. When the supernatant fluid from this shocked material was afterwards centrifuged at a force calculated to sediment the nucleic acid, streaks drawn from the resulting pellet were negatively birefringent. An aliquot of this same supernatant fluid treated with deoxyribonuclease yielded a pellet approximately one-fiftieth the size of the undigested material, and streaks of it were non-birefringent. The results of these experiments, therefore, are consistent with the idea that the birefringence is caused by the nucleic acid contained within the bacteriophage particle.

Attempts have been made to demonstrate alignment of the bacteriophage particles within the streak using the electron microscope. Since areas of the streak sufficiently thick to exhibit birefringence with polarization optics were too thick for electron microscopy, the surface of the streak was replicated. It was observed that large areas demonstrate close packing of the particles, as in a crystalline array,

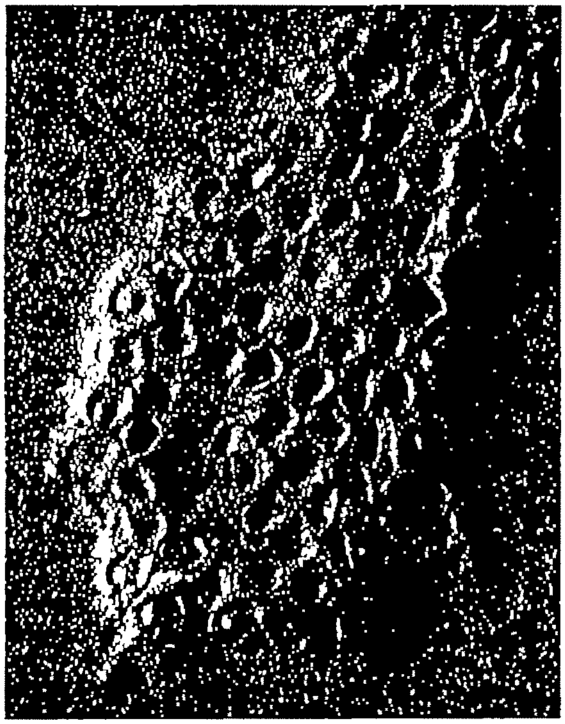


Fig. 2. Platinum preshadowed carbon replica of a streak from a T_2 bacteriophage pellet drawn on freshly cleaved mica (ref. 3) (× c. 75,500)

although the difficulty in visualizing the tails makes it impossible to establish conclusively by electron microscopy that the individual particles are preferentially oriented within the pattern. One such area is shown in Fig. 2. In this picture there is a strong suggestion of orientation with the long axes of the particles lying perpendicular to the shadow direction.

The principal evidence, however, in favour of the orientation of the T_2 bacteriophage particles with their long dimension in the direction of the streak comes from hydrodynamic considerations. As a general experience, when viscous suspensions of anisometric particles are subjected to stretching forces, such as in the streaking experiment described above, the particles are oriented with their long dimension in the direction of the stress. Furthermore, preliminary flow birefringence experiments with T_2 bacteriophage suspensions in pH 5·2 phosphate buffer have indicated negative birefringence, although weak in comparison to the strong positive flow birefringence demonstrated by a tobacco mosaic virus solution subjected to the same velocity gradient. This is, of course, what one might expect in view of the considerably smaller axial ratio of the T_2 virus.

That alignment of rods in a medium of different index of refraction will produce form birefringence independent of whether the particles themselves are intrinsically birefringent was postulated by Wiener in 1912 [4]. Lauffer[5] showed that for tobacco mosaic virus the double refraction of flow decreased in magnitude as the difference in refractive index between that of the virus and the suspending medium decreased. The latter result implies that the flow birefringence produced by tobacco mosaic virus is mostly form and only minimally intrinsic. The fact that T_2 bacteriophage is much less anisometric than tobacco mosaic virus, yet contains considerably more nucleic acid, suggests that its intrinsic birefringence should be of greater significance. The net negative birefringence observed means that the intrinsic birefringence exceeds any positive form birefringence in oriented suspensions of T_2 bacteriophage. Since deoxyribonucleic acid fibres oriented parallel to the optic axis are negatively birefringent, the results thus obtained would indicate that the intrinsically negative birefringent nucleic acid of the bacteriophage is at least partially oriented parallel to the long axis within the virus particle. Preliminary quantitative double refraction measurements indicate that the extent of internal deoxyribonucleic acid orientation is high.

X-ray diffraction patterns of oriented *Sepia* and *Loligo* sperm have led Wilkins and Randall[6] to conclude that the sperm head consists of material possessing a crystalline order. Certain advanced stages in the differentiation of the spermatid of the grasshopper, *Gelastorrhinus bicolor*, have, when sectioned longitudinally for electron microscopy, revealed parallel elements running lengthwise to the long axis of the nucleus[7]. Since the similarity between bacteriophage and sperm has been alluded to by many investigators, one additional similarity may be postulated; namely, alignment of the deoxyribonucleic acid strands within their heads, parallel to their long axes.

We wish to thank Dr. Robert V. Rice, of the Mellon Institute, for making the flow birefringence equipment available.

This work was partially supported by a grant from the Office of Naval Research.

IRWIN J. BENDET
DAVID A. GOLDSTEIN
MAX A. LAUFFER

Department of Biophysics,
University of Pittsburgh,
Pittsburgh 13, Pennsylvania.

[1] Bernal, J. D., and Fankuchen, I., *J. Gen. Physiol.*, **25**, 111 (1941).

[2] Herriott, R. M., and Barlow, J. L., *J. Gen. Physiol.*, **40**, 809 (1957).

[3] Hall, C. E., *J. Biochem. Biophys. Cytology*, **2**, 605 (1956).

[4] Wiener, O., *Abhandl. Math. Phys. Kl. der Konigl. Säch. Gesell. der Wissensch.*, **32**, 507 (1912).

[5] Lauffer, M. A., *J. Phys. Chem.*, **42**, 935 (1938).

[6] Wilkins, M. H. F., and Randall, J. T., *Biochim. Biophys. Acta*, **10**, 192 (1953).

[7] Yasuzumi, G., and Ishida, H., *J. Biophys. Biochem. Cytology*, **3**, 663 (1957).

PHYSIOLOGY

Lipæmic Clearing Action of Artificial Anticoagulants

THE action of heparin in clearing lipæmic plasma is well known[1]. We have investigated the *in vivo* clearing action of several anticoagulants, including heparin, using isotopically labelled fats, and have found that all the anticoagulants tested so far clear lipæmic plasma *in vivo*.

The tests were carried out in man using glyceryl trioleate (triolein) labelled with iodine-131. The fasting subject was given a test meal containing 100 gm. fat which included 50 μc. of the iodine-131 triolein, in the manner described by Ruffin and others[2]. Blood samples were collected over the next 48 hr. Free iodide was removed from the blood samples by exchange resins, and the remaining radioactivity per ml. of blood expressed as percentage of the administered dose. This figure, times the subject's blood volume (70 ml./kgm.), then gave the alimentary

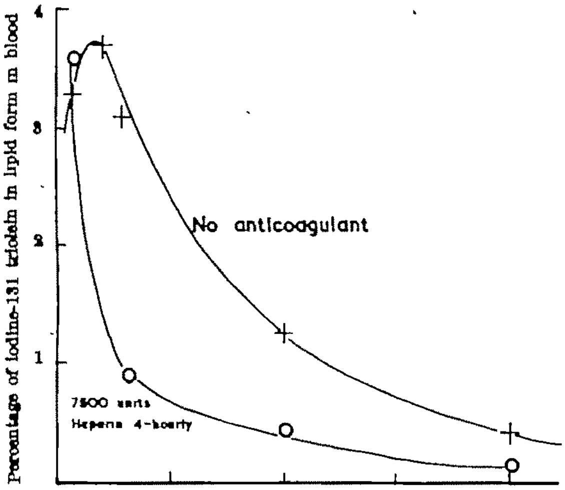


Fig. 1. Effect of heparin on alimentary lipæmia

lipæmia as a percentage of the fat ingested. A typical curve is shown in Fig. 1, upper curve.

The test was then repeated on the same patient while receiving 7,500 units heparin 4-hourly and a typical result is shown in the lower curve of Fig. 1. This response to heparin was found in each of 12 subjects investigated in this way. The curve rises to a maximum in 2–6 hr. The subsequent decline is found to be representable in the form:

$$C = C_0 \exp(-bt) \quad (1)$$

where C is the concentration of tracer fat per ml., t is the time measured from the maximum, C_0 the peak concentration and b, a rate constant.

By plotting the results semi-logarithmically, we extracted the coefficient b and used this as an indication of the rate of lipæmic clearance. In terms of this coefficient, our findings with heparin are summarized in Table 1.

These results are similar to those obtained previously by other methods.

It is generally assumed that the artificial anticoagulants do not clear lipæmic plasma[3]. However, we have found that under the conditions of our experiments the artificial anticoagulants do clear post-alimentary lipæmia *in vivo*. A series of 40 patients has been investigated both on and off anticoagulant therapy using indanedione. In this series phenindione ('Dindevan') and diphenadione ('Oragulant') were used alternatively. The dosage used was adjusted to maintain each patient's prothrombin time within the range 40–60 per cent of his own normal value. The results are summarized in Table 2, and a typical result showing the *in vivo* effect of phenindione is shown in Fig. 2.

This series of 40 subjects comprised patients in hospital following coronary occlusion. The tests were carried out at least 6 weeks after infarction and the order of the consecutive tests (on and off anticoagulant) was randomized. In some cases three tests were carried out on the same subject in the order 'Off', 'On', 'Off' anticoagulant. No change in the lipid tolerance curve was recorded in two cases and a positive effect was recorded in 38 in this series of 40 patients tested while under the influence of indanedione derivatives.

Table 1

	Mean lipæmic clearance constant, b (hr.$^{-1}$)
No heparin	0·09 ± 0·02
Same subjects on heparin	0·24 ± 0·04

Table 2

	Mean lipæmic clearance constant, b (hr.$^{-1}$)
No phenindione or diphenadione	0·09 ± 0·02
Same subjects on either phenindione or diphenadione	0·20 ± 0·04

The importance of determining whether this was a property of the indanedione type of anticoagulant only, or was a property of anticoagulants in general, was suggested to us (Thorp, R. H., private communication).

To this end a further series of six patients was tested while under and while not under treatment with the coumarin derivative 3-(1-phenylpropyl)-4-hydroxy coumarin ('Marcoumar'). The results of this trial are given in Table 3.

Table 3

	Mean lipæmic clearance constant, b (hr.$^{-1}$)
Six patients without anticoagulant	0·07 ± 0·02
Same six patients receiving 3-(1-phenylpropyl)-4-hydroxy coumarin	0·16 ± 0·03

We may therefore conclude that the artificial anticoagulants possess the property of clearing lipæmic plasma *in vivo*. This effect does not appear to depend strongly on the molecular structure of the anticoagulant used. The rate of removal of alimentary lipæmia is approximately trebled by the therapeutic dosage of heparin used, and approximately doubled by the normal therapeutic dosage of artificial anticoagulants.

These results may be related to the efficacy of anticoagulants in the management of post-infarction coronary disease patients[4], in view of the part played by lipids in blood coagulation[5].

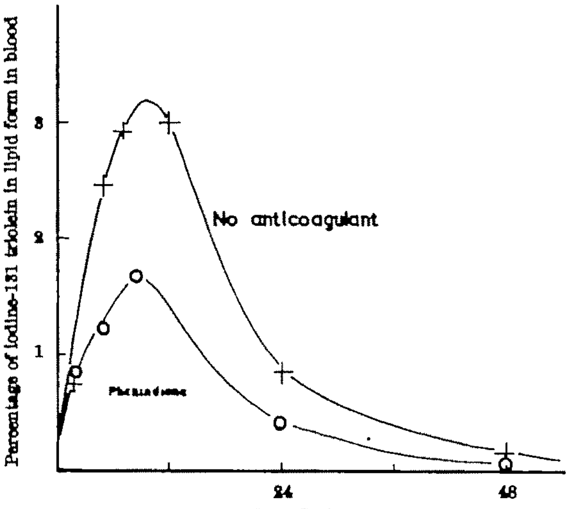


Fig. 2. Effect of synthetic anticoagulant on alimentary lipæmia

This investigation was supported by the Post-Graduate Medical Foundation, University of Sydney, and will be described more fully elsewhere.

E. P. George
G. V. Hall
G. S. Farkas

Departments of Medicine and Physics,
St. Vincent's Hospital,
Sydney.

[1] Hahn, P. F., *Science*, 98, 19 (1943).

[2] Ruffin, J. M., *New England J. Med.*, 255, 594 (1956). Hall, G. V., George, E. P., and Hickie, J. B., *Austral. Ann. Med.*, 8, 307 (1959).

[3] Robson, J. M., and Keele, C. A., "Recent Advances in Pharmacology" (Churchill, London, 1956).

[4] Report of working party on anticoagulants in coronary thrombosis, *Brit. Med. J.*, i, 803 (1959).

[5] Poole, J. C. F., *Brit. Med. Bull.*, 14, 253 (1958).

Mechanism of the Physiological Action of Rotenone

ROTENONE has been widely used as a poison for the extinction of fish populations. Its action was earlier ascribed to a histolysis of the gills[1] and a blocking of the circulation[2] in the gills. Recently, one of us[3] has demonstrated that these effects are secondary changes due to advanced stages of poisoning.

Excised gill filaments from specimens of *Leuciscus rutilus* L. pretreated with rotenone ($3 \cdot 1 \times 10^{-7}$ *M*) for 8 min. show an inhibition of the respiration of 79 per cent (Warburg experiments, medium Krebs–Ringer solution). Addition of 3×10^{-6} *M* methylene blue to the medium restores respiration up to 83 per cent. Also in mouse liver slices rotenone causes an inhibition of the respiration, a concentration of 160×10^{-7} *M* giving an inhibition of 47 per cent.

In order to gain further information on the point of attack of rotenone, we studied its effect on the respiration of rat liver mitochondria, isolated according to Schneider and Hogeboom[4]. The medium was a sucrose–phosphate buffer *p*H 7·4 (2·0 ml.), containing 50 μmoles phosphate, 10 μmoles magnesium chloride, to which were added 2 μmoles adenosine diphosphate, 80 μmoles glucose, and an excess of hexokinase in order to secure maximum phosphorylation. Each experimental sample contained mitochondria corresponding to 350–400 mgm. wet weight tissue. Rotenone was dissolved in ethanol, the final concentration of which in the experimental samples did not exceed $8 \cdot 4 \times 10^{-3}$ *M*. Succinate or pyruvate was used as substrate, and added in amounts of 60 μmoles per sample. It appears from Table 1 that the respiration of mitochondria is inhibited by rotenone only when pyruvate is the substrate. This inhibition is reversed by methylene blue. In order to find out if the inhibition is caused by a block in electron transport or in oxidative phosphorylation we studied the effect of 10^{-4} *M* dinitrophenol on the inhibition caused by rotenone in the same mitochondrial system as above. This substance did not cause any change in the effect of rotenone upon respiration. Obviously rotenone inhibits electron transport, the block being situated on the substrate side of cytochrome *b*. Viewed against the generally accepted opinion that methylene blue acts as an acceptor of electrons from diaphorase, our results suggest that the block caused by rotenone is located between diaphorase and cytochrome *b*. Difference spectra (Fig. 1) between samples identical with those used in the respiration experiments with pyruvate as substrate, and kept under partial anaerobiosis, show, however, that cytochrome a_3, *a*, *c*, *b* and diaphorase are oxidized in the presence of rotenone. We will not comment at present on these results.

Table 1. RESPIRATION OF RAT LIVER MITOCHONDRIA MEASURED AT 30° C. IN THE WARBURG APPARATUS. GAS PHASE AIR. FOR MEDIUM, SEE TEXT

Substrate	Respiration μl. O_2/30 min.		
	Control	6×10^{-7} *M* rotenone	6×10^{-7} *M* rotenone + 2×10^{-6} *M* methylene blue
Pyruvate (sparker: 3 μmoles glutamate)	112·3	5·5	96·0
Succinate	205·0	217·2	—

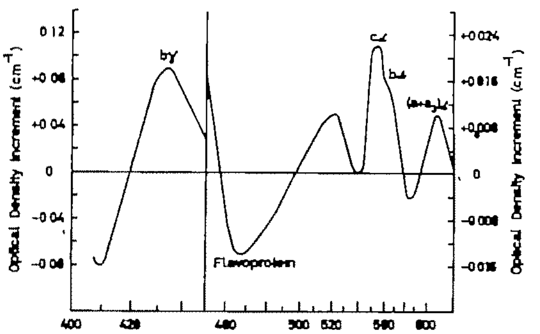


Fig. 1. Spectra representing the differences of absorption between two samples of mitochondria, one of which contained 6×10^{-7} *M* rotenone, registered with the Beckman spectrophotometer *DK*-2. The experimental and control cuvettes contained the reaction media with pyruvate as used in the Warburg experiments. Optical density along the ordinate: to the left for the spectral range 400–450 mμ, to the right 450–625 mμ. Temperature, 22° C. Optical depth of cuvettes, 10 mm.

A detailed report is being published elsewhere.

Financial support from the Fishery Revenue Funds, and a grant from Stiftelsen J. C. Kempes Minne to one of us (K. E. Ö.) are gratefully acknowledged. We are indebted to Dr. Karl-Heinz Kiessling for introducing us to methods for preparing mitochondria and to Prof. Olof Lindberg for valuable discussion.

P. E. Lindahl
K. E. Öberg

Institute of Zoophysiology,
University of Uppsala,
Sweden.

[1] Danecl, Rolf, *Z. vergl. Physiol.*, 18, 524 (1933).

[2] Hamilton, H. L., *Iowa Acad. Sci.*, 48, 467 (1941).

[3] Öberg, K. E., *Arkiv för Zoologi*, 12, No. 25, 383 (1959).

[4] Schneider, W. C., and Hogeboom, G. H., *J. Biol. Chem.*, 183, 123 (1950).

Influence on the Effect of Vasoconstrictor Amines by Pretreatment with Reserpine

I HAVE examined the influence of reserpine pretreatment (5 mgm./kgm./2 days, intraperitoneal) on the vasoconstrictor action of a series of sympathomimetic amines and of acetylcholine in high concentration, using the hind legs of a rat and Jackson's toad preparation.

The results obtained with norepinephrine, epinephrine, phenylephrine, ephedrine, *d-l*-amphetamine, *d*-amphetamine, and mephentermine confirmed that reserpine potentiates or leaves unchanged the motor effects of catechol or phenolethanolamines, but inhibits those of phenylethanolamines reversibly and those of phenyl or phenolethylamines irreversibly[1].

I found, however, that reserpine in some instances transformed vasoconstrictor effects into vasodilatation. Thus, in animals treated with reserpine, mephentermine produced vasodilatation, instead of vasoconstriction. After similar pretreatment, ephedrine also occasionally produced vasodilatation (3 animals among 20). This effect might be due to an unmasking and/or potentiation of actions on β receptors. In fact, it was found that reserpine not only potentiated the motor effects of norepinephrine but also the inhibitory actions of *iso*proterenol. Pretreatment with reserpine enhanced the vasoconstrictor effect of naphazoline and reduced that of *cyclo*pentamine (without statistical significance). Therefore, these drugs seem to act directly on vasoconstrictor receptors, adrenergic or not.

Acetylcholine in high concentration produces vasoconstriction instead of vasodilatation, by releasing an epinephrine-like substance[2]. I have confirmed this effect and found that it disappeared in animals treated with reserpine.

For comparison I also studied the influence of pretreatment with cocaine on the vascular action of some sympathomimetic amines. In Jackson's toad preparation, the effects of phenylephrine, *iso*proterenol, ephedrine, *cyclo*pentamine and naphazoline, are influenced by cocaine in the same way as by reserpine.

This work was carried out with the aid of a scholarship from the Asociación Argentina para el Progreso de las Ciencias.

H. C. Sabelli*

Curso de Psicófarmacología,
Facultad de Ciencias Médicas,
Universidad de Buenos Aires.

---

* Present address: Laboratorio de Investigaciones Psicofarmacologicas, Hospital Neuropsiquiatrico Nacional, Buenos Aires.

[1] Maxwell, R. A., Povalski, H., and Plummer, A. J., *J. Pharm. Exp. Ther.*, 125, 178 (1958).

[2] Burn, J. H., and Rand, M. J., *J. Physiol.*, 143, 15 (1958).

Proportion of Noradrenaline to Adrenaline in the Adrenal Glands of Litter-mate Cats

It is well known that the proportion of noradrenaline to adrenaline in the adrenal glands of cats varies considerably from cat to cat. Butterworth and Mann[1] have obtained a range of 13–91 per cent of noradrenaline in the adrenal glands of a group of 38 cats of both sexes. This animal-to-animal variation is in marked contrast to most other laboratory animals, where the proportion of noradrenaline to adrenaline is constant for a given species.

To investigate this variability, litters of healthy, young cats were used. All animals were of such an age as to obviate any factor concerned with an increased noradrenaline content in early life[2]. Each cat was given 120 mgm./kgm. of pentobarbitone sodium, intraperitoneally. Two minutes later both adrenal glands were rapidly removed and an extract prepared in $N/10$ hydrochloric acid. The noradrenaline and adrenaline contents of the extracts were determined by different biological assay techniques, using the cat nictitating membrane and blood pressure as separate test preparations.

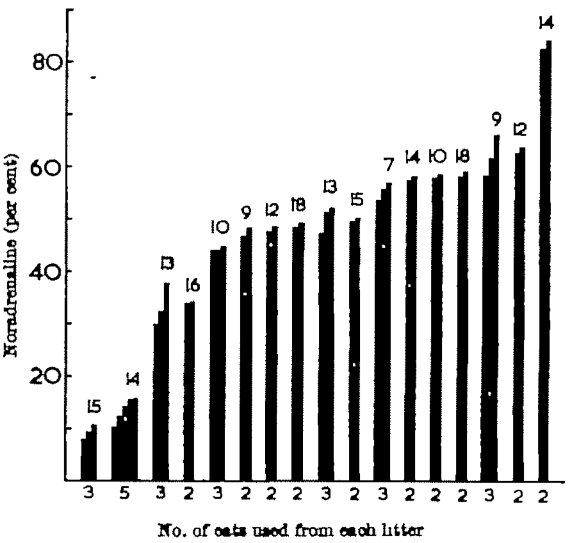


Fig. 1. To show the percentage of noradrenaline in the adrenal glands of litter-mate cats. The numbers at the head of each set of columns indicate the ages in weeks of the cats at the time of removal of the adrenal glands

Fig. 1 shows the percentage of noradrenaline in the adrenal glands of litter-mate cats. 43 animals from 17 litters were used and a range of 8–84 per cent of noradrenaline was found in their glands. This variation was independent of the ages, weights and diets of the animals. However, although there was a wide variation in the percentage of noradrenaline between litters, there was little or no variation within a litter. This is true in every litter studied, and is independent of the size of the litter, the sex and general appearances of the animals.

It appears therefore that, although there is this considerable variability in the percentage of noradrenaline in cat adrenal glands, there is little variation within a litter. Previously it has been necessary to compare the catechol amine content of the adrenal glands of an individual cat, one gland being removed as a control before the experiment is begun. The application of the above observations is that now it is possible to divide litters of cats into test and control groups, in the same way as many other laboratory species are used.

A detailed account of this work, together with information concerning the relationship between the adrenal glands of the parents and their offspring, will be published elsewhere.

K. R. Butterworth

Department of Pharmacology,
St. Mary's Hospital Medical School.
Paddington, London, W.2.

Monica Mann

Department of Pharmacology,
School of Pharmacy,
29/39 Brunswick Square,
London, W.C.1.

---

[1] Butterworth, K. R., and Mann, M., *J. Physiol.*, 136, 294 (1957).

[2] Shepherd, D. M., and West, G. B., *Brit. J. Pharmacol.*, 6, 665 (1951).

Polyenoic Acid in Hypercholesterolæmia induced by Pyridoxine Deficiency in Rats

SINCLAIR[1] first suggested that development of atherosclerosis may be related to the level of polyenoic fatty acids in blood, and, since pyridoxine is known to be a factor for conversion of linolineate to arachidonate[2], atherosclerosis observed in pyridoxine-deficient monkeys[3] may be related to the deficiency of arachidonate. To test the validity of the hypothesis, we decided to make a detailed study of the unsaturated fatty acid content of the blood and of cholesterol and unsaturated fatty acids in the aortæ of pyridoxine-deficient rats and to find whether the hypercholesterolæmia observed had any relationship to cholesterol synthesis in the deficient condition. We have therefore determined simultaneously liver and bile cholesterol, since bile cholesterol is known to reflect faithfully the status of cholesterol synthesis by liver.

Sixty weanling rats were allowed to feed, *ad libitum*, a purified basal diet containing vitamin-free casein 22·0 per cent, sucrose 66·5 per cent, fat (coco-nut oil) 7·0 per cent, salt mixture[4] 2·5 per cent and sulphaguanidine to deplete vitamins. After three weeks, the animals were divided into groups of 20 each. Group I animals received the basal diet supplemented with vitamin mixture; Group II animals received the same diet but the amount of food given was so restricted as to make their growth curves correspond to the Group III animals which also received the same diet with the exception of pyridoxine. After nine weeks the animals were killed. Blood was drawn directly from the heart after opening the thorax, and serum obtained from two such animals were pooled and analysed for polyenoic fatty acids and cholesterol.

For polyenoic fatty acids, serum (2 ml.) was refluxed under nitrogen for 8 hr. with Bloor's mixture, filtered, residue further extracted for an additional 8 hr. under nitrogen, the two extracts mixed, dried over anhydrous sodium sulphate and total lipids re-extracted with 10 ml. petroleum ether. The petroleum ether extract was passed through a silicic acid column[5] (21 × 300 mm.) operating under a slight but constant pressure of nitrogen. The column was then eluted with 350 ml. petroleum ether containing 1 per cent ethyl ether at a rate of about 150 ml. per hr. The solvent was removed from the extract under reduced pressure at 60°, saponified with alcoholic potassium hydroxide, extracted quantitatively with petroleum ether after acidification, made to standard volumes, and 15 ml. were isomerized at 180° with potassium hydroxide–ethylene glycol in reaction tubes[6]. Absorption spectrum was determined in the ultra-violet range of a Unicam *S.P.* 500 spectrophotometer. Concentrations of polyenoic acids were calculated by using the equation of Herb and Riemenschneider[7]. The iodine value was determined in another aliquot. Bile was collected from fistulæ from rats under urethane anæsthesia. For histochemical observations frozen sections of aortæ were used. Unsaturated fatty acids were stained by the bromination method (Sen, P. B., personal communication) and cholesterol was determined by polarization microscopy and by the Schultz techniques.

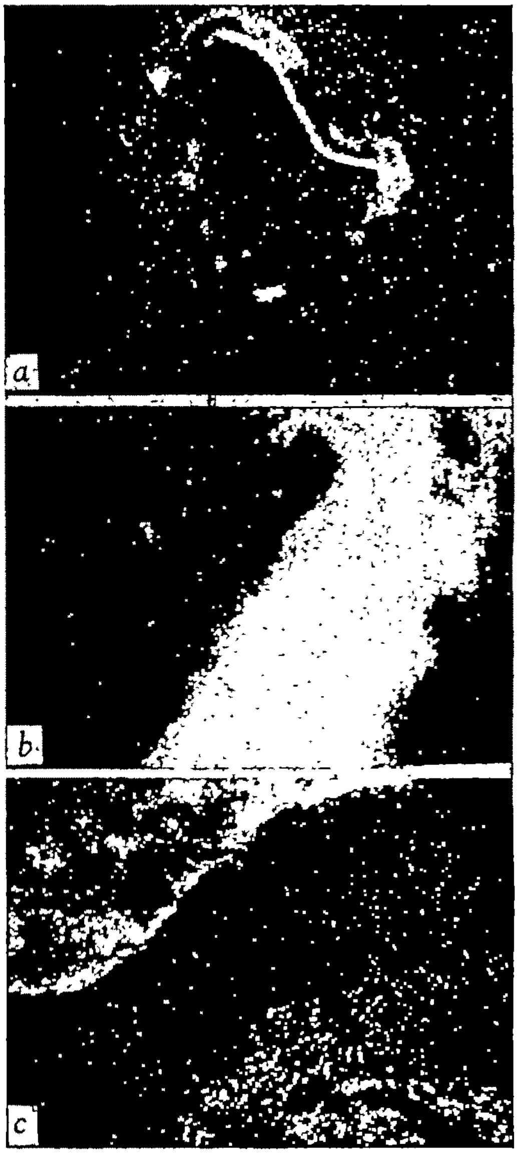


Fig. 1. Sections of aortæ showing *a*, birefringence of intima and media. Note protrusion of intima into the lumen. (× *c.* 100); *b*, intense birefringence of intima around the region of an atheromatous plaque produced in a pyridoxine-deficient rat. (× *c.* 450); *c*, intense Lieberman–Burchard reaction of aortic intima of pyridoxine-deficient rat. (× *c.* 450)

The results are shown in Table 1 and in the photomicrographs (Fig. 1). The Group III animals showed characteristic pyridoxine deficiency morphologically;

Table 1. DISTRIBUTION OF TETRAENOIC ACID IN SERUM, FREE AND ESTER CHOLESTEROL IN SERUM AND LIVER, FREE CHOLESTEROL IN BILE IN MGM. PER CENT AND IODINE VALUE OF SERUM EXTRACT IN THE THREE GROUPS OF RATS

Group	Serum tetraenoic acid	Serum cholesterol		Liver cholesterol		Free cholesterol in bile	Iodine value of serum extract
		Free	Ester	Free	Ester		
I Control	5·7 ± 0·8	43 ± 4·8	60 ± 8	218 ± 15	65 ± 8	12·4 ± 0·2	42·0 ± 1·7
II Inanition	4·4 ± 0·5	40 ± 3·8	55 ± 2	213 ± 11	38 ± 9	9·1 ± 0·3	39·5 ± 2·1
III Experimental	2·3 ± 0·9	62 ± 2·7	112 ± 5	183 ± 17	35 ± 8	10·8 ± 1·4	21·0 ± 6·6

their serum tetraenoic acids were significantly lower and cholesterol deposition in aortæ was also significant. The hypercholesterolæmia appears to be due to increased mobilization from liver, and cholesterol synthesis *in vivo* appears to be unaffected. Staining reactions revealing unsaturated fatty acids did not, however, show significant difference between controls and experimental animals.

We are grateful to the Council of Scientific and Industrial Research for financial assistance and permission to publish, and to Principal K. C. Mukerjee for his interest and advice.

AJIT GOSWAMI
D. P. SADHU

Department of Physiology and Nutrition,
Bengal Veterinary College,
Calcutta, 37.

[1] Sinclair, H. M., *Lancet*, i, 381 (1956).
[2] Witten, P. W., and Holman, R. T., *Arch. Biochem. Biophys.*, 41, 266 (1952).
[3] Rinehart, J. F., and Greenberg, L. D., *Amer. J. Pathol.*, 25, 481 (1949).
[4] Hubbell, R. B., Mendel, L. B., and Wakeman, A. J., *J. Nutrit.*, 14, 273 (1937).
[5] Herb, S. F., Witnauer, L. P., and Riemenschneider, R. W., *J. Amer. Oil Chem. Soc.*, 28, 505 (1951).
[6] Pikaar, N. A., and Nijhoff, J., *Biochem. J.*, 70, 52 (1958).
[7] Herb, S. F., and Riemenschneider, R. W., *J. Amer. Oil Chem. Soc.*, 30, 433 (1952).

Strain Differences in Acetylcholine Concentration in the Brain of the Rat

WE have recently published results indicating individual and strain differences in cortical and subcortical cholinesterase activity in two strains of rats regularly maintained in the Department of Psychology colony[1]. These strains were developed from a heterogeneous foundation stock by Tryon[2] through selective breeding for maze brightness (the S_1 strain) and for maze dullness (the S_3 strain). The brain cholinesterase activity of the S_1 strain was found to be consistently higher than that of the S_3 strain. More recently, Roderick[3] developed two additional sets of strains of rats differing in cortical and subcortical cholinesterase by a selective breeding programme using the cortical cholinesterase of the sire as the basis of selection. One set was derived from the Dempster and one from the Castle foundation stock of the University of California Genetics Laboratory. Within each set, one strain has a considerably higher brain cholinesterase activity than the other. These four sub-groups are therefore labelled as the *RDH* (Roderick Dempster High cholinesterase) and *RDL*, *RCH*, and *RCL* strains. We thus have three sets of animals, each deriving from a different foundation stock, and each set further subdivided by selective breeding into strains of high and low brain cholinesterase activity.

Our original interest in individual and strain differences in cholinesterase activity stemmed from our observations which indicated a relationship between the adaptive behaviour of the rat and the activity of its brain cholinesterase[4]. We have tended to explain this relationship by reference to the part which the acetylcholine–cholinesterase system plays in transmission at some synapses in the central nervous system, and by assuming that the cholinesterase activity of the brain was highly correlated with its acetylcholine content and would thus give a useful index of the activity of this system. Further work on the relationship between behaviour and cholinesterase indicated that this latter assumption was questionable and led to the hypothesis that the genetic determinants of cholinesterase and acetylcholine were independent (a report of all the relevant behavioural and biochemical data and of the theoretical argument in support of this hypothesis is now in preparation). Fortunately, in the animals already described we had the material at hand to test this hypothesis. If cholinesterase and acetylcholine are genetically linked, then in each set of strain the strain higher in cholinesterase should be higher in acetylcholine.

In this communication we report the preliminary results of a study of the brain acetylcholine content of animals from each of these six strains.

As acetylcholine is a very labile constituent of brain, the technique used for killing the animal and extracting the acetylcholine must eliminate or minimize changes in the 'normal' acetylcholine content. The brain was frozen *in situ* by immersing the rat in a small cage into a large Dewar flask containing liquid oxygen[5]. The brain (excluding cerebellum, medulla, and pons) was removed from the frozen head, weighed rapidly, crushed[6] and then extracted with acidulated alcohol with slight modifications of the technique originally described by Stone[7]. This method of extraction gave a higher yield of acetylcholine than did the use of trichloracetic acid.

The acetylcholine in the extracts was assayed on the rectus abdominis muscle of the frog *R. pipiens*, sensitized with neostigmine bromide[8]. Allowance for the presence of sensitizing substances (which occur in high concentration in brain extracts from animals frozen in liquid oxygen [air][5]) was made by Feldberg's method[9]. Instead of recording contractions of the muscle by a conventional isotonic lever, virtually isometric conditions were imposed by attaching the muscle to a transducer (Statham Instrument Co. model 987-*G7A* ± 0·15 oz.) connected to a Leeds and Northrup 'Speedomax' recorder with a 4-mV. full-scale sensitivity. A 1-gm. increase in tension exerted on the transducer resulted in a full-scale deflexion of the recorder, and this arrangement provided a convenient system which gave reliable and reproducible assays.

All samples were coded and the analysis order was randomized to avoid bias or systematic errors. Duplicate analyses by several different analysts gave similar results.

The results of the acetylcholine determinations are summarized in Table 1. Each high cholinesterase group (the S_1, the *RCH* and the *RDH*) is compared with its corresponding low cholinesterase group (S_3, *RCL*, *RDL*). Table 1 indicates that the acetylcholine concentration ($m\mu M$/gm.) of the S_1 rats is about 14 per cent higher than that of the S_3 strain. This difference is statistically significant at better than the 0·001 level of confidence. Thus, for the Tryon animals, the strain higher in cholinesterase is also found to be higher in acetylcholine. However, the correspondence does not hold for the Roderick animals. For the *RC* rats the high cholinesterase strain (*RCH*) has an acetylcholine concentration which is about 9 per cent higher than the low cholinesterase strain (*RCL*). This difference is significant at the 0·05 level of confidence. The acetylcholine concentration of the *RDH* rats is essentially equal to that of the *RDL* rats. The difference of 0·6 per

Table 1.* BRAIN ACETYLCHOLINE CONCENTRATION OF SIX STRAINS OF RATS

Strain	S_1	S_3	*RCH*	*RCL*	*RDH*	*RDL*
No.	16	19	11	11	14	16
Age (days)	125–151	134–166	144–152	144–159	150–179	150–177
ACh./gm. $m\mu M \pm$	27·34	24·07	24 52	22·47	23·13	22·98
sigma	2 00	2·33	1·57	2·70	1·48	1 96
Difference	3 27		2·05		0·15	
t	4·46		2·17		0·23	
P	<0 001		<0·05		n.s.	

cent, which does exist, does not approach statistical significance.

These results seem to support our hypothesis that the genetic mechanisms controlling cholinesterase activity and acetylcholine concentration in rat brain are independent. If this be true, one might expect various ratios of acetylcholine to cholinesterase to occur in Nature. The acetylcholine/cholinesterase ratios cannot be given at present for the six strains, since the tissue samples were not completely comparable for the two types of analyses. For the acetylcholine determination, the brain tissue excluded the cerebellum and the lower brain stem. For the cholinesterase determinations, separate values were obtained for samples of the dorsal cortex and for a subcortical sample which included the cerebellum and lower brain stem. Cholinesterase analyses are now being made on samples comparable to those used in the acetylcholine determinations, and the results will be reported elsewhere. If different ratios occur, this in turn suggests that neither acetylcholine nor cholinesterase alone may be an adequate index of efficiency at cholinergic synapses. Furthermore, another compound intimately involved is choline acetylase. Determination of brain choline acetylase activities in rats of our six strains is planned. This should allow for the testing of our hypothesis that the efficiency of neuronal functioning and adequacy of adaptive behaviour is a function of the balance among choline acetylase, acetylcholine and cholinesterase.

This research was supported in part by a research grant, No. G-2542, from the National Science Foundation, and in part by a research grant, No, M-1292, from the National Institutes of Health, Public Health Services. It also received support from the U.S. Atomic Energy Commission.

We wish to acknowledge the skilled analytical assistance of Marie Hebert, Ann Ohlander and Hiromi Morimoto.

EDWARD L. BENNETT
JAMES CROSSLAND*
DAVID KRECH
MARK R. ROSENZWEIG

Lawrence Radiation Laboratory and
Department of Psychology,
University of California,
Berkeley 4, California.

---

* Present address: Department of Physiology, University of St. Andrews, Scotland.

[1] Bennett, E. L., Rosenzweig, M. R., Krech, D., Karlsson, H., Dye, N., and Ohlander, A., *J. Neurochem.*, 3, 144 (1958).

[2] Tryon, R. C., in "Yearbook Nat. Soc. Stud. Educ.", 39, Part 1, 111 (1940).

[3] Roderick, T. H. (unpublished doctoral dissertation, University of California, 1958).

[4] Rosenzweig, M. R., Krech, D., and Bennett, E. L., in "Neurological Basis of Behaviour", edit. by Wolstenholme, G. E., and O'Connor, C. M., 337 (Ciba Foundation Symposium: Churchill, London, 1958).

[5] Crossland, J., *J. Physiol.*, 114, 318 (1951).

[6] Crossland, J., Pappius, H. M., and Elliott, K. A. C., *Amer. J. Physiol.*, 183, 27 (1955). Stone, W. E., *Biochem. J.*, 32, 1908 (1938).

[7] Stone, W. E., *Arch. Biochem. Biophys.*, 59, 181 (1955).

[8] Crossland, J., and Merrick, A. J., *J. Physiol.*, 125, 56 (1954).

[9] Feldberg, W., *J. Physiol.*, 114, 318 (1951).

Variability in Levels of Blood Uric Acid in Five Species of Birds

OUR preliminary studies on serum uric acid in birds showed the existence of diurnal differences in concentration. Therefore, it seemed appropriate to study the factors associated with these differences. This work is based on 123 birds of four species: *Carpodacus mexicanus*, *Lophortyx californica*, *Passer domesticus* and *Zonotrichia leucophrys*. The birds were housed individually at temperatures ranging from 22 to 26° C. on a daily photoperiod of 5 hr. To test a non-flying bird, week-old chicks kept at 33° C. in a brooder on a 5-hr. photoperiod were used. Water consumption was measured to check the degree of hydration prior to obtaining blood samples. Blood sera were analysed colorimetrically[1]. Activity was induced by (*a*) placing the birds in a cylindrical cage 8 in. in diameter and 24 in. in length and forcing them to hop by slowly rotating the cage at 6 r.p.m. with an electric motor for 2½ hr. or by (*b*) releasing them in mid-air in an empty room illuminated by dim red light. The birds were not attracted by the red light, although we had previously observed them flying towards any stray white light when they were permitted to fly in a darkened room. Because it was impossible to keep the birds flying in the dim red light for more than a few minutes, they were picked up at the end of each flight and re-released a sufficient number of times to give the approximate equivalent of 10 min. continuous flight.

The concentrations of uric acid in the sera of birds of all five species were statistically similar after an 18-hr. period of darkness (Table 1). Levels of uric acid in serum samples removed at the middle of the

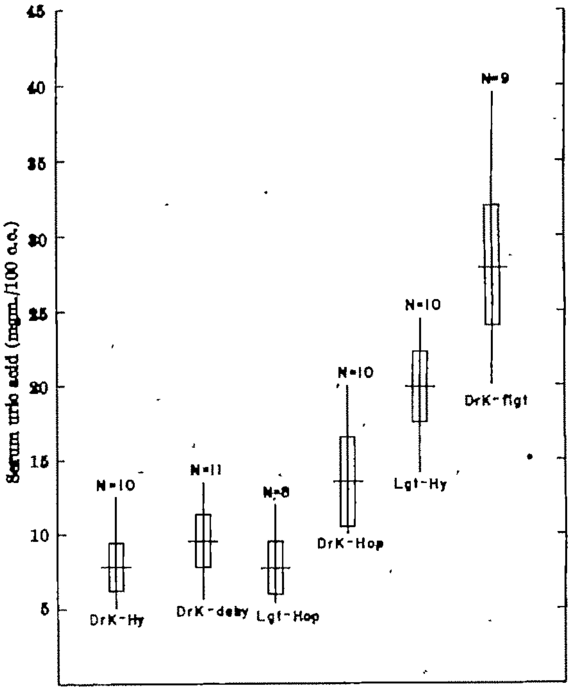


Fig. 1. Serum uric acid levels of *P. domesticus* under different conditions. The vertical lines indicate the range; the horizontal lines indicate the mean ($\bar{x}$); and the rectangles indicate the interval $\bar{x} + 2\sigma_M$ to $\bar{x} - 2\sigma_M$. The number above each line indicates the sample size. *Drk-Hy*, hydrated in the dark; *Drk-dehy*, dehydrated in the dark; *Lgt-Hop*, hopping in the light; *Drk-Hop*, hopping in the dark; *Lgt-Hy*, hydrated in the light; *Drk-flgt*, flight in the dark

Table 1. DIURNAL VARIATIONS IN SERUM URIC ACID LEVELS OF BIRDS GIVEN WATER *ad libitum*

	Serum uric acid (mgm./100 c.c.)	
	Dark ($\bar{x} \pm 2\sigma_M$)*	Light ($\bar{x} \pm 2\sigma_M$)
Carpodacus mexicanus	8·5 ± 2·5 (6)†	14·7 ± 2·9 (10)
Lophortyx californica	9·5 ± 5·1 (5)	32·2 ± 9·6 (5)‡
Passer domesticus	7·8 ± 1·6 (10)	19·8 ± 2·5 (10)
Zonotrichia leucophrys	11·2 ± 2·4 (6)	25·4 ± 6·8 (10)
Gallus domesticus	8·4 ± 0·9 (12)	7·1 ± 0·6 (11)

* Where samples were less than 8, three times standard error used.
† Numbers in parentheses indicate sample size.
‡ Birds induced to fly.

photoperiod (after 2¼ hr. of light) were approximately double the value of dark-treated individuals of *C. mexicanus*, *P. domesticus* and *Z. leucophrys* (Table 1), but were unchanged in *G. domesticus*. A high concentration of serum uric acid was found in *L. californica* when forced to fly during the light period. The behaviour of the birds during the light period suggested at least three factors as possible causes of the increase in uric acid: (1) temporary dehydration; (2) light; (3) activity. These factors were tested singly or in combination (Fig. 1) on a single species, *P. domesticus*. Measurements made at the end of the dark period on birds deprived of water for the preceding 24 hr. showed no significant differences from birds which had water available. White light does not appear to be the major cause of elevated uric acid levels during the light period since values from birds forced to hop in the light were among the lowest obtained. We assume that the high values obtained from birds hopping in the dark were caused by their increased activity due to disorientation while being forced to remain active in the dark. The rotation of their cylindrical cage caused some fluttering which was not seen under similar conditions in the light. Birds forced to fly in the dark showed an increase of 3·5 times the mean values of serum uric acid measured at the end of the dark period. The birds frequently flew in their cages during light periods. Thus, it appears that the activity associated with flight is the primary factor in the production of diurnal fluctuations in levels of serum uric acid.

The underlying mechanism for the elevated serum uric acid is unknown. There is the possibility of an increase in protein metabolism during flight[2-5]. Histological evidence for the existence of a renal portal valvular mechanism which could function as a shunt has been found in 24 species of birds including both *Passer domesticus* and *Gallus domesticus*[6]. Thus there is also the possibility that through the action of a renal portal shunt the pattern and volume of blood flow to the kidney are altered during flight and this, together with any increased production of nitrogenous waste, causes the increase in circulating uric acid.

JACK W. HUDSON

University of California,
Los Angeles.

CHARLES R. TAYLOR

Occidental College,
Los Angeles.

[1] Kern, A., and Stansky, E., *Biochem. Z.*, 290, 419 (1937).
[2] George, J., and Jyoti, D., *J. Univ. Bombay*, N.S., 21 (B, 5), 72 (1953).
[3] George, J., and Jyoti, D., *J. Animal Morphol. and Physiol.*, 4 (2), 119 (1957).
[4] George, J., and Jyoti, D., *J. Animal Morphol. and Physiol.*, 5 (1), 57 (1958).
[5] Thompson, W., and Monroe, H., *J. Nutr.*, 56, 139 (1955).
[6] Sperber, I., *Zool. Bidrag, Uppsala*, 27, 429 (1949).

HÆMATOLOGY

Absorption-Elution Grouping of Dried Blood-stains on Fabrics

THE principle of absorption-elution grouping in the ABO system using dried blood smears on microscope slides has already been described[1]. This communication is to show that a similar procedure can be adopted with blood-stains on fabrics. I have used several variations of the method; but that which is most consistently satisfactory is described here.

A fragment of the blood-stained cloth to be examined is cut out with an unstained cloth control, together in one piece of fabric. A convenient size will yield about 10 mm.² of blood-stain and a similar area of unstained cloth. The fabric is plunged into boiling McIlvaine buffer (pH 7·4) for 30 sec. then removed and placed in the antiserum for absorption. Several fragments can be absorbed together in the same antiserum.

Next the cloth is allowed to absorb antibody for 2 hr., then removed and washed three times in saline before being cut into separate stained and unstained fragments. These separate fragments (each about 10 mm.²) are placed separately in the wells of cavity slides (12 mm. diameter wells) and covered by single drops (about 30 µl.) of 2 per cent v/v red cell suspension. The slide is then removed to a moist chamber at 50–55° C. for 5 min. On removal from the moist chamber the slide is rotated vigorously, the fabric pushed to one side of the well and the cells then allowed to stand for 15 min. at room temperature before rotating and reading. Agglutination intensities can be increased by carrying out the final 30 min. of the absorption period at 5° C., and washing in saline at the same temperature.

Results generally parallel those described before[1], but most of my experience in the present work has been with anti-A and anti-B antisera only. My experience of this technique shows that the manipulation involved is only a small fraction of that in using classical absorption-inhibition methods and further that it is a technique which the untrained worker can master very quickly. Points to observe during the use of this technique are:

(1) When fixing, keep the buffer just under boiling point, otherwise with small fragments of fabric the weave is broken up. (2) When fixing and absorbing several stains together either label with water-insoluble ink or rely on the different shapes of the stains used. With very small stains this latter may be the only practical method although different fabric colours often renders labelling unnecessary. (3) Wash well with saline at room temperature. The whole technique depends on efficient removal of uncombined antibody. (4) Efficient elution and agglutination depend on transferring as much antibody from stain to cells as possible. Do not allow the cells to settle before eluting. (5) A convenient warm chamber is made from an inverted Petri dish holding a wet filter paper in the upper part. This is held at 50–55° C. in an incubator. With the small volume of cell suspension used the atmosphere must be saturated with water vapour. (6) The size of blood-stained fragment and cloth control used will vary with many factors, including the amount available, the experience of the operator and the number of antisera employed. As a guide, however, a convenient

size of fabric fragment for each slide well is 5 mm. × 2 mm.

S. S. KIND

Home Office Forensic Science Laboratory,
32 Rutland Drive,
Harrogate.

[1] Kind, S. S., *Nature*, 185, 397 (1960).

Non-specific Hæmagglutinin from Cellulose and Cellulose Ion Exchanger

IN our work on the fractionation of ether-treated influenza viruses by chromatography on *DEAE*-columns (N,N-diethylaminoethylcellulose)[1] it was found that samples of cellulose exchangers released different amounts of non-specific hæmagglutinin which has to be removed by thorough washing (refs. 1 and 2 and McCrea, J. F., personal communication). We have found similar non-specific hæmagglutinins in batches of normal cellulose, CAM-cellulose and ECTEOLA-cellulose (Schleicher and Schüll, Dassel, Germany; Serva-Entwicklungslabor, Heidelberg, Germany).

With reference to the increasing importance of the cellulose ion exchangers, for example, for fractionation of hæmagglutinating agents[1-3], it seems to be useful to know, and to exclude, this hæmagglutinin.

The dialytic behaviour of the non-specific hæmagglutinin from *DEAE*-cellulose indicates a high molecular weight. The agglutinin was shown to be heat-resistant (½ hr., 100° C.), not susceptible to the receptor-destroying-enzyme, lysozyme, and trypsin, susceptible to sodium periodate, acid and alkali hydrolyses.

Furthermore it is able to agglutinate red cells of different species, for example, rabbit, mouse, chicken, and guinea pig; also human red cells without respect to the blood-group antigens A_1, A_2, AB and O.

The highest agglutinin titre proved to be at *p*H 7·2–7·8. The fixation of the hæmagglutinin to the red cell surface appears to be firm, as proved by hæmolysis on elution. It may be assumed that the agglutinin is a pan-agglutinin and that it belongs to the group of polysaccharides, which is further indicated by its susceptibility to sodium periodate and by a positive Molisch reaction.

B. SCHMIDT
K. GROSSGEBAUER
D. HARTMANN

Institut fur Hygiene und Medizinische Mikrobiologie
der Freien Universität,
Berlin.

[1] Schmidt, B., Hartmann, D., and Grossgebauer, K., *Arch. ges. Virusforschg*. (in the press).

[2] McCrea, J. F., and O'Loughlin, J., *Virol.*, 8, 127 (1959).

[3] Prager, M. D., and Speer, R. J., *Proc. Soc. Exp. Biol. Med.*, 100, 68 (1959).

The Rh Factor C in South African Bantu

FOLLOWING the recent work of Sturgeon *et al.*[1] on a variant of Rh antigen C common in Negroes, Allen and Tippett[2] on factor G, Wiener and Unger[3] on the complexities of D and Rosenfield and Haber[4] on Rh factor Ce, we considered it timely to undertake a re-appraisal of the Rh factor C in South African Bantu. It was planned to test a series of type Cde Bantu blood donors with a variety of anti-C and anti-CD sera in order to investigate the nature of C and the possible incidence of Allen's G factor. The material consisted of Bantu donors bled during 1959, and, in order to study antibody formation, a series of D-negative Bantu ante-natal patients was also included. In the preliminary stages we referred a number of specimens to Dr. A. E. Mourant for his opinion and we are grateful to him not only for investigating these specimens but also for putting us in touch with Dr. Philip Sturgeon of Los Angeles, who sent us a copy of his paper on the C variant in Negroes and a hitherto unpublished paper extending his original studies; he also gave us a supply of his key serum anti-C^N, which we were able to use for the last five months of the investigation.

The specimens were obtained from healthy male and female Bantu donors and ante-natal cases. We screen all specimens in tubes with two anti-D sera, one complete and one incomplete. Negatively reacting specimens are tested further with from two to four additional anti-D sera, after which a check for D^u variants is carried out by the use of two or three incomplete sera and the indirect antiglobulin technique. The D negatives are screened with saline anti-CD and anti-E sera. Those reacting with anti-CD were tested with a panel of anti-C and anti-CD sera and a small series with anti-C^w. The last 64 Cde donors were also tested with Sturgeon's anti-C^N.

A total of 10,173 Bantu blood donors was investigated of whom 488 proved to be D-negative, and of these 98 gave strongly positive reactions with saline anti-CD sera. On further testing all 98 specimens gave strongly positive reactions with panels of saline anti-C + D sera and sera which contained saline anti-C + albumin anti-D; variable results were obtained with saline anti-C, two giving negative results while three others gave a proportion of positives. No positive results were obtained with anti-C^w. The really significant finding was that not one of the 64 Cde donors reacted with anti-C^N serum although controls on Europeans gave positive results This is in agreement with Sturgeon's findings on Negroes. In order to find out whether there was an antigenic difference between the C of Cde persons and the C of CDe persons, 100 consecutive Rh D-positive Bantu donors were tested for the C antigen; 16 type CDe were found and of these 1 gave a positive reaction with anti-C^N and also strongly positive reactions with the panel of test sera as in the case of European controls, but those negative with anti-C^N behaved as the Bantu Cde type, and it would seem that the Bantu CDe group consists of two types of C, a very small minority conforming to the Caucasian type and the great majority belonging to Sturgeon's Negro variant. One is tempted to speculate that the fifteen anti-C^N negatives belonged to the genotype C^nde/cDe, while the one anti-C^N positive was of the type CDe/cde and, furthermore, that C is a characteristic of Caucasians and not of Bantu.

Of the 365 consecutive ante-natal D negative cases, 50 gave strong reactions with anti-CD sera and 30 of those tested with anti-C^N were all negative. Of 21 D-negative sensitized Bantu females with Rh antibodies, 5 belonged to the 'Negro' type Cde; two of these have not yet been delivered, in two cases the babies required exchange transfusion, and the fifth case was a patient in the country whose baby was severely jaundiced.

In summary, our findings show that of 853 consecutive Bantu D-negative persons, 148 belonged to the type Cde and none to type cdE. This is in keeping with the results reported by Zoutendyk[5] on the Rh types of 300 Bantu. In every case the C resembled Sturgeon's Negro variant in their reactions with saline anti-C sera and in the 94 cases tested with anti-C^N. It was also found that of 50 type cDe tested, none reacted with anti-C^N.

The Rh mosaic has become so confused and complex during the past two years that at present the interpretation of our results can only be speculative. They show that the C factor of type Cde Bantu and most type CDe-Bantu is antigenically different from Caucasian C and one may be able to classify type CDe Bantu into genotypes C^nde/cDe and either C^NDe/cDe or C^NDe/cde according to the reactions obtained with anti-C and anti-C^N sera. Sturgeon[6], in a paper read at the eleventh annual meeting of the American Academy of Forensic Sciences, 1959, has presented evidence that his anti-C^N and the anti-Ce of Rosenfield and Haber are essentially identical reagents, and he suggests the possible interpretation that C^N, c^v, C^n and G may be different expressions of type C.

Whatever the ultimate theoretical significance may be, the immediate practical applications of our findings are obviously important. Tests on Bantu donors should include the use of saline anti-CD sera, and in medico-legal work, for example in tests for disputed paternity, a selected panel of C and CD sera is essential, as not infrequently these cases involve both Europeans and Bantu with a correspondingly complex Rh set-up.

A. ZOUTENDYK
H. TEODORCZUK

South African Institute for
Medical Research,
Johannesburg.

---

[1] Sturgeon, P., Fisk, R., Wintler, C., and Chertock, R., Proc. Seventh Congr. Int. Soc. Blood Transf., 293 (Rome, 1958).

[2] Allen, jun., F. H., and Tippett, P. A., *Vox Sang.*, 3, 321 (1958).

[3] Wiener, A. S., and Unger, L. J., *J. Amer. Med. Assoc.*, 169, 696 (1959).

[4] Rosenfield, R. E., and Haber, G. V., *Amer. J. Hum. Genet.*, 10, 474 (1958).

[5] Zoutendyk, A., *S. Afr. J. Med. Sci.*, 12, 167 (1947).

[6] Sturgeon, P., *J. Forensic Sci.*, 5, 287 (1960).

Effect of Heat on the Serum Factors Gm^a, Gm^b, Gm^x and Gm-like

GRUBB[1] reported that Rh-positive red blood cells coated with an incomplete anti-D serum could be caused to agglutinate by serum from some patients with rheumatoid arthritis. He showed also that serum from some healthy patients could inactivate the rheumatoid arthritis serum when mixed with it, so that sensitized red blood cells would not be caused to agglutinate.

Grubb and Laurell[2] showed that the presence of the inhibitor in normal serum is due to a dominant gene (*Gm^a*). Those with the factor are called Gm (a+) and those without it are called Gm (a −). Grubb and Laurell reported also that Gm (a +) sera did not lose their ability to inhibit after exposure to 63° C. for 25 min. but that the rheumatoid arthritis sera were inactivated by such treatment.

We have attempted to repeat Grubb and Laurell's experiments on Gm and to extend them to the other known Gm factors, Gm^b (Harboe[3]), Gm^x (Harboe and Lundevall[4]), and Gm-like (Steinberg, Giles and Stauffer[5]).

Table 1. EFFECT OF HEATING AT 63° C., UNTIL VISIBLE AGGREGATES ARE FORMED, ON THE GM FACTORS OF NORMAL SERA

Factor	Number heated	Reaction after heating neat	Reaction after heating diluted 1/2 or 1/8 saline
		A. Gm (+) sera	
Gm^a	12	12 Gm (a+)	12 Gm (a+)
Gm^b	12	12 Gm (b+)	12 Gm (b+)
Gm^x	12	12 Gm (x+)	12 Gm (x+)
Gm-like	9	9 Gm-like (−)	8 Gm-like (−) 1 Gm-like (+)*
		B. Gm (−) sera	
Gm^a	12	12 Gm (a+)	12 Gm (a−)
Gm^b	10	10 Gm (b−)	10 Gm (b−)
Gm^x	16	16 Gm (x+)	16 Gm (x−)
Gm-like	12	12 Gm-like (−)	12 Gm-like (−)

* Heated for 30 min.

All Gm tests were made by the slide technique, described by Harboe and Lundevall[4], using rheumatoid arthritis serum (Bomb.) with anti-D (Ham.) to test for Gm^b, and with anti-D (Warren) to test for Gm-like; and rheumatoid arthritis serum (Bowers) with anti-D (Kimb.) to test for Gm^a, and with anti-D (Ham.) to test for Gm^x (Steinberg, Giles and Stauffer[5]).

We found that undiluted rheumatoid arthritis sera were inactivated and that undiluted Gm (a +) sera were unaffected by heating to 63° C. for 30 min., as Grubb and Laurell had reported. We found, too, that diluting these sera 1/2 or 1/8 with saline did not affect their response to treatment with heat.

Tests with Gm (b +) and Gm (x +) sera indicated that they also remained unchanged when heated neat or diluted in saline. Gm-like (+) sera, on the other hand, became Gm-like (−) and this also was independent of whether the sera were heated neat or diluted in saline. We emphasize, in the light of results to be reported below, that dilution with saline does not affect the above reactions.

Gm (*a* −) and Gm (x −) sera become Gm (a +) and Gm (x +), respectively, when heated neat, but remain unchanged when heated diluted in saline. We have heated one such serum diluted 1/2 in saline for 3 hr. at 63° C. without any change in its Gm type. Gm (b −) and Gm-like (−) sera, on the other hand, remain unchanged on heating. The results are presented in Table 1. Table 2 shows an example of the protocols of the titration of two Gm (a+), two Gm (a −) sera, and a heated Gm (a −) serum.

The change from Gm (a −) to Gm (a +) or from Gm (x −) to Gm (x +) has not been observed in sera heated for less than 15 min. Furthermore, we have noted these changes only when visible aggregates have formed during heating, or on dilution in saline after heating. We have noted, also, that there is a slight positive correlation between the length of time required to form these aggregates and the length of time the serum has been stored at − 20° C. Of the two sera which changed from Gm (a −) to Gm (a +) and from Gm (x −) to Gm (x +) only after heating for 60 min. at 63° C., one had been stored for two months and the other for one year. Neither serum developed visible aggregates when heated for 30 min. but each did so when heated for 60 min. Other sera

Table 2. TITRATION OF TWO GM (A+), TWO GM (A−) SERA AND A HEATED GM (A−) SERUM

Serum	Gm^a	Dilution of test serum 1/4	1/8	1/16	1/32	1/64	1/128	Score
43	+	0	0	0	0	0	++	2
S-9	+	0	0	0	+	++	++++	6
H	−	0	+++	+++	+++	++++	++++	17
S-1	−	0	0	++	+++	+++	++++	12
S-1 (heated)		0	0	0	0	0	+++	3

Table 3. EXAMPLES OF THE EFFECT OF HEAT (63° C. UNTIL VISIBLE AGGREGATES FORM) ON THE GM CHARACTER OF INDIVIDUALS WITH DIFFERENT GM FACTORS*

Individual		Gm factors *a*	*b*	*x*	like
S-1	unheated	−	+	−	−
	heated	+	+	+	−
S-6	unheated	+	+	−	+
	heated	+	+	+	−
S-8	unheated	+	+	−	−
	heated	+	+	+	−
S-14	unheated	+	−	−	−
	heated	+	−	+	−

* The only other Gm phenotypes we have observed are Gm (a + b + x + like −) and Gm (a + b − x + like −), but these do not change on heating.

stored equally long, however, did change after ½ hr. of heating. Attempts to make this observation quantitative, and to analyse the nature of the change in the serum with storage, are planned for the future.

The explanation of the changes in Gm^{a}, Gm^{x} and Gm-like reactivity recorded above is not obvious. Grubb[6] reported that the Gm^{a} factor in normal serum is γ-globulin. γ-Globulin has been shown to be composed of at least two major primary components, one with a sedimentation-rate of 7 *S* and a second with a sedimentation-rate of 19 *S* [7]. Dr. Hugh Fudenberg (personal communication) reports that ultracentrifugation tests show that all four Gm factors of normal serum are located in the 7 *S* γ-globulin and that the 19 *S* component is inactive. Heat is known to aggregate γ-globulin[8]. Hence, after heating it would be expected that there would be a reduction of the amount of 7 *S* γ-globulin and probably a comparable reduction in Gm activity. It is surprising, therefore, that only one factor (Gm-like) becomes negative on heating and that Gm (a −) and Gm (x −) become positive on heating. It is unlikely that the latter change is due to a non-specific interaction of the aggregates with the rheumatoid arthritis serum, of the sort reported by Franklin *et al.*[8], because of the failure of Gm^{b} to change and because of the change of Gm-like (+) to Gm-like (−).

The changes cannot be explained on the basis of antigens competing for the surface of a molecule as has been reported, for example, in *Paramecium*[9], because they are not influenced by the other Gm factors present (Table 3). We hope to be able to submit the aggregated protein to analysis in the ultra-centrifuge.

The different responses of the factors to heat indicate that while they may all be associated with the 7 *S* component of γ-globulin, the molecules for the factors are qualitatively different. At least three molecules or active sites must exist, one for Gm^{a} and Gm^{x}, one for Gm^{b}, and one for Gm-like.

Among white individuals three alleles exist at the Gm locus, *Gm^{a}*, *Gm^{ax}* and *Gm^{b}* (Grubb and Laurell[2], Harboe[3] and Harboe and Lundevall[4]). These three alleles seem to determine two qualitatively different molecules as judged by their reactions to temperature, one for Gm^{b}, and one for Gm^{a} and Gm^{x}. Among Negroes there appears to be an allele *Gm^{ab}* (Steinberg, Stauffer and Boyer[10]) and an allele or a separate gene, Gm-like[5]. It is interesting that Gm (b +) in the Negro as determined by the allele *Gm^{ab}* is stable while Gm-like (+) which appears to be 'serologically' related to Gm^{b} (Sylvia Lawler, personal communication, and unpublished results of the authors) is not. The rare Gm (a −) sera from Negroes become Gm (a +) on heating while the similarly rare Gm (b −) sera from Negroes do not change. This is to be expected because these factors are probably determined by genes from white ancestors.

ARTHUR G. STEINBERG
RACHEL STAUFFER

Department of Biology,
Western Reserve University,
Cleveland, Ohio. March 21.

[1] Grubb, R., *Acta Path. Microbiol. Scand.*, **39**, 195 (1956).

[2] Grubb, R., and Laurell, A. B., *Acta Path. Microbiol. Scand.*, **39**, 390 (1956).

[3] Harboe, M., *Acta Path. Microbiol. Scand.*, **47**, 191 (1959).

[4] Harboe, M., and Lundevall, J., *Acta Path. Microbiol. Scand.*, **45**, 357 (1959).

[5] Steinberg, A. G., Giles, Brenda Dawn, and Stauffer, Rachel, *Amer. J. Human Genet.*, **12**, 44 (1960).

[6] Grubb, R., *Acta Haemat.*, **20**, 246 (1958).

[7] Muller-Eberhard, H. J., Kunkel, H. G., and Franklin, E. C., *Proc. Soc. Exp. Biol. N.Y.*, **93**, 146 (1956).

[8] Franklin, E. C., Holman, H. R., Muller-Eberhard, H. J., and Kunkel, H. G., *J. Exp. Med.*, **105**, 424 (1957).

[9] Sonneborn, T. M., *Proc. U.S. Nat. Acad. Sci.*, **34**, 413 (1948).

[10] Steinberg, A. G., Stauffer, Rachel, and Boyer, S., *Nature* (in the press).

PATHOLOGY

Inhibition of Aerobic Glycolysis in Yoshida Ascites Hepatoma by Tartronic Acid

THE inhibition of lactic dehydrogenase should allow a blocking of aerobic glycolysis of neoplastic cells, thus depriving them of a high percentage of adenosine triphosphate without damaging the normal cells which, in conditions of normal functional activity and sufficient oxygen supply, do not need this enzyme[1]. According to this premise, the action of tartronic acid, which is a lactic dehydrogenase inhibitor[2,3], on the growth of Yoshida's ascites hepatoma and Ehrlich's ascites tumour was studied[1].

The present experiments were carried out to ascertain what are the tartronic acid concentrations needed to attain *in vitro* a significant inhibition of aerobic glycolysis of the intact cells of Yoshida's ascites hepatoma. Experiments were also performed to ascertain whether parabanic acid, which is a strong lactic dehydrogenase inhibitor of *Bacterium coli*[3], also inhibits aerobic glycolysis of the same tumour.

Each experiment was carried out as follows: 3 flasks (I, II, III) were used, each containing 1 ml. of phosphate buffer solution (*p*H 7·4). In flasks I and II 0·5 ml. of saline containing 1·6 per cent glucose was added. In flask III was added 0·5 ml. of the same solution containing also the acid under test, neutralized with sodium hydroxide. The phosphate buffer solution had been obtained by mixing 43 volumes of 0·154 *M* disodium hydrogen phosphate with 10 volumes of 0·154 *M* sodium dihydrogen phosphate. After having brought the contents of the flasks up to 37°, to each one was added 0·5 ml. ascitic fluid which had been withdrawn immediately before from a rat having borne ascites hepatoma for 7–8 days. Lactic acid concentration was measured in the contents of one of the two flasks (I) without the acid under test, immediately after addition of ascitic fluid; the same determination in the contents of the other two flasks (II and III) was made after 1 hr., during which the flasks were uninterruptedly shaken at 37° in air. Thus the amounts of lactic acid formed with and without the substance under test were assessed. At the end of the experiment care was taken to check the *p*H of the contents of the flasks (II and III) to make sure it had not been modified. For the determination of lactic acid, 0·5 ml. of the contents was removed and poured into 8 ml. of 9 per cent trichloracetic acid solution. After centrifugation the lactic acid content of the supernatant 0·5 ml. was determined by the method of Barker and Summerson[4], taking precautions as suggested by Le Page[5].

It had been established in previous experiments that neither tartronic nor parabanic acid, which may be present in the sample tested for lactic acid determination, interferes with Barker and Summerson's method.

Tartronic acid employed for these experiments was synthesized in the Institute of Organic Chemistry, University of Bologna, according to Bak's method[6] (m.p., 154–156°). Parabanic acid was supplied by the Nutritional Biochemicals Corporation, Cleveland (m.p., 207°).

TARTRONIC ACID

	μgm. of lactic acid formed in 1 hr. by 0·5 ml. ascitic fluid		
Concentration of tartronic acid when present	Without tartronic acid	With tartronic acid	Inhibition (per cent)
10^{-3} M	1,856	1,428	23
,,	612	435	29
,,	816	585	28
,,	1,115	816	27
		Mean values	
,,	1,100	816	26
2×10^{-3} M	1,394	972	30
,,	1,244	830	33
,,	1,244	768	38
,,	979	619	37
		Mean values	
,,	1,215	797	34
5×10^{-3} M	1,856	836	55
,,	952	360	62
,,	748	292	61
,,	1,027	435	58
		Mean values	
,,	1,146	481	58

PARABANIC ACID

	μgm. of lactic acid formed in 1 hr. by 0·5 ml. ascitic fluid		
Concentration of parabanic acid when present	Without parabanic acid	With parabanic acid	Inhibition (per cent)
10^{-3} M	1,802	1,802	—
	925	925	—
2×10^{-3} M	1,074	1,156	—
	864	911	—
5×10^{-3} M	1,217	1,312	—
,,	639	714	—
,,	1,020	1,020	—

Results are given in Table 1. It appears that while the amounts of lactic acid produced are subject to considerable variations from one experiment to another, comparison of the lactic acid produced in each single experiment by the same ascitic fluid with and without tartronic acid shows a constant ratio. Variations in the production of lactic acid from one experiment to another are in close relationship, as was seen in previous unpublished experiments, with the amount of neoplastic cells in the ascitic fluid, which is greatly different from animal to animal.

The present experiments show that concentrations of 10^{-3} M, 2×10^{-3} M and 5×10^{-3} M inhibit the aerobic glycolysis of Yoshida's ascites hepatoma at a rate of 26, 34 and 58 per cent, respectively. On the contrary, parabanic acid, even at a concentration of 5×10^{-3} M, has no inhibitory action on the aerobic glycolysis of this tumour.

Further experiments will be carried out to ascertain what concentrations of tartronic acid can be attained *in vivo*. Of interest in this connexion is the observation[7] that tartronic acid is not transformed by animal tissues, and that 15 hr. after intramuscular administration of 40 mgm. tartronic acid in the rat, only 27 per cent is found in the urine.

L. FIUME

Institute of General Pathology,
University of Bologna.

---

[1] Fiume, L., *Boll. Soc. Ital. Biol. Sper.*, 34, 434 (1958).

[2] Quastel, J. H., and Wooldridge, W. R., *Biochem. J.*, 22, 689 (1928).

[3] Fiume, L., and Reggianini, O., *Boll. Soc. Ital. Biol. Sper.*, 33, 234 (1957).

[4] Barker, S. B., and Summerson, W. H., *J. Biol. Chem.*, 138, 535 (1941).

[5] Le Page, G. A., in "Manometric Techniques", edit. by Umbreit, W. W., Burris, R. H., and Stauffer, J. F., 104 (Burgess, Minneapolis, 1948).

[6] Bak, B., *Ann. Chem.*, 537, 236 (1939).

[7] Rieben, W. R., and Hastings, A. B., *Helvetica Physiol. et Pharmacol. Acta*, 4, C, 52 (1946).

The Ouchterlony Technique using Antigen or Antiserum labelled with Iodine-131

THE Ouchterlony agar plate technique[1] has been used a great deal for the analysis of antibody–antigen systems, but it was not until recently that it was used quantitatively[2]. An autoradiographic agar plate technique employing radioactive proteins has been described by Perlmann and Hultin[3] for the demonstration of proteins in complex systems, but their method was not in any way quantitative.

A quantitative method employing either antigen or antiserum labelled with iodine-131, cellulose acetate paper, and autoradiography has recently been found useful for certain purposes in our laboratory.

In an earlier series of studies, agar was used as the diffusion medium. 4 ml. of 2 per cent agar was distributed in a thin layer (about 1 mm. thick) on a glass slide. The antigen and antiserum were placed in small holes in the agar opposite each other, and the slide was left to stand in a moist atmosphere for some days. Free antigen and antibody were washed out by immersing the slide in saline containing merthiolate for 1–2 days. It was then dried and placed in contact with an X-ray film for a few days. The distribution of bands of radioactive antibody–antigen precipitate could clearly be seen on the developed film. Afterwards it was found more convenient to use cellulose acetate paper instead of agar as diffusion medium (suggested by Kohn, J., personal communication). The details of the procedure are as follows: Strips or disks of 'Oxoid' cellulose acetate paper ('Oxoid' membrane filter strips and disks obtained from Messrs. Oxo, Ltd. (Med. Dept.), 16 Southwark Bridge Road, London) of the appropriate dimensions are prepared as follows: A ball-point pen is used to mark the spots on each strip where the antigen solution and antiserum are to be placed. For example, in the case illustrated in Fig. 1, a row of 8 dots about 1 cm. apart was made for the antigen and another parallel row, with the same spacing, was made for the antiserum 0·8 cm. from the antigen row. The strip is 'floated' on phosphate buffer pH 7·6 so that the liquid soaks in of its own accord. It is then taken out and 'blotted' on filter paper. The antigen and antiserum solutions are then applied to the appropriate spots in 1-μl. quantities with a micro-constriction pipette. Either the antigen or the antiserum is labelled with iodine-131. As soon as all the solutions have been applied the strip is placed in oil 'Whitemor 120' (kindly supplied by the Manchester Oil Refinery (Sales),

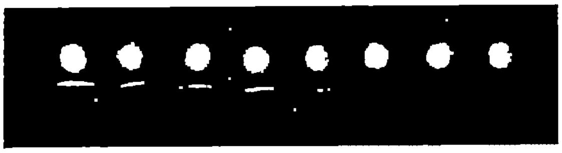


Fig. 1. Autoradiograph of the reaction between human serum albumin (labelled with iodine-131) with rabbit anti-human albumin serum on cellulose acetate strips. Labelled human serum albumin 0·5 µgm./µl. was used as antigen. 1 µl. antigen was applied to the cellulose acetate paper 0·8 cm. from 1 µl. of the serum dilutions. Rabbit anti-human albumin serum diluted as follows: 1/1, 1/4, 1/16, 1/64, 1/128, 1/256, 1/512, and 1/1,024 beginning at the left-hand side

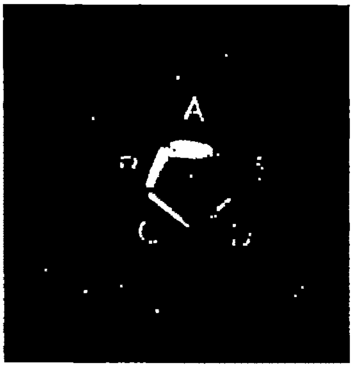


Fig. 2. Autoradiograph of the reaction between human serum albumin labelled with iodine-131 with dilutions of rabbit anti-human albumin serum on cellulose acetate disk. 2 µl. iodine-131 labelled human serum albumin (0·5 µgm./µl.) were placed in the centre. 1 µl. of the serum dilutions was applied 1 cm. from the centre. *A*, 1/1 dilution; *B*, 1/4 dilution; *C*, 1/16 dilution; *D*, 1/64 dilution, and *E*, 1/128 dilution

Ltd., 76 Jermyn Street, London, S.W.1) for 24 hr. (Kohn, J., personal communication), after which it is removed, quickly rinsed in ether, and put into phosphate buffer, *p*H 7·6, for 2–4 hr. After the strip has been allowed to dry completely between two pieces of filter paper it is placed in direct contact with an X-ray film ('Kodirex') in complete darkness for a few hours or a few days depending on the specific activity and quantity of the material labelled with iodine-131. The film is developed by the usual procedure.

Figs. 1 and 2 show typical pictures obtained when a constant amount (0·5 µgm./µl.) of human serum albumin labelled with iodine-131 was applied to strips or disks of cellulose acetate and tested against twofold and fourfold dilutions of rabbit anti-human albumin serum. The last dilution of antiserum to give a detectable precipitate in Fig. 1 contained about 1 µgm. antibody nitrogen/ml.

Similar results were obtained when rabbit γ-globulin against human albumin was labelled with iodine-131 (according to the technique of McFarlane[4]) and tested against unlabelled human serum.

The advantages of this procedure are sensitivity and that it requires only very small amounts of antiserum and antigen.

JOAN M. RHODES

Tuberculosis Immunization Research Centre,
c/o Statens Seruminstitut,
Copenhagen.

---

[1] Ouchterlony, O., *Acta Path. Microbiol. Scand.*, **25**, 186 (1948).

[2] Wright, S. T. C., *Nature*, **183**, 1282 (1959).

[3] Perlmann, P., and Hultin, T., *Nature*, **182**, 1530 (1958).

[4] McFarlane, A. S., *Nature*, **182**, 53 (1958).

Pathogenicity of *Metarrhizium anisopliae* (Metch.) Sor. and *Beauveria bassiana* (Bals.) Vuill. to Two Species of Elateridae

DURING 1950–59 numerous elaterid eggs, larvæ, pupæ and adults died and became 'mouldy' in rearing or storage at the Saskatoon Research Station. Seven fungi were isolated from such specimens in 1959. In initial screening trials, only two of these, *Metarrhizium anisopliae* isolated from a larva, and *Beauveria bassiana* from an adult of *Hypolithus bicolor* Esch., increased the rate of mortality of this elaterid and of *Ctenicera aeripennis destructor* (Brown). These fungi have not been recorded previously from *H. bicolor*, and *Beauveria* has not been recorded from *C. a. destructor*. It was of interest, therefore, to determine whether they are primary pathogens of these elaterids.

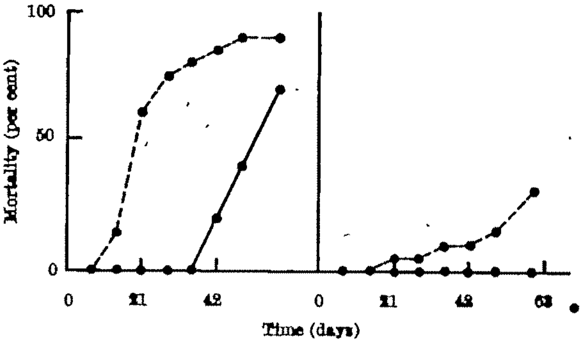


Fig. 1. The mortality of *Hypolithus bicolor* (left) and *Ctenicera aeripennis destructor* larvæ in soil infested with *Metarrhizium anisopliae* (– – – –), and not infested (———)

Larvæ that were in, or near, the last instar and female adults were collected in the field and stored at 5° C. For the tests, the larvæ were placed in soil in individual salve boxes, and the adults on blotting paper in plastic boxes, five of each species per box. They were exposed to the fungi by uniformly infesting the soil in which the larvæ were placed and by spraying

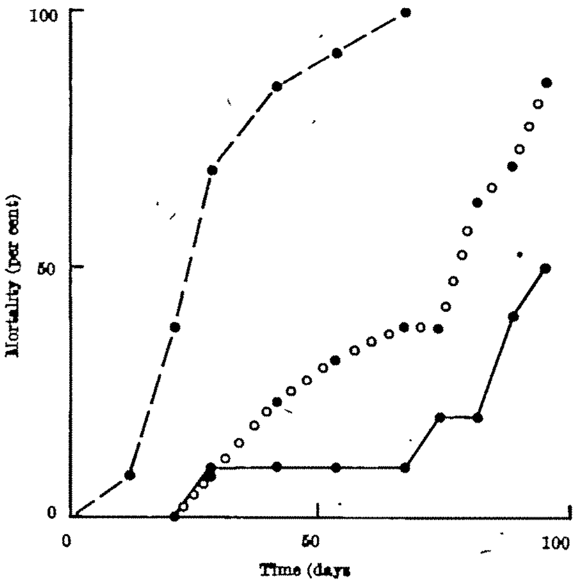


Fig. 2. The mortality of *Hypolithus bicolor* larvæ in soil infested with *Metarrhizium anisopliae* (– – – –), infested with *Beauveria bassiana* (o o o o), and not infested (———)

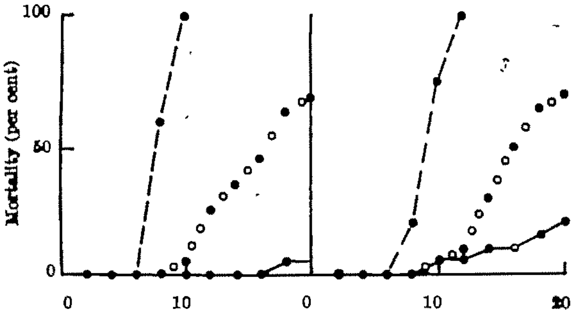


Fig. 3. The mortality of female adults of *Hypolithus bicolor* (left), and *Ctenicera aeripennis destructor*, inoculated with *Metarrhizium anisopliae* (– – – –), *Beauveria bassiana* (o o o o), and uninoculated (———)

the adults directly with aqueous suspensions of spores. The suspensions were prepared from cultures of the fungi on a glucose–nitrate agar medium. Generally in a test the numbers of larvæ or adults of a species were 10 in the control and 20 in the treated series. The insects were kept at 20° C. during the tests.

As shown in Fig. 1, *Metarrhizium* increased the rate of mortality of the larvæ of the two elaterid species, but the larvæ of *C. a. destructor* appeared more resistant to it than were those of *H. bicolor*. *Beauveria* increased the rate of mortality of *H. bicolor* (Fig. 2). In an initial screening test it did not increase the incidence of mortality among larval populations of *C. a. destructor*. Both fungi increased the rate of mortality of the adults of the two elaterid species, which appeared about equally susceptible (Fig. 3). *Beauveria* was less virulent than *Metarrhizium* to the larval (Fig. 2) and adult (Fig. 3) stages of the elaterids. The respective fungi were re-isolated, even after surface disinfection, from the majority of larvæ and adults that died in the treated series. The fungi were not obtained from the dead insects of the control series. The results therefore indicate that the two fungi are primary pathogens of one or more stages of *H. bicolor* and *C. a. destructor*.

Metarrhizium anisopliae and *B. bassiana* have been reported from other elaterid species[1-5], but tests indicated that they were generally only mildly virulent[3,4,5]. It is interesting to note, therefore, that these fungi are highly virulent to some stages of the two most common elaterid species in Saskatchewan, and that they differ in virulence to species and to stages within a species. Further work is in progress to determine the nature and extent of these differences.

We are indebted to Dr. D. M. MacLeod for confirming the species identification of the fungi.

R. D. Tinline
R. Y. Zacharuk

Research Station,
Research Branch,
Canada Department of Agriculture,
Saskatoon,
Saskatchewan.

---

[1] Hall, G. A., *J. Agric. Res.*, **41**, 571 (1930).

[2] Thomas, C. A., *Entomol. News*, **43**, 149 (1932).

[3] Charles, V. K., *U.S. Dept. Agr., Bur. Pl. Ind. Insect Pest Survey Bull.*, **21**, 770 (1941).

[4] Rockwood, L. P., *Ann. Entomol. Soc. Amer.*, **43**, 495 (1950).

[5] Fox, C. J. S., and Jaques, R. P., *Can. Entomologist*, **90**, 314 (1958).

A Rapid Method for studying Tumour Blood Supply using Lissamine Green

Goldacre and Sylvén[1] have described a method for making visible those regions of solid malignant tumours supplied with flowing blood. They used a high blood concentration of the triphenylmethane dye, lissamine green (Gurr), which turned the whole animal green except where there were barriers. Ten to twelve days following the transplantation of sarcoma 37, mammary carcinoma and Erhlich Landschutz tumours in mice and Walker sarcoma in rats it was observed that vascular obstruction occurred, confining the flowing blood to a thin surface layer of the tumour. Tumours measuring 1–3 cm. across had a white centre and a green periphery. The dye does not penetrate the living cell membrane but the surrounding tissues become green due to the green blood in them and the green interstitial fluid derived from the blood. Extensive regions not supplied with flowing blood but with a thin coating layer supplied with blood were also found in various large spontaneous and methylcholanthrene-induced tumours of rodents. Cells dissected out from the non-coloured tumour region were found to be dead except when within about 300μ from the green region, where mixtures of living and dead cells were found.

As an extension of this work, lissamine green 2 per cent solution in Ringer's solution is being used to study the blood supply in spontaneous tumours occurring in the dog and cat. Preliminary experiments with rats and mice, injecting 1 ml. into the tail vein in mice and 8 ml. in rats, confirmed that the whole animal turned green except for the brain and the spinal cord, the interior of the eye, the material on the fœtal side of the placenta, and to a large extent the testis, ovary and mammary gland. Essentially the same picture has been found after intravenous injection of the dye in the guinea pig, cat and dog. Smaller quantities of the dye—2–4 ml. per kgm. body-weight—have been used in dogs and cats. This does not appear to be toxic, as one normal dog showed no ill effects and the green colour had disappeared within 48 hr. Postmortem examination of the injected dogs showed the testicles to be green, though paler than in many other tissues. Using this lower concentration of dye in the blood stream, the liver and lungs retained some of their original colour. The pituitary and meninges were green but no green colour crossed to the brain. An area of hæmorrhage and necrosis in a cerebral hemisphere of one dog remained free from green coloration.

Three cats and five dogs affected with spontaneous tumours were anæsthetized with sodium pentobarbitone and injected intravenously with 2 per cent lissamine green in Ringer's solution. 3–5 min. later a lethal dose of sodium pentobarbitone was given intravenously and postmortem examination carried out. Table 1 shows the tumours studied and the results. There was complete or almost complete distribution of lissamine green throughout the tumour tissue in squamous cell carcinomas in cats. A similar picture occurred in a lipoma in a dog and in all metastases less than 1 cm. across in the lungs and kidney arising from an osteo-sarcoma of the humerus in a dog. The distribution of lissamine green in other cases showed that some vascular obstruction occurred near junctions of viable and necrotic tumour tissue. Thus in the large (14 cm. diameter) osteo-sarcoma of the humerus there was a diffuse green distribution

Table 1

Tumour	Location	Primary	Secondary	Green	Not green	Remarks
Squamous cell carcinoma. Cat	Larynx	*		*		Few scattered small white areas 1 mm. across
	Submaxillary lymph node		*	*		
Squamous cell carcinoma. Cat	Pharynx	*		*		Few scattered small white areas 1 mm. across
Squamous cell carcinoma. Cat	Tonsil, pharynx, tongue	*		*		Few scattered small white areas 1 mm. across
	Retropharingeal lymph node. Lungs		*	*		
Lipoma. Dog	Shoulder	*		*		Tumour size, 10 cm. × 12 cm × 7·5 cm.
Osteosarcoma. Dog	Humerus	*		*		Thin layers surrounding cysts pale green or white
	Lungs		*	*	* One metastasis 3 cm. across	Size, 0·1–1 cm., all green
	Kidney		*	*		
Seminoma. Dog 1	Testicle	*			*	White, with few small areas of pale green
Seminoma. Dog 2	Testicle	*			*	
Spheroidal-celled carcinoma. Dog	Subcutaneous thorax. Ribs 2–6	*			*	7 cm. × 3·5 cm. Dark red. 0·5 cm. at periphery and intersecting connective tissue green
	Lung		*	*		1 cm. across. Some central areas grey-white

throughout the tumour, except for areas of 1–3 mm. thickness surrounding cysts and occurring mainly in the centre of the tumour mass. The large number of lung metastases, 0·1–1 cm. diameter, stood out sharply as round, deep green lesions, in contrast to a background of pink and pale green lung tissue. One larger metastasis about 3 cm. in diameter was full of caseous white material and surrounded by non-green tumour tissue except at the extreme periphery. Seminomas remaining white were found on histological examination to be essentially cellular with little other tissue. Smaller areas appearing green were nearly all connective tissue. A spheroidal celled carcinoma in an old dog showed a striking colour contrast similar to that described by Goldacre and Sylvén[1] in malignant tumours of mice. This large circular tumour with central necrosis and hæmorrhage extended a distance of about 7 cm. in the deep subcutaneous tissues from the second to the sixth ribs. A peripheral layer of about 0·5 cm. and the intersecting connective tissue in the tumour substance were green. The remainder of the tumour was dark red. Secondary deposits in the lungs were green, some showing grey-white areas centrally.

This vascular obstruction or blood tumour barrier is not strictly comparable to the blood brain barrier. Goldacre and Sylvén found that dyes such as neutral red and methylene blue, while having a similar distribution in tumour tissue, were unlike lissamine green in that they entered the brain. Recognition that this blood tumour barrier may occur in some spontaneous tumours of domestic animals but not in others is of fundamental importance in the attempted treatment of neoplasia when surgery is not practicable. In those tumours showing complete green coloration it would be theoretically possible, using systemic chemotherapeutics, to destroy all the malignant cells. In other tumours, viable cells lying between the necrotic centre and the periphery of the tumour would be exposed to a relatively low concentration of drugs administered systemically, thereby seriously interfering with cancer chemotherapy.

I wish to thank Mr. A. R. Jennings for help with the histological examination of these tumours.

L. N. Owen

University of Cambridge
Department of Veterinary Clinical Studies,
School of Veterinary Medicine,
Madingley Road,
Cambridge.

---

[1] Goldacre, R. J., and Sylvén, B., *Nature*, 184, 63 (1959).

IMMUNOLOGY

6-Mercaptopurine in Immunological Responsiveness

Schwartz and Dameshek[1,2] have reported the apparent production of immunological tolerance in rabbits by the administration of a purine analogue, 6-mercaptopurine. Rabbits receiving concomitantly human serum albumin and 6-mercaptopurine failed to develop an immune response to the protein antigen, and weeks later, when antigen alone was administered, the animals remained tolerant. In an effort to confirm this finding and to explore the possible effects of 6-mercaptopurine on homografts in rabbits, two groups of rabbits received injections of ovalbumin in Freund's adjuvant and were grafted with skin from a common donor rabbit. One of these groups received 6-mercaptopurine in the maximum dose employed by Schwartz and Dameshek, the other group serving as controls. The 6-mercaptopurine did not produce immunological tolerance for ovalbumin nor did it result in successful homografts.

Each of seven New Zealand rabbits, weighing approximately 2 kgm., received a small homograft of

Table 1. SUMMARY OF IMMUNOLOGICAL RESPONSES OF CONTROL ANIMALS AND ANIMALS TREATED WITH 6-MERCAPTOPURINE

Group	Rabbit No.	Day animal died (post-graft)	Day of homograph change*	14-day sera		21-day sera	
				Antibody N_2 (μgm./ml.)	*PCA* titre	Antibody N_2 (μgm./ml.)	*PCA* titre
Controls	25	Alive at 75 days	19	27	—	70	—
	26	Alive at 75 days	23	40	640	173	640
	29	Alive at 75 days	17	10	—	56	—
6-Mercaptopurine-treated	30	23	22	0	< 20	12	160
	31	17	Viable at death	0	< 20	—	—
	32	Alive at 75 days	35	0	< 20	0†	< 20†
	33	20	Viable at death	0	< 20	—	—

* First detectable difference between autograft and homograft reactions.
† After secondary antigenic stimulation (see text) the serum contained 105 micrograms of antibody nitrogen/ml.
PCA, Passive cutaneous anaphylaxis.

skin from the back of a common donor rabbit on to a site prepared on the left ear. Similarly, an autograft of skin from the back of each rabbit was sutured into a site prepared on its own right ear. Four of these animals received daily intramuscular injections of 6-mercaptopurine (6 mgm./kgm./day) for 14 days, the first injection being given the day prior to operation. Three rabbits served as controls. On the third and the tenth post-operative days, a mixture of ovalbumin (8·4 mgm. ovalbumin nitrogen) and complete Freund's adjuvant was injected subcutaneously. Those animals surviving for 21 days were bled on the fourteenth and twenty-first days. Two of the rabbits treated with 6-mercaptopurine died within 20 days of operation. One of the rabbits (No. 32) receiving 6-mercaptopurine was re-injected subcutaneously with ovalbumin and Freund's adjuvant on the forty-eighth day and on the fifty-sixth day after operation. On the sixty-first day after operation, this animal was bled again. The skin grafts were observed at intervals throughout the period of the study.

Analyses for anti-ovalbumin antibody included: (1) quantitative precipitin studies[3], and (2) passive cutaneous anaphylaxis[4]. In the latter method, dilutions of sera (1 : 20 to 1 : 640) were injected intradermally (0·1 ml.) into guinea pigs. Two hours later, 5 mgm. of ovalbumin in 1·0 ml. of 1 per cent Evans blue dye were injected intravenously. Thirty minutes after injection of antigen, the animals were killed and the extent of bluing noted. The passive cutaneous anaphylaxis titre was that dilution of serum which gave an area of bluing of 5 mm. or more in diameter.

Results are summarized in Table 1. The sera of control animals contained precipitins against ovalbumin (both 14-day and 21-day bleedings). Precipitating antibodies were not detectable in the 14-day sera of the 6-mercaptopurine-treated animals and the potentially more sensitive passive cutaneous anaphylaxis reactions were negative. One of the two animals treated with 6-mercaptopurine that survived beyond 21 days had precipitins demonstrable in the 21-day serum, and the other rabbit (No. 32), when restimulated with ovalbumin and adjuvant, developed precipitating antibodies. Homografts were rejected in all animals living beyond 21 days. Rabbit No. 32, which had the poorest initial immunological response to ovalbumin, had the longest surviving homograft (35 days). Autografts were successful in all animals.

The number of animals in the present study was small. The two animals treated with 6-mercaptopurine that survived beyond 21 days developed serum precipitins against ovalbumin, although there was unequivocal suppression of immune response during such treatment. The difference between these results and those of Schwartz and Dameshek is probably related to the method of antigenic stimulation. Incorporation of an antigen in complete Freund's adjuvant provides a maximal stimulation, while a single intravenous injection of a soluble protein antigen is a weak stimulus. During treatment with 6-mercaptopurine, animals lost varying amounts of weight (average loss 14 per cent initial weight). (Not included in the table of results were three additional rabbits treated with 6-mercaptopurine that died before completion of their course of the drug.) The lesser immunological response during administration of 6-mercaptopurine may be an expression of general inanition of the animals rather than a specific alteration of nucleic acid metabolism.

This work was supported in part by a grant from the U.S. Public Health Service.

Note added in proof. Delayed rejection of homografts with 6-mercaptopurine treatment and the failure of 6-mercaptopurine completely to suppress antibody formation, when antigen was incorporated in Freund's adjuvant, have been noted in recent reports (Meeker, W., *et al.*, *Proc. Soc. Exp. Biol Med.*, 102, 459 (1959); and Hoyer, L., *et al.*, *Fed. Proc.* 19, 208 (1960).

JOHN L. ROBINSON[*]
CHARLES L. CHRISTIAN

Department of Medicine,
Columbia University College of
Physicians and Surgeons,
and
Edward Daniels Faulkner
Arthritis Clinic of the
Presbyterian Hospital,
New York.

[*] Supported by Student Research Fellowship from the New York State Chapter of the Arthritis and Rheumatism Foundation.

[1] Schwartz, R., and Dameshek, W., *Nature*, 183, 1682 (1959).

[2] Schwartz, R., Eisner, A., and Dameshek, W., *J. Clin. Invest.*, 38, 1394 (1959).

[3] Kabat, E. A., and Mayer, M., "Experimental Immunochemistry" (C. C. Thomas, Springfield, 1948).

[4] Ovary, Z., *Internat. Arch. Allergy and App. Immunol.*, 3, 162, 293 (1952).

BIOLOGY

Expanded Ilio-Sacral Joint in the Toad *Xenopus laevis*

THE pelvis of Salientia is characterized by very long ilia which connect with transverse processes of the sacral vertebræ. In some Salientia these processes are greatly expanded laterally. The functional significance of this modification was, however, not clear[1].

The pipid species *Xenopus laevis*, the South African clawed toad, provides an interesting example of this modified condition. The Pipidæ are non-jumping but powerfully swimming forms; the upper (anterior) ends of the two ilia are in contact over a large area with the lateral edges of the expanded wing-like transverse processes of the sacral vertebra (Figs. 1*a* and *b*). Green[2], Gadow[3] and Grobbelaar[4] regarded this contact as a more or less rigid joint; Ridewood[5] and Nauck[6], on the other hand, described the joint as movable though without commenting on its musculature.

Dissection of a freshly killed *Xenopus* shows that the vertebral column slides freely backwards and forwards on the pelvic girdle, in a groove in the medio-dorsal aspect of the ilia. In the living animal a slow-motion cinematograph film revealed a 20 per cent range of extension and contraction of the total body-length as a result of this movement; in one specimen the 'normal' trunk-length of 9·5 cm. could be contracted to 8·5 cm. or, when the hind-feet pushed against a solid surface, expanded to 10·0 cm.

Two pairs of muscles control this movement (Fig. 2). The coccygeo-iliac muscles (*A*) serve to extend the body by projecting the trunk forwards in relation to the anterior surface of the ilia. The ilio-lumbar muscles (*B*) draw the pelvic girdle forwards with respect to the vertebral column. This pair has its insertion on the lateral aspect of the ilia. There are two positions of origin (i) from the latero-ventral side of the 2nd–5th vertebræ, as in *Rana*, and (ii) from backwardly curving processes from the 4th vertebræ. These processes are derived from the ribs of the tadpole and are found also in *Pipa*[1].

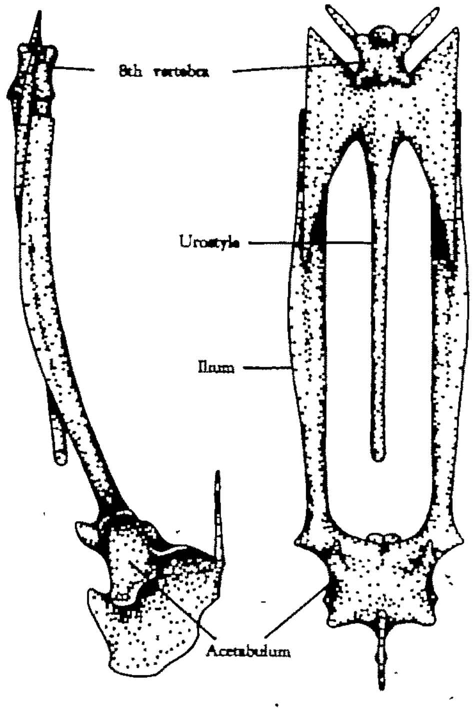


Fig. 1. Girdle and vertebral column to show the sliding articulation. *a*, from the lateral side; *b*, from the dorsal side

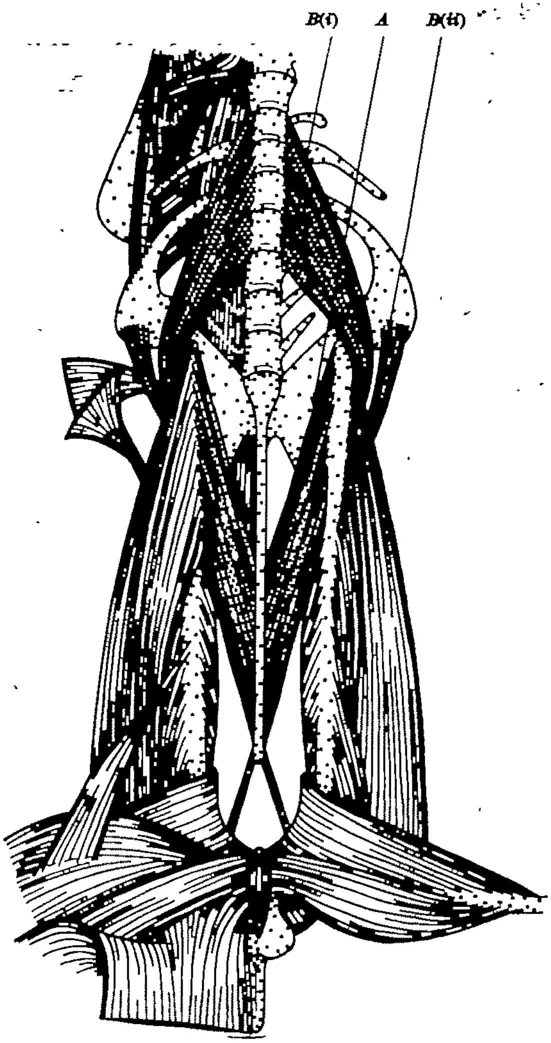


Fig. 2. Girdle and vertebral column from the ventral side with relevant muscles emphasized

In *Xenopus*, the whole propulsive effort in swimming and in burrowing occurs in one plane. The forward thrust of the hind-limbs must be transmitted through the coccygeo-iliac muscles. These muscles, together with their antagonists, will provide an effective shock-absorbing mechanism and assist in drawing the hind-limbs forward into the mud during under-water burrowing.

This work was done in the Department of Zoology of the University of Bristol. I am grateful for valuable assistance from Prof. J. E. Harris and Dr. H. P. Whiting.

MARGARET PALMER

Department of Zoology,
The University,
Bristol, 8.

---

[1] Noble, G. K., "The Biology of the Amphibia" (McGraw-Hill, N.Y. (1931)).

[2] Green, T. L., *Proc. Zool. Soc. Lond.*, 1259 (1931).

[3] Gadow, H., "Amphibia and Reptiles". "The Cambridge Natural History" (1901).

[4] Grobbelaar, C. S., *Z. ges. Anat.* (Abt. 1, *Z. Anat.*), 72, 131 (1924).

[5] Ridewood, W. G., *Anat. Anz.*, 13 (1897).

[6] Nauck, E. T., *Vergl. Anat.* (Bolk *et al.*), 5 (1938).

Use of Collagenase in the Characterization of Pseudocoelomic Membranes of *Ascaris lumbricoides*

THE longitudinal muscle cells of *Ascaris lumbricoides* are enclosed in sheaths that form part of the system of pseudocoelomic membranes covering the internal organs of nematodes. The nature of these membranes is obscure, though Monné[1] demonstrated that they stain like collagen. Collagenous structures previously described in *Ascaris* are the cuticle and the basal lamella of the intestine. The collagenous nature of the former was inferred from the results of X-ray studies[2] and paper chromatographic analysis[3], that of the latter from X-ray studies only[4]. Neither material showed any trace of a banded structure in electron micrographs, nor did X-ray diffraction photographs suggest the presence of long spacings.

As the membranes are difficult to isolate in bulk for physical and chemical analysis, it was decided to test for the presence of collagen by using collagenase. Doubts have been expressed about the specificity of the collagenases present in *Clostridium welchii* and *C. histolyticum* filtrates, but Seifter *et al.*[5] have shown that the purified collagenase of *C. histolyticum* degrades only collagen and gelatin. Robb-Smith[6], working with mammalian tissues, showed the specificity of *C. welchii* collagenase under defined conditions, particularly when antisera are used to neutralize other enzymes present in the filtrate. As *C. histolyticum* collagenase was unobtainable, it was decided to follow the technique of Robb-Smith.

Enzyme tests were carried out using a Wellcome Physiological Research Laboratory *C. welchii* filtrate (*B* 637 *C*) with the following specifications: collagenase, 52 *k* units/mgm. (22 *Q* units/mgm.); lecithinase, 4·3 units/mgm.; protein, N 3·6 per cent; hyaluronidase, 8 units/mgm., and a small quantity of λ, a protease of unspecified concentration. A refined antiserum (*RX* 5755/36) of the following concentrations was also supplied: anti-collagenase, 1·5 units/ml.; anti-lecithinase, 220 units/ml.; anti-hyaluronidase, 650 units/ml.; anti-λ, 6,000 units/ml., which should be sufficient to neutralize the λ in *B* 637 *C*.

A solution containing approximately 1,560 *k* units (660 *Q* units) of collagenase was obtained by adding 30 mgm. of *B* 637 *C* to 1·5 ml. of *RX* 5755/36 in 100 ml. of Palitisch's[7] borate buffer at *p*H 6·8. Material was fixed in Carnoy's fluid, and paraffin sections were cut at 10μ. After the removal of paraffin, and hydration, the slides were incubated at 37° C. either in collagenase solution or in buffer solution as control. At intervals, slides were removed, washed, 'Celloidinized', and stained by the Gomori[8] modification of the Bielschowsky-Maresch silver method for collagen.

After 6 and 10 hr., the material appeared unchanged; but 12 hr. and longer incubation caused digestion not only of the basal lamella of the intestine but also of the sheaths surrounding the muscle cells. After 16 hr. incubation, the cuticle had completely disappeared apart from the external cortical layer. Bird[9] has presented evidence that this layer is a tanned protein, so its resistance is not surprising. Digestion of the basal lamella of the intestine and the internal portion of the cuticle, as well as of the sheaths surrounding the muscle cells, strongly suggests that the sheaths are collagenous.

Studies with the electron microscope are envisaged for the future.

Now that the specificity of the collagenases of clostridial filtrates has been established[5,6], its use could conveniently form a diagnostic test for collagenous materials.

I wish to thank Prof. C. F. A. Pantin for supervising this work and the Wellcome Physiological Research Laboratory for the gift of collagenase and antiserum. The investigation was undertaken during the tenure of an Agricultural Research Council Studentship.

BARBARA DAWSON

Department of Zoology,
University of Cambridge.

[1] Monné, L., *Ark Zool.*, 11, 1 (1957).

[2] Fauré-Fremiet, E., and Garrault, H., *Bull. Biol.*, 78, 206 (1944).

[3] Watson, M. R., and Silvester, N. R., *Biochem. J.*, 71, 578 (1958).

[4] Rudall, K. M., Symp. Soc. Exp. Biol., 9, 49 (1955).

[5] Seifter, S., Gallop, P., Klein, L., and Meilman, E., *J. Biol. Chem.*, 234, 285 (1959).

[6] Robb-Smith, A. H. T., "Nature and Structure of Collagen", edit. by Randall (Butterworths Scientific Publications, London, 1953).

[7] Clark, W. M., "Determination of Hydrogen Ions" (Baillière, Tindall and Cox, London, 1928).

[8] McClung Jones, R., "Handbook of Microscopical Technique" (Hoeber, Inc., New York, 1950).

[9] Bird, A. F., *Exp. Parasit.*, 16, 383 (1957).

Isolation of a Phytoalexin from *Pisum sativum* L.

THE presence of an antifungal 'principle (or principles)' produced by pods of *Phaseolus vulgaris* L. in response to infections with *Sclerotinia fructicola* (Wint.) Rhem. has been demonstrated on the basis of biological assays by Muller[1,2]. We now report the isolation of an antifungal compound produced in similar hypersensitivity studies using pods of *Pisum sativum* L., and describe some of its chemical, physical and biological properties.

The biological conditions provided for the interaction of host and fungus were similar to those reported by Muller[1], namely, the inoculation of the endocarps of detached, opened pods with a fungal spore suspension and the recovery of the drops of liquid ('diffusate') remaining on the tissue after suitable incubation periods. Quantitative bioassays, based on the inhibition of spore-germination in seeded agar blocks, with *S. fructicola* as test organism, were used to determine antifungal activity.

The active material was extracted from the crude diffusate by light petroleum (b.p. 55–60° C.); the residue was not antifungal. When concentrated extracts were fractionated using paper chromatography (solvent *n*-propanol/water, 20 : 80 v/v), the fraction with an R_F 0·6–0·7 contained most of the biological activity. An antifungal compound from this fraction has been obtained since in crystalline form by repeated re-crystallization from light petroleum. It is sparingly soluble in water but is soluble in a wide range of organic solvents. Microanalyses and molecular weight determinations are consistent with the formula $C_{17}H_{14-16}O_6$. Other physical properties include m.p. 61° C.; ultra-violet absorption maxima in water at 307 mμ (log ε 3·85) and 286 mμ (log ε 3·7); molecular optical rotation $[M^{20}_{589\,m\mu}] = 880$ ($c. = 0{\cdot}1$ in ethanol). The substance is stable in alkaline or neutral solution, but in acid solution it loses a molecule of water and becomes optically inactive and almost insoluble in water. The ultra-violet absorption maxima are displaced towards the visible and intensified, $\lambda_{max.}$ 358 mμ (log ε 4·5) and 342 mμ (log ε 4·5), in ethanol. The infra-red spectrum of the new substance confirms the loss of the hydroxyl grouping. The active material is not phenolic, nor does it contain other acidic groups.

We consider that this compound is an example of the biologically active class of compounds defined by Muller[3] as 'phytoalexins'. We propose that the trivial name of this compound should be 'pisatin' after the host plant from which it was originally isolated. *S. fructicola* was the main fungus used in this work; however, the same antifungal compound was identified in the diffusates on pea pods after inoculation with a random selection of both facultative (*Ascochyta pisi* Lib., *Cladosporium* sp., *Phoma lingam* (Tode ex Fr.) Desm., and *Septoria apii* (Briosi and Cav.)) and obligate (*Erisyphe cichoracearum* D.C., *Peronospora tabacina* Adam. and *Uromyces fabae* Pers.) plant pathogens. On our evidence the fungus used, although necessary to promote the formation of the antifungal compound, does not appear to play any specific part in determining the nature of the substance.

The median effective dose (*ED*50) of pisatin required to inhibit *S. fructicola* was around 10^{-4} *M*. The concentration for complete inhibition of this fungus was $2 \cdot 8 \times 10^{-4}$ *M*. Several washings with sterile water of spores, treated with pisatin at $2 \cdot 8 \times 10^{-4}$ *M* for 48 hr., followed by further incubation in water, resulted in part-germination, indicating that the action of pisatin was, however, only fungistatic at this concentration.

Spectroscopic and chromatographic analysis of diffusates from inoculation comparisons using a pathogen (*A. pisi*) and a non-pathogen (*S. fructicola*) of peas showed that pisatin was produced in both cases at similar concentrations. Sensitivity tests of these two fungi towards pisatin *in vitro* showed, however, that a concentration ($2 \cdot 8 \times 10^{-4}$ *M*) of this compound which completely inhibited germination of *S. fructicola* inhibited germination of *A. pisi* by only 25 per cent under the same conditions.

Detached pods have normally been used in our tests; however, pisatin has been detected at a concentration adequate to inhibit completely germination of *S. fructicola* in pods inoculated on growing plants with this fungus. Pisatin has also been detected in pods naturally infected with *A. pisi* under field conditions.

Extracts prepared from *Phaseolus vulgaris* and *Capsicum frutescens* L. under similar inoculation conditions to those described in the earlier sections of this communication show antifungal activity comparable with extracts from *Pisum sativum*, and the effective substances can be extracted into light petroleum. However, the spectrophotometric evidence shows that pisatin is not the antifungal substance in the other host plants. This may indicate a degree of host specificity for this biological class of compounds.

Flor[4] postulated a gene-for-gene relationship in host/pathogen systems. It is suggested that the situation required for a resistant reaction, namely, a host in which infection stimulates the production of a phytoalexin at a concentration above the threshold which inhibits the fungus, is consistent with this hypothesis.

The interest of Dr. W. Bottomley is gratefully acknowledged.

A full account of this work will be published elsewhere.

I. A. M. Cruickshank
Dawn R. Perrin

Division of Plant Industry,
Commonwealth Scientific and Industrial
Research Organization,
Canberra.

[1] Muller, K. O., *Phytopath. Z.*, 27, 237 (1956).
[2] Muller, K. O., *Aust. J. Biol. Sci.*, 11, 275 (1958).
[3] Muller, K. O., *J. Nat. Inst. Bot.*, 6, 346 (1953).
[4] Flor, H. H., *J. Agric. Res.*, 73, 335 (1946).

BACTERIOLOGY

Transformation of Resistance to 8-Azaguanine in *Diplococcus pneumoniae*

Because of the importance of purine analogues in the chemotherapy of human neoplastic disease[1], several investigations have been made on their mode of action and the mechanism of resistance[2] to them in bacterial and animal systems.

We describe here the induction of resistance to 8-azaguanine in *Diplococcus pneumoniae* by means of a transformation mediated by deoxyribonucleate. This suggests that the acquisition of resistance to this antimetabolite, like many other inhibitors, occurs by an alteration of the genetic substance in cells normally sensitive to the drug and provides a means for genetic manipulation, already shown to be unique in its advantages for investigations of gene-controlled resistance mechanisms.

Strains resistant to 8-azaguanine were obtained by isolation of single cells from cultures of a rough variant of *D. pneumoniae* serially transferred in purine-free medium containing increasing concentrations of drug. The growth medium (Table 1) was that of Adams and Roe[3], modified by replacing acid-hydrolysed casein with enzymatically digested casein; adding sodium acetate; decreasing the concentrations of cystine, glutamine, asparagine, choline, calcium chloride, and dipotassium hydrogen phosphate; and omitting tryptophan, adenine, uracil, and potassium chloride. By the addition of small amounts of specific agglutinating rabbit serum, growth, following the dilution of culture material in this medium, occurred in the form of distinct colonies on the bottom of the culture tube. The

Table 1

Component	Amount/lit.	Component	Amount/lit.
Casein hydrolysate*	12·5 gm.	Choline chloride	5·0 mgm.
Sodium acetate	0·75 gm.	Glutamine	100·0 mgm.
Glucose	2·0 gm.	Sodium thioglycollate†	200·0 mgm.
l-Cystine	40·0 mgm.	$FeSO_4.7H_2O$	0·5 mgm.
Biotin	6·0 μgm.	$CuSO_4.5H_2O$	0·5 mgm.
Nicotinic acid	0·6 mgm.	$ZnSO_4.7H_2O$	0·5 mgm.
Pyridoxine hydrochloride	0·6 mgm.	$MnSO_4.4H_2O$	15·0 mgm.
Calcium pantothenate	2·4 mgm.	$MgCl_2.6H_2O$	0·5 gm.
Thiamine hydrochloride	0·6 mgm.	$CaCl_2$	4·0 mgm.
Riboflavin	0·28 mgm.	K_2HPO_4	4·4 gm.
Asparagine	50·0 mgm.	$NaHCO_3$†	20·0 mgm.

pH adjusted to 7·4 prior to sterilization by filtration.
* Enzymatic casein hydrolysate (vitamin-free), General Biochemicals, Inc., Chagrin Falls, Ohio.
† Added immediately prior to inoculation.

Table 2

Deoxyribonucleic acid Source	μgm./ml.	Resistant cells (No./ml. × 10^6) Experiment 1	2	3
Resistant strain [*R6/AZAG*(1)]	0·6	7·0	8·4	4·3
	0·2	3·5		
	0·1	2·5		
	0·04	1·3		
	0·02	0·8		
,, ,, treated with ribonuclease	0·6	6·3	10·8	4·9
,, ,, treated with deoxyribonuclease	0·6	0	0	0
Sensitive strain	2·0	0	0	0
No deoxyribonucleic acid	—	0	0	0

enumeration of colonies in this medium made selective by the addition of drug formed the basis of our quantitative procedure[4].

Deoxyribonucleic acid was prepared from cultures of resistant cells lysed by deoxycholate using the 'Duponol' deproteinization method of Kay *et al.*[5]. After growth of the drug-susceptible parent strain at 37° C. for a period of 2–3 hr. in the casein hydrolysate medium supplemented with 0·16 per cent bovine albumin (Armour fraction V), deoxyribonucleic acid was added and the culture re-incubated for 2 hr. at 37° C. to allow for adequate genetic expression. The results of typical experiments with deoxyribonucleic acid extracted from a strain of *D. pneumoniae* [*R6/AZAG*(1)] resistant to 0·5 μgm./ml. 8-azaguanine (a 100-fold increase in resistance over that exhibited by the parent strain) are shown in Table 2.

The presence of drug-resistant organisms was determined by diluting aliquots of the culture which had been exposed to deoxyribonucleic acid in the purine-free anti-serum medium containing 0·5 μgm./ml. 8-azaguanine. After incubation at 37° C., resistant colonies were observed, with the number depending on the concentration of deoxyribonucleic acid. These colonies were assumed to arise from individual transformants induced by deoxyribonucleic acid, since none was obtained from parallel cultures which were: (*a*) not exposed to deoxyribonucleic acid, (*b*) exposed to deoxyribonucleic acid pretreated with deoxyribonuclease (in 0·002 *M* magnesium chloride), or (*c*) exposed to deoxyribonucleic acid isolated from a parent strain susceptible to 8-azaguanine.

It was later determined that after addition of deoxyribonucleic acid only a brief period of incubation at 37° C. (about 10 min.) was required before the transformed cells could be exposed to selective concentrations of 8-azaguanine. This was not due to a rapid phenotypic expression of the newly transformed character but to the inability of 8-azaguanine to inhibit drug-sensitive cells immediately.

All the transformants obtained with deoxyribonucleic acid extracted from strain *R6/AZAG*(1) displayed a level of resistance equal to that of the original donor strain (first transformation, Table 3). On the other hand, deoxyribonucleic acid from another mutant strain [*R6/AZAG*(2)], resistant to 5·0 μgm./ml. 8-azaguanine, induced more than one class of transformants. Following dilution of cultures exposed to deoxyribonucleic acid in antiserum medium containing varying drug concentrations, the majority of transformants were found to be resistant to either 0·5 or 0·8 μgm./ml. 8-azaguanine, while only a few transformants were resistant to the same level as the original donor strain. In other transformations (second transformation, Table 3), transformants derived from *R6/AZAG*(1) and low-level transformants from *R6/AZAG*(2) all transmitted their markers intact. When high-level transformants from *R6/AZAG*(2) were used as donors of deoxyribonucleic acid, the same three classes of transformants that were derived from the original donor strain were again obtained. Strain *R6/AZAG*(1) appears to bear only a single genetic marker for 8-azaguanine resistance. The results obtained with the other donor strain, *R6/AZAG*(2), indicate a dissemination during transformation of two genetic markers in its deoxyribonucleic acid. The high-resistance level transformants would be expected to occur with lower frequency since the simultaneous addition of both markers to the genome of the recipient cell would be required.

Table 3

Donor Strain	Donor Resistance level (μgm./ml.)	Transformants Resistance level (μgm./ml.) First transformation	Second transformation
R6	0·005	—	—
R6/AZAG(1)	0·5	0·5	0·5
R6/AZAG(2)	5·0	0·5	0·5
		0·8	0·8
		5·0	0·5
			0·8
			5·0

It appears that resistance to 8-azaguanine, in this organism at least, originates by more than one genetic alteration, and that the development of a specific level of resistance to the drug, like resistance to other agents, may occur in increments (stepwise) following the addition by successive mutations of additional genetic markers.

This work was supported by research grant *T*107 from the American Cancer Society, by grant *CY*-3192 from the National Cancer Institute, National Institutes of Health, Public Health Service, and by Contract No. *SA*-43-*ph*-2445 from the Cancer Chemotherapy National Service Center, National Cancer Institute, Public Health Service.

FRANCIS M. SIROTNAK
RAMONA B. LUNT
DORRIS J. HUTCHISON

Division of Experimental Chemotherapy,
Sloan-Kettering Institute for Cancer Research,
Sloan-Kettering Division of Cornell University
Medical College,
New York.

[1] Burchenal, J. H., in "Current Research in Cancer Chemotherapy", Report No. 4, National Cancer Institute (U.S.) (1956).

[2] Mandel, H. G., *Pharmacol. Rev.*, 11, 743 (1959).

[3] Adams, M. H., and Roe, A. S., *J. Bact.*, 49, 401 (1945).

[4] Hotchkiss, R. D., *Proc. U.S. Nat. Acad. Sci.*, 40, 49 (1954).

[5] Kay, E. R. M., Simmons, N. S., and Dounce, A. L., *J. Amer. Chem. Soc.*, 74, 1724 (1952).

Absence of Carbon Monoxide-sensitive Respiration in a Streptomycin-dependent Mutant of *Escherichia coli* grown in Limited Amount of Streptomycin

Miller and Bohnhoff[1] were the first to report the existence of streptomycin-dependent micro-organisms. Since then various species of bacteria have been found to give rise to streptomycin-dependent mutants[2–4].

The problem of streptomycin-dependency has been studied very little and at present is still unsolved.

Schaeffer[5] found a decrease in cytochrome content in a streptomycin-dependent mutant of *Bacillus cereus* when deprived of streptomycin. Since under similar conditions the cytochromes of a streptomycin-dependent mutant of *Escherichia coli* were unaffected, he concluded that although streptomycin may be necessary for the mutant strain of *B. cereus* to synthesize cytochromes, its role in streptomycin-dependent mutants of other species may be of a different nature.

This communication constitutes a preliminary report of our work on electron transport systems of streptomycin-dependent bacteria.

Escherichia coli Sd-4, a streptomycin-dependent mutant, was used. The cells were grown on the surface of Roux bottles in the synthetic medium of Davis[6], supplemented with streptomycin. For optimal and suboptimal growth 100 and 1 μgm. of streptomycin per 1 ml. of medium were added, respectively. For the preparation of non-proliferating suspensions an 18-hr. old culture was employed. Experiments on oxygen uptake were carried out by the conventional method in Warburg apparatus. The filling of vessels with the various carbon monoxide–oxygen mixtures was done by the evacuation method of Umbreit[7].

Our experiments have shown that in the presence of all the substrates tested (glucose, pyruvate, lactate, malate, succinate, α-ketoglutarate, acetate, glutamate and serine) the rate of respiration of the non-proliferating cells grown in sub-optimal amount of streptomycin was markedly lower than that of cells grown under optimal conditions. Experiments on the effect of carbon monoxide on the respiration of the aforementioned cells showed that the bacteria grown in a limited amount of streptomycin, in contrast to those grown under optimal conditions, lacked the carbon monoxide-sensitive pathway of respiration.

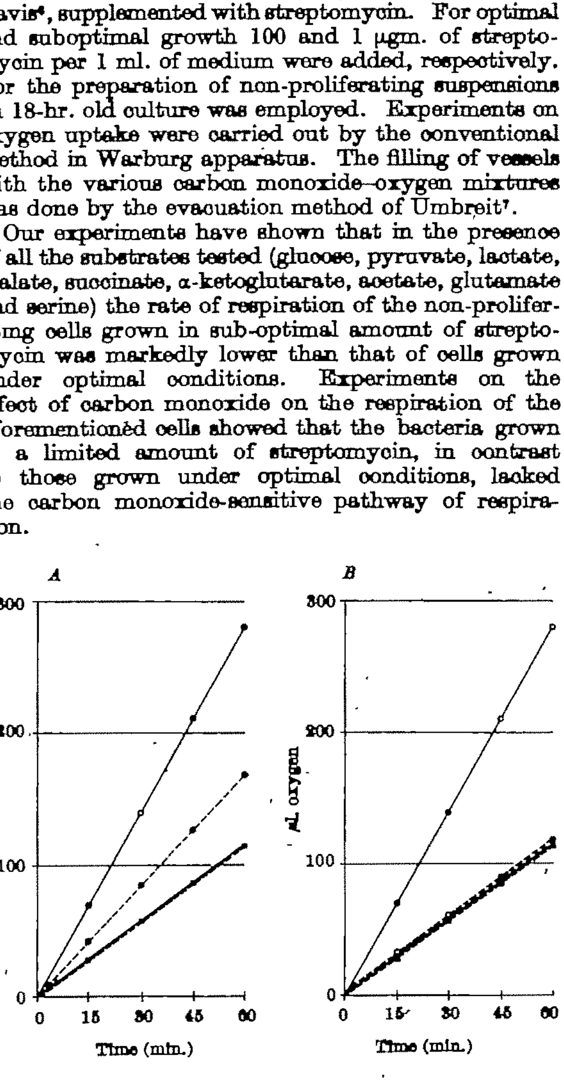


Fig. 1. Effect of carbon monoxide on respiration of non-proliferating cells of a streptomycin-dependent mutant of *E. coli* grown in optimal and suboptimal amounts of streptomycin. Each Warburg flask contained: 0·125 mgm. *N* bacterial suspension, 0·5 ml.; 0·1 *M* phosphate buffer *p*H 7·0, 0·5 ml.; 0·2 *M* sodium lactate, 0·3 ml. (in the side bulb, tipped after 15 min. of equilibration); 15 per cent potassium hydroxide, 0·2 ml. in the centre well; the final volume was 2·2 ml. made up with distilled water. The temperature of the water-bath was 37° C. *A*, Ratio of oxygen : carbon monoxide = 0·1; *B*, ratio of oxygen : carbon monoxide = 0·05, continuous line, controls without carbon monoxide; broken line, with carbon monoxide; ○, cells grown in the presence of 100 μgm. of streptomycin per 1 ml. of medium; ■, cells grown in the presence of 1 μgm. of streptomycin per 1 ml. of medium

A typical experiment on respiration of cells grown in limited and unlimited amount of streptomycin and the effect of carbon monoxide on their oxygen uptake is shown in Fig. 1. It can be seen from the curves in the figure that, in the presence of lactate, the $Q_{O_2}^{N}$ of the optimally grown cells is 2,240 as compared to 920 of the cells grown with limited streptomycin. Carbon monoxide inhibits only the respiration of optimally grown cells, and is completely without effect on the respiration of the suboptimally grown ones. At a ratio of oxygen : carbon monoxide equal to 0·1 the inhibition of the total oxygen uptake by cells grown under optimal conditions is about 40 per cent while the respiration of cells grown in limited amount of streptomycin is unaffected. On lowering the ratio of oxygen : carbon monoxide to 0·05 the inhibition of respiration of the former increases, reaching 60 per cent, whereas the respiration of the latter remains unimpaired. As a result the rate of respiration of both kinds of cells becomes equal.

We may, therefore, conclude that the low rate of respiration displayed by bacteria grown with limited streptomycin is brought about by cytochrome oxidase, being either absent or non-functional.

Full results and discussion of the above findings in relation to streptomycin dependency will be reported at a later date.

We are indebted to Dr. Demerec for his gift of the *E. coli Sd-4* strain. This is a preliminary report on an investigation carried out by one of us (H. E.) in partial fulfilment of the requirements for the Ph.D. degree of the Hebrew University—Hadassah Medical School.

HANNA ENGELBERG
M. ARTMAN

Department of Bacteriology,
Hebrew University—Hadassah Medical School,
Jerusalem.

[1] Miller, P. C., and Bohnhoff, M., *J. Bacteriol.*, 54, 467 (1947).

[2] Paine, T. F., and Finland, M., *J. Bact.*, 56, 207 (1948).

[3] Yegian, D., and Budd, V., *J. Bact.*, 55, 459 (1948).

[4] Olitzki, A. L., and Szenberg, E., *Proc. Soc. Exp. Biol. and Med.* 83, 539 (1953).

[5] Schaeffer, P., *Biochim. Biophys. Acta*, 9, 563 (1952).

[6] Davis, B. D., and Mingioli, E., *J. Bact.*, 60, 17 (1950).

[7] Umbreit, W. W., Burris, R. H., and Stauffer, J. F., "Manometric Techniques", third ed., 70 (Burgess Pub. Co., Minneapolis).

A Bacterial Mutant with Impaired Potassium Transport

THE transport of substances across cell membranes against electrochemical potential gradients is attributed to the operation of energy-dependent pumps in the cell membrane. However, the exact chemical nature of these pumps and their link to metabolic energy sources remain unknown. The purpose of the present communication is to report the isolation of a genetic variant of the bacterium *Escherichia coli* (strain *K*-12) which differs from the original strain (prototroph) with respect to the accumulation and metabolism of intracellular potassium. (Since this communication was submitted, M. Lubin and D. Kessel, *Biochem. and Biophys. Res. Comm.*, 2, 249 (1960), have discussed a similar topic.) Preliminary evidence demonstrates that, whereas the prototroph transports potassium into the cell with a half-time of 3½ min., the potassium mutant transports potassium at a rate so slow as to be scarcely detectable.

The potassium mutant, called Φ_{K}-, was isolated by means of the penicillin method described by Davis[1,2] and Lederberg and Zinder[3], with some modifications similar to those recently described by Gorini and Kaufman[4]. 10 ml. of *E. coli* growing exponentially in a minimal medium containing 1 per cent glucose[5] were exposed to a pre-calibrated dose of ultra-violet radiation calculated to reduce the viable count to approximately 0·1 per cent of the initial population size. Following a 12–24 hr. intermediate cultivation in an enriched medium ('Nutrient Broth', Difco), a 10 ml. sample was centrifuged and the pellet washed three times with cold potassium-free buffer solution (identical with the minimal medium[5] except for a mole for mole substitution of sodium for potassium). Approximately 0·1 ml. of the resuspended pellet was inoculated into 50 ml. of nutrient broth which had been twice passed through an ion exchange resin column ('Dowex 50'). This procedure resulted in the replacement of 99·96 per cent of the potassium initially present with sodium, reducing the concentration of potassium from 24 m*M* to 0·01–0·03 m*M*. The inoculum was then shaken for 6–8 hr. at 37° C. until a stationary phase was reached as was to be expected when intracellular potassium reserves had been depleted. Crystalline sodium penicillin (Nutritional Biochemical) was added to give a final concentration of 10,000 units/ml. In addition, potassium dihydrogen phosphate was added to raise the concentration of potassium in the broth to 1 m*M*. Previous studies had shown that the *E. coli* prototroph will grow normally at this extracellular potassium concentration, accumulating potassium against a more than 100-fold concentration gradient. If a mutant incapable of concentrating potassium were present, it alone should be incapable of growth in this enriched, potassium-poor medium, thus escaping the bactericidal action of penicillin on growing cells. A large volume of broth was used in this step to minimize increase in extracellular potassium following lysis of the potassium-rich cells.

Following 8–10 hr. of incubation at 37° C., the culture was centrifuged. 0·1 ml. of resuspended precipitate was spread on potassium-rich agar plates (broth, potassium > 24 m*M*), which were then incubated at 37° C. When growth had resulted in colonies 1–2 mm. in diameter, replicas were made on potassium-poor plates (broth, potassium < 1 m*M*). A single colony grew on the potassium-rich plate but failed to grow on the potassium-poor plate. The control prototroph grew equally well on both plates. Two repeated platings on potassium-rich and potassium-poor minimal agar plates revealed the same differential growth pattern, ruling out the possibility that the auxotroph required a nutrient which was inadvertently removed by the ion exchange resin.

A series of experiments was then performed to compare the effect of potassium concentration on growth of prototroph and Φ_K- in minimal liquid media containing 1 per cent glucose. Unexpectedly, the growth of Φ_K- now appeared to be independent of external potassium from 0·1 to 10^{-5} *M* ; Φ_K- growth exceeded that of the prototroph below 10^{-3} *M* potassium. This result indicated that the organism originally isolated, Φ_K-, had become adapted to growth in the presence of potassium too low to permit normal growth of the prototroph. Furthermore, determinations of intracellular potassium in both prototroph and Φ_K- grown to the stationary phase in liquid media of varying concentrations of potassium revealed striking differences. As shown in Fig. 1, the prototroph maintained its internal potassium at 115–125 m.equiv./(l. cell water) in a 10^{-5} *M* medium, whereas Φ_K- was characterized by significantly lower intracellular potassium.

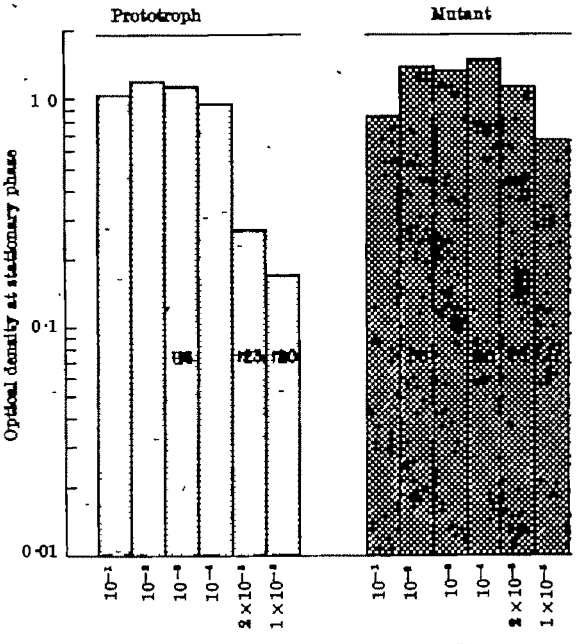


Fig. 1. The relative growth of the *E. coli* prototroph and mutant in media with varying concentrations of potassium as measured by the stationary phase optical density at 550 mμ. The figures in the bars represent the intracellular potassium concentrations in m.equiv./(l. cell water)

Potassium-42 was used to study the potassium fluxes in prototroph and auxotroph suspensions in potassium-poor minimal media. Fig. 2 shows the time-course of disappearance of potassium-42 from the extracellular phase in a suspension of freshly grown cells. Normal cells (1·6 mgm. dry wt./ml. suspension ; medium potassium = 1·25 m*M*) take up potassium-42 avidly, as shown in the lower curve. An initial rapid phase is followed by a slower phase characterized by a half-time of 3¼ min. The points represent experimental results and the curve for the slower phase has been drawn according to two-compartment kinetics with an efflux transfer coefficient of 0·16/min. Since the cells were in the early lag phase, cell growth was negligible during the 12-min. kinetic study, as demonstrated by the observation that the fractional

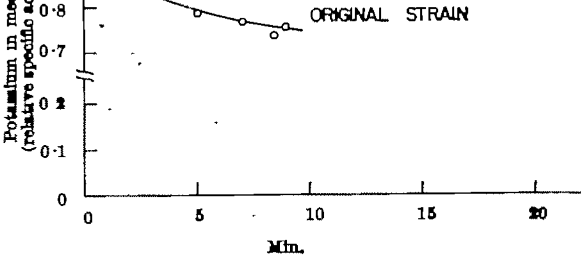


Fig. 2. Potassium-42 influx into the prototroph and mutant. It can be seen that the original strain takes up potassium-42 much more rapidly than the mutant. The points represent experimental data and the curves have been drawn as described in the text

volume of cells in the medium increased less than 5 per cent during this period.

On the other hand, the mutant (2·1 mgm. dry wt./ml. suspension ; medium potassium = 2·5 mM) takes up potassium very slowly. The dashed line in Fig. 2 has been drawn for a linear uptake of 4·5 per cent in 10 min. After 135 min., the specific activity of the auxotroph is 0·3 that of the medium, which is consistent with a slow rate of uptake of potassium-42. Since the mutant was present in a more concentrated suspension and exposed to a higher extracellular potassium concentration than the prototroph, the true difference in their rate of uptake of potassium-42 is probably greater than our present estimate. As our studies indicate that growth of Φ_K- can be maintained in a potassium-poor minimal medium, it may be inferred that the lesion in potassium transport resides either in the transport system or in its energy supply.

In summary, our preliminary studies suggest that the Φ_K- auxotroph we have isolated differs from the prototroph of *Escherichia coli* in two respects. First, its ability to accumulate potassium against a concentration gradient is greatly impaired. Secondly, the auxotroph has the capacity to adjust itself to a potassium-deficient environment. This Φ_K- mutant would appear to offer promise as a tool to investigate both the nature of the potassium transport mechanism and the role of potassium in intracellular metabolism.

This work has been supported in part by the National Science Foundation and by the Atomic Energy Commission.

We are grateful to Dr. B. D. Davis for his discussion in the early phases of the project and his assistance in the development of the technique, and to Mr. A. F. Hurley for his incisive and helpful comments.

STANLEY G. SCHULTZ*
A. K. SOLOMON

Biophysical Laboratory,
Harvard Medical School,
Boston, Massachusetts.
March 22.

* National Research Fellow in Academic Medicine.

[1] Davis, B. D., *J. Amer. Chem. Soc.*, 70, 4267 (1948).
[2] Davis, B. D., *Proc. U.S. Nat. Acad. Sci.*, 35, 1 (1949).
[3] Lederberg, J., and Zinder, N., *J. Amer. Chem. Soc.*, 70, 4267 (1948).
[4] Gorini, L., and Kaufman, H., *Science*, 131, 604 (1960).
[5] Davis, B. D., and Mingioli, E. S., *J. Bacteriol.*, 60, 17 (1950).

GENETICS

Mechanisms of Meiotic Non-disjunction in Man

IT is now well known that there is an abnormal chromosome number in mongolism in chromatin-positive Klinefelter's syndrome, and in chromatin-negative Turner's syndrome. It is also known that mongolism is associated with increased maternal age, and there is some evidence that a similar association exists in chromatin-positive Klinefelter's syndrome[1,2] and in chromatin-negative Turner's syndrome[1]. In cases of chromatin-positive Klinefelter's syndrome previously studied the available data (Table 1) provide supporting evidence that there is an association with, among other possibilities, increased maternal age. Fifty-four cases were classified with respect to position in the sibship. Four were in the centre of the sibship and of the remaining 50 cases, 17 were in the first half and 33 in the second half. This is significantly different from the expected 25 to 25 distribution.

Table 1. POSITION OF PATIENT IN SIBSHIP

		1	2	3	4	5	6	7	8	9	10	11	12	13	
Number in sibship	1	3													3
	2	3	10												13
	3	0	1	8											9
	4	1	2	0	2										5
	5	0	1	0	1	5									7
	6	1	0	1	1	0	1								4
	7	0	0	0	0	0	0	2							2
	8	0	0	0	1	0	0	0	1						2
	9	1	0	0	0	0	0	0	1	0					2
	10	0	0	1	0	0	0	0	0	1	3				5
	11	0	0	0	0	0	0	0	0	0	0	1			1
	12	0	0	0	0	0	0	0	0	0	0	0	0		0
	13	0	1	0	0	0	0	0	0	0	0	0	0	0	1
		9	15	10	5	5	1	2	2	1	3	1	0	0	54

It is generally agreed that meiotic non-disjunction is the most probable cause of these conditions. Further information about the number and origin of X chromosomes can be obtained from colour-blindness studies[3-5]. A colour-blind chromatin-positive case of Klinefelter's syndrome with colour-normal parents could be due to a defect of oogenesis. This was pointed out independently by Stewart[3] and Stern[4]. Stern considers that available data on chromatin-positive Klinefelter's syndrome suggest an abnormality of the first meiotic division but they are, in fact, equally consistent with a defect of the second meiotic division. The expected frequency of colour-blindness following a second meiotic abnormality which he quotes (8 per cent) is correct for a locus close to the centromere but he does not consider the expected frequency for a locus sufficiently far from the centromere to give random segregation. The frequency of females homozygous for colour-blindness is 0·5 per cent. All XX eggs from such individuals will be homozygous recessive for colour-blindness. The frequency of females heterozygous for colour-blindness is 15 per cent and with random segregation one-sixth of their secondary oocytes will carry the gene for colour-blindness on both chromatids. Non-disjunction at the second meiotic division gives exceptional XX eggs and 2·5 per cent of these will be homozygous recessive (one-sixth × 15 per cent). The expected frequency of colour-blindness in exceptional individuals due to a second meiotic abnormality is therefore 3 per cent (2·5 per cent from heterozygous mothers and 0·5 per cent from homozygous mothers). Thus the expected limits of colour-blindness incidence in exceptional individuals following an abnormality of the second meiotic division of oogenesis are 3–8 per cent. Collection of further data may provide information about the position of the colour-blindness locus relative to the centromere, about the relative frequency of non-disjunction in oogenesis and spermatogenesis and about the state of meiosis at which non-disjunction occurs[5].

There is good evidence that some cases of chromatin-negative Turner's syndrome are due to a defect of spermatogenesis and that some cases of chromatin-positive Klinefelter's syndrome are due to a defect of oogenesis ; and the opposite situations probably occur[5]. A defect of oogenesis may be assumed if a colour-normal case of chromatin-negative Turner's syndrome is found with a colour-blind mother and a colour-normal father, and a defect of spermatogenesis would be indicated by a colour-normal case of chromatin-positive Klinefelter's syndrome with a colour-blind mother and a colour-normal father[6]. Defects of spermatogenesis in the chromosomal intersexes may be related to the unequal size of the X and Y chromosomes with consequent failure of pairing leading to non-disjunction during meiosis. In oogenesis all chromosomes are paired, but a similar causal mechanism might operate for a chromosomal aberration such as inversion could lead to failure of pairing and non-disjunction. A chromosomal aberration of this sort might be inherited or it might be caused by environmental influences. A possible clue to the mechanism is provided in the reports that mongolism is associated with increased maternal age but not with increased paternal age[1], and that there is little increase in the number of female germ cells after birth[7]. Environmental influences, including temperature, hormones and those such as radiation which cause genetic change, may predispose to defects of oogenesis but not to defects of spermatogenesis if old women have old eggs but old men have young sperm.

JOHN S. S. STEWART

Department of Surgery,
Queen's College,
Dundee.

[1] Penrose, L. S., Symposium (in the press) (abstract, *Lancet*, ii, 448 (1959)).

[2] Lenz, W., Nowackowski, H., Prader, A., and Schirren, C., *Swiss med. Wsch.*, 89, 727 (1959).

[3] Stewart, J. S. S., *Lancet*, ii, 833 (1959).

[4] Stewart, J. S. S., *Proc. Roy. Soc. Med.*, 52, 817 (1959) (abstract, *J. Endocrinol.*, 18, 29 (1959)).

[5] Stewart, J. S. S., Symposium (in the press) (abstract, *Lancet*, ii, 448 (1959)).

[6] Stern, C., *Nature*, 183, 1452 (1959).

[7] Zukerman, S., Ciba Colloquium on Ageing, 2, 31 (1956).

IT is useful at this stage of human cytogenetics to keep in mind the whole spectrum of possibilities of chromosomal behaviour. In this sense Dr. Stewart's emphasis on the possibility of non-disjunction during the second meiotic division is valuable. His discussion rests on the assumption that non-disjunction is preceded by crossing-over between homologous chromosomes. In my discussion of second division non-disjunction I had specified absence of crossing-over (and, thus, made no assumption as to closeness of the locus for colour blindness to the kinetochore). According to Dr. Stewart's scheme it would follow that genes distantly located would less often become homozygous than proximal genes. This is the opposite to what is well established in *Drosophila*, although it cannot be excluded, of course, that human chromosomes may behave differently. In *Drosophila* the more frequent homozygosis for distal than proximal genes signifies that non-disjunction preceded by crossing-over occurs during the first meiotic division.

Apart from the question whether non-disjunction occurs during the first or second meiotic division, Ford's suggestion that it may also occur in early cleavage cannot be dismissed[1]. This suggestion accounts for homozygosis of the locus for colour-blindness by mitotic non-disjunction without reference to crossing-over or of gene location.

I wish to add two minor points in reference to my earlier communication: (1) The statement about a 'maximum' of recessive homozygosis of 16·7 per cent was in error; instead this frequency follows from random assortment. (2) The choice of 0·5 per cent as the incidence of colour-blind women was made for the sake of a round number; 0·45 or 0·4 per cent are more accurate values.

CURT STERN

Department of Zoology,
University of California,
Berkeley 4, California.

[1] Ford, C. A., *Amer. J. Hum. Genet.*, 12, 104 (1960).

Effect of Variations in Temperature on Meiosis in *Gagea reticulata* Schultes

PREVIOUS cytological investigations on the genus *Gagea* have been confined to eight species[1]. Recently, Malik and Sehgal[2] contributed to the cytology of one more species, *Gagea reticulata* Schultes. The haploid chromosome number determined was twelve. The meiotic behaviour of chromosomes, as seen from the dividing pollen mother cells, was regular in plants growing in their normal season (February). The pairing of the chromosomes was perfectly normal, followed by regular anaphasic separations, and resulted in a high degree of fertility.

A few plants of *G. reticulata* were collected from the same locality growing late in the season (May). A number of meiotic irregularities were recorded in these individuals. These comprised non-pairing of chromosomes, early disjunction, the presence of bridges and laggards with unequal distribution of chromosomes at anaphases. As a result of all these irregularities, quantitatively equal or unequal tetrads, pentads and even configurations above this level were formed. Pollen-grains thus formed were extremely variable in size.

These meiotic irregularities could not be due to the fixative, for in both cases this was kept constant.

Several workers have artificially induced many meiotic abnormalities such as desynapsis, stickiness, laggardism and formation of diploid spores. Sax[3] has described such meiotic aberrations after subjection to various temperatures in *Tradescantia paludosa*. Similar effects of temperature on pollen formation and meiosis in *Hieracium robustum* have been reported by Gustafsson and Nygren[4]. Such chromosomal irregularities are also reported to be caused by various environmental conditions. Matsuura and Haga[5] reported that normal meiosis occurred in *Trillium kamtschaticum* during winter. When these plants were grown in warmer temperatures, they showed a breakdown in meiosis. The course of meiosis was normal in buds of *G. reticulata* plants collected in February. The abnormalities described above were from plants collected in May and apparently due to the reaction of the plant to its environmental factors. Since these aberrations were observed in the hot months of May, it is reasonable to assume that the extreme heat could be responsible for the disturbances in meiosis. In this connexion, it is pertinent to compare the average maximum temperature in these months in the same locality, which during February was 18° C. and in May 38° C. It is tempting to suggest that the course of meiosis in flowers of plants in May was modified by high temperature to which the plant is ordinarily not adapted; and ever since the observations of Malik and Tandon[6,7] on *Asparagus curillus* Ham. and *Suaeda fruticosa* Forsk., it has become increasingly clear that there is a correlation between temperature and meiotic course. Khoshoo[8] has also reported a similar situation in *Sisymbrium irio*, in which meiotic disturbances were caused by summer heat.

A detailed account of these investigations will be published elsewhere.

I am indebted to the principal of this College, Dr. A. N. Banerji, for providing the necessary facilities in connexion with the present investigations.

C. P. MALIK

Department of Botany,
Deshbandhu College,
University of Delhi,
New Delhi 19.

---

[1] Darlington, C. D., and Wylie, A. P., "Chromosome Atlas of Flowering Plants" (George Allen and Unwin, Ltd., London, 1955).
[2] Malik, C. P., and Sehgal, S. M., *J. Sci. Indust. Res.*, 18, c, 155 (1959).
[3] Sax, Karl, *Amer. J. Bot.*, 24, 218 (1937).
[4] Gustafsson, A., and Nygren, A., *Hereditas*, 32, 1 (1946).
[5] Matsuura, H., and Haga, T., *Cytologia*, 10, 382 (1940).
[6] Malik, C. P., and Tandon, S. L., *Ind. J. Hort.*, 16, 39 (1959).
[7] Malik, C. P., and Tandon, S. L., *J. Sci. Indust. Res.*, 18, c, 233 (1959).
[8] Khoshoo, T. N., *Caryologia*, 11, 297 (1959).

Race Differences in the Ability to excrete Beetroot Pigment (Betanin)

IT has been suggested that lack of betanin excretion in urine is a hereditary trait in man[1]. This could result from an inborn incapacity to metabolize the pigment. This communication reports a study of the frequencies of betanin excretors among different racial groups. Classification of the excretors necessitated taking into account the time-range necessary for excretion, the amount of beetroot eaten and the *p*H of the urine. The effect of these variables on the validity of the test was determined before establishing the following procedure. 100–150 gm. of cooked beetroot was given to each individual examined. Two test-tube samples were taken, one before and the other 5 hr. after the beetroot was eaten. The classification of the individuals as excretors and non-excretors was based on visual comparison of the colour of the two urine samples. When any reddish tint could be observed in the second sample relative to the first the subject was recorded as 'excretor', and if otherwise, 'non-excretor'. It should be noted that a great deal of variation was observed in the intensity of the red tint in the urine of the excretors.

As betanin is a *p*H indicator, the possibility that a high *p*H in the urine could suppress the appearance of the colour was checked. It was found that lowering the *p*H near 5 in the urine of the 'non-excretor' group failed to reveal any reddish tint. On the other hand, an increase of *p*H to 8 in the 'excretor' group was needed to make the tint fade. Since human urine has a *p*H varying between 4·8 and 8·2 (average, 6) it can be concluded that the *p*H value of the urine does not appreciably affect the results.

It was observed that betanin elimination by the adult excretors occurs 4–11 hr. after eating beetroot, the most intense concentration of the pigment in urine being about 5–6 hr. after ingestion. Among children 8–14 years old, the corresponding time is 3–4 hr.

A group of 338 individuals from São Paulo was examined in State schools for resident pupils, where the tests could be controlled. The investigation includes 181 Japanese of age-range between 7 and 24 years, 50 Negroes 'pure' and 'mixed' of age-range between 20 and 46 years and 107 Whites of age-range between 13 and 53 years. The frequencies of excretors in the three samples are given in Table 1.

Table 1

Sample	Mean age	No. of individuals examined	Excretors No.	Excretors Per cent
Japanese	14·6	181	80	44·2
Negro	31·9	50	16	32·0
White	23·0	107	33	30·8
Total	19·4	338	129	38·2

Heterogeneity, $\chi^2_{(2)} = 6{\cdot}13$, $P < 0{\cdot}05$.

It should be noted that the frequencies of excretors among two different samples of Japanese taken at random were 47·6 per cent ($n = 103$) and 45·3 per cent ($n = 64$). The frequency of excretors among Whites from São Paulo, who came from different European immigrant groups, is higher than that observed for the English group (10 per cent)[1]. This fact is likely to be caused by the heterogeneous origin of our White sample (mainly of Italian and Portuguese derivation) and/or by differences in technique. The difference in frequencies of excretors between the White and the Negro samples ($\chi^2_{(1)} = 0{\cdot}02$, $P > 0{\cdot}90$), or between the Negro and the Japanese samples ($\chi^2_{(1)} = 2{\cdot}40$, $P = 0{\cdot}12$) is not significant. However, the difference in frequencies of excretors between the White and the Japanese samples ($\chi^2_{(1)} = 5{\cdot}03$, $P = 0{\cdot}025$) is significant. The overall frequencies of excretors among male (41·1 per cent) and female (36·1 per cent) individuals are not significantly different ($\chi^2_{(1)} = 0{\cdot}52$, $P = 0{\cdot}53$). A group of 40 individuals of the Japanese sample has been investigated previously for taste thresholds for phenylthiourea[2], but the two traits showed no association ($\chi^2_{(1)} = 2{\cdot}43$, $P = 0{\cdot}12$).

The samples from the three ethnic groups investigated have different average ages. If betanin excretion changes with the age of the individual, this perhaps could explain the differences found. However, classifying the individuals according to the overall mean age (about 20 yr.) the results given in Table 2 were obtained.

Table 2

Sample	Age group	No. of individuals	Excretors (per cent)
Japanese	below 20 yr.	158	44·3
	20 yr. and over	23	43·5
White	below 20 yr.	34	26·5
	20 yr. and over	73	32·9

Hence, it can be seen that age variation cannot account for the differences found. Therefore, our results suggest marked differences in the frequency of betanin excretors among racial groups. Studies of this trait in other populations should be of interest.

P. H. SALDANHA
L. E. MAGALHÃES
WANDA A. HORTA

Laboratório de Genética Humana,
Faculdade de Medicina,
and
Departamento de Biologia Geral,
Universidade de São Paulo,
Brazil.

---

[1] Allison, A. C., and McWhirter, K. G., *Nature*, 178, 748 (1956).
[2] Saldanha, P. H., *Ann. Hum. Genet.*, 22, 380 (1958).

FORTHCOMING EVENTS

Wednesday, August 31—Wednesday, September 7

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at Cardiff)—122nd Annual Meeting.

Wednesday, August 31

At 8 p.m.—Sir George Thompson, F.R.S: "The Two Aspects of Science" (Presidential Address).

Thursday, September 1

At 10 a.m.—Dr. James Taylor: "Chemistry is Not Enough, or the Increasing Scope of Scientists' Work in Industry" (Presidential Address, Section B).

At 10 a.m.—Dr. G. S. Carter: "Tropical Climates and Biology" (Presidential Address, Section D).

At 10 a.m.—Sir Alfred Pugsley, F.R.S.: "Statics and the Engineer" (Presidential Address, Section G).

At 10 a.m.—Prof. E. Estyn Evans: "The Peasant and the Past" (Presidential Address, Section H).

At 10 a.m.—Prof. T. M. Harris, F.R.S.: "The Origin of Angiosperms" (Presidential Address, Section K).

At 10 a.m.—Dr. William Davies: "Pastoral Systems in Relation to World Food Supplies" (Presidential Address, Section M).

At 11.15 a.m.—Mr. T. B. Peace: "The Dangerous Concept of the Natural Forest" (Chairman's Address, Section K*).

At 2.15 p.m.—Mr. A. B. Oldfield-Davies: "Science Broadcasting in Sound and Television" (Presidential Address, Section X).

Friday, September 2

At 10 a.m.—Dr. R. van der Riet Woolley, F.R.S.: "Stellar Motions" (Presidential Address, Section A).

At 10 a.m.—Prof. E. G. Bowen: "Welsh Emigration Overseas" (Presidential Address, Section E).

At 10 a.m.—Prof. R. S. Sayers: "Monetary Thought and Monetary Policy in Great Britain" (Presidential Address, Section F).

At 10 a.m.—Prof. William Burns: "The Physiology of Hearing" (Presidential Address, Section I).

At 10 a.m.—Prof. H. C. Dent: "Sixty Years of Progress in English Education" (Presidential Address, Section L).

At 11.30 a.m.—Prof. R. C. Oldfield: "Experiment in Psychology—a Centenary and an Outlook" (Presidential Address, Section J.)

At 11.30 a.m.—Dr. Michael P. Reece: "The Physical Principles of Switches and Circuit-Breakers" (Kelvin Lecture).

At 11.30 a.m.—Mr. W. M. Williams: "The Social Study of Family Farming" (Lister Lecture).

At 8 p.m.—Prof. H. Bondi, F.R.S.: "The Structure of the Universe" (Evening Discourse).

Sunday, September 4

At 11 a.m.—Service at Llandaff Cathedral. Preacher: The Bishop of Llandaff.

Monday, September 5

At 10 a.m.—Symposium on "World Food and Population". Chairmen: Sir George Thomson, F.R.S., and Sir James Gray, F.R.S. Principal Speakers: Dr. N. C. Wright, Prof. D. V. Glass, Prof. W. A. Lewis, Dr. L. Dudley Stamp, Sir Alexander Fleck, F.R.S., Dr. H. D. Kay, F.R.S., Prof. P. M. S. Blackett, F.R.S.

At 8 p.m.—Dr. E. B. Chain, F.R.S.: "Microbiological Methods in the Development of Drugs" (Evening Discourse).

Tuesday, September 6

At 10 a.m.—Mr. G. F. Mitchell: "Pleistocene History of the Irish Sea" (Presidential Address, Section C).

At 10 a.m.—Prof. D. V. Glass: "Population Growth, Fertility and Problems of Policy" (Presidential Address, Section N).

Wednesday, September 7

At 10 a.m.—Mr. Martin J. Wells: "What the Octopus Makes of it: Our World from Another Point of View" (Darwin Lecture).

Thursday, September 1

BRITISH INTERPLANETARY SOCIETY, and the SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 10.30 a.m.—Joint Symposium on "Rocket and Satellite Instrumentation".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

BIOLOGIST (with research experience, and preferably with Ph.D. qualification) IN THE DEPARTMENT OF ZOOLOGY, to head a small research team investigating tank culture of bivalves and marine phytoplankton—The Secretary and Registrar, The University, Southampton (August 31).

RESEARCH ASSISTANTS (3) (with, or candidates for, B.Sc. special chemistry or B.Pharm. degree of the University of London). Two posts in the CHEMISTRY DEPARTMENT, for projects in the fields of organic and physical chemistry, and one in the PHARMACY DEPARTMENT, for a project in any branch of pharmacy approved by the Head of the Department—The Registrar, Brighton Technical College, Brighton (September 3).

TEMPORARY TUTOR IN PHILOSOPHY—The Registrar, University College, Singleton Park, Swansea (September 3).

LECTURER (with a good honours degree and preferably teaching experience) IN MATHEMATICS at the Nigerian College of Arts, Science and Technology, Enugu—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (September 5).

SENIOR LECTURER IN MECHANICAL ENGINEERING at the Jamaica College of Arts, Science and Technology, Kingston—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (September 6).

SCIENTIFIC OFFICER, for research on environmental physiology of the pig—The Secretary, Institute of Animal Physiology, Babraham, Cambridge (September 9).

LECTURER or ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Sheffield (September 10).

TUTORIAL STUDENT (graduate, or about to graduate) IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, King's College (University of London), Strand, London, W.C.2 (September 10).

ASSISTANT (with a degree in science, preferably honours) IN THE CHEMISTRY DEPARTMENT, West of Scotland Agricultural College, Auchincruive, Ayr, for work relating to the spectrographic analysis of agricultural materials—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (September 14).

LECTURER (engineer or physicist with special qualifications to teach one or more branches of electronic engineering, and a good honours degree followed by at least three years research or industrial experience) IN THE DEPARTMENT OF ENGINEERING—The Secretary, The University, Edinburgh (September 17).

LECTURER (medical or honours science graduate) IN THE DEPARTMENT OF BACTERIOLOGY—The Secretary, The University, Edinburgh (September 17).

CHAIR OF PSYCHOLOGY in the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, September 30).

LECTURER/ASSISTANT LECTURER (preferably with a good honours degree with suitable research and teaching experience, together with a good knowledge of both plant and animal biochemistry, with specialist qualifications in either) TO TEACH AGRICULTURAL BIOCHEMISTRY at the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Kuala Lumpur and London, September 30).

LECTURER IN ANATOMY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 30).

LECTURER or ASSISTANT LECTURER (preferably with a special knowledge and research experience in cytology or genetics) IN BOTANY at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 30).

LECTURER (preferably with qualifications in one or more of the following fields: climatology, geomorphology, biogeography, or the regional geography of North America) IN GEOGRAPHY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or The Registrar, University of Otago (New Zealand and London, September 30).

LECTURER (with particular interest in the Iron Age of Africa) IN ARCHAEOLOGY at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 30).

LECTURER (with postgraduate qualifications and research or clinical experience, in addition to competence in general psychology, and preferably special qualifications in psychological measurement and the assessment of personality) IN PSYCHOLOGY at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, September 30).

SENIOR LECTURER IN SOIL SCIENCE in the Institute of Agriculture, University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 30).

SENIOR LECTURER IN PREHISTORY IN THE DEPARTMENT OF ANTHROPOLOGY, University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, September 30).

SENIOR LECTURER IN SOIL SCIENCE in the Institute of Agriculture, University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 30).

READER IN PHYSICS at St. Bartholomew's Hospital Medical College—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 3).

LECTURER or SENIOR LECTURER (with a degree in pure science and/or in agriculture, preferably with postgraduate experience in genetics) IN GENETICS at Canterbury Agricultural College, University of New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, October 15).

AGRICULTURAL CHEMIST (with a good honours degree in agricultural chemistry or chemistry, and at least two years postgraduate research experience in agricultural chemistry) in Kenya, to take charge of research projects into soil and plant nutrition problems of coffee—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/7/050/T.

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree in physics or physical chemistry or H.N.C. or equivalent qualifications), to participate on both experimental work and the design of experimental apparatus—The Secretary, Low Temperature Research Station, Agricultural Research Council, Downing Street, Cambridge.

ASSISTANT LECTURER (Grade B) IN MATHEMATICS—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3.

ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Nottingham.

ASSISTANT PROFESSOR or ASSOCIATE PROFESSOR (PHYSIOLOGIST, with an M.D. or Ph.D. degree, and capable of independent research) IN THE DEPARTMENT OF PHYSIOLOGY—Prof. M. Beznak, Department of Physiology, University of Ottawa, Ottawa, Canada.

CHAIR OF MECHANICAL ENGINEERING in the Faculty of Engineering of University College, Ibadan, Nigerian College of Arts, Science and Technology—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

CHEMIST (with a good honours degree in chemistry or equivalent professional qualification, and preferably specialization or experience in public analyst work) IN THE GOVERNMENT CHEMISTS DEPARTMENT, Government of Tanganyika, for general analytical work in the fields of toxicology, food and drugs, and water; and the supervision of assistants—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.117/8/037.

DEPUTY DIRECTOR (with an honours degree in natural science, together with considerable postgraduate research experience, preferably not less than 10 years) OF AGRICULTURAL RESEARCH, Moor Plantation, Ibadan, Nigeria, to assist the Director of Agricultural Research in administrative duties—The Appointments Secretary, Federal Public Service Commission, Nigeria House, 9 Northumberland Avenue, London, W.C.2, quoting B.14/1.

HISTOLOGICAL SENIOR TECHNICIAN or TECHNICIAN IN THE DERMATOLOGICAL DEPARTMENT, mainly for research—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

LECTURER or JUNIOR LECTURER IN THE DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY—The Secretary, The Medical College of St. Bartholomew's Hospital, West Smithfield, London, E.C.1.

LECTURER (preferably with a knowledge of heat transfer and its application to the design and operation of furnaces, etc., or practical experience of fuel using plant generally) IN FUEL TECHNOLOGY IN THE DEPARTMENT OF FUEL SCIENCE of the Houldsworth School of Applied Science—The Registrar, The University, Leeds 2.

PEST CONTROL OFFICER (preferably with a degree in general science and considerable practical experience in the control and elimination of insect pests and diseases of groundnuts) in Gambia, to eliminate or control insect pests and diseases affecting groundnuts and to enforce the Pest Control Legislation—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/12/09/T.

PHYSICIST (Basic grade), for work which will include problems of dosimetry of a new type linear accelerator as well as the existing cobalt unit and conventional X-ray apparatus—The Superintendent, Guy's Hospital, London, S.E.1.

POSTGRADUATE STUDENTS IN (1) MOLECULAR QUANTUM MECHANICS, and (2) ORGANIC NATURAL PRODUCTS, IN THE DEPARTMENT OF CHEMISTRY, for work leading to M.Sc. or Ph.D. degrees—Head, Chemistry Department, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

RESEARCH ASSISTANT or TECHNICIAN (preferably with some experience of photography and/or workshop practice) IN THE PHYSICS DEPARTMENT, to help with experimental work on the strength of glass—The Professor of Physics, University College of North Staffordshire, Keele, Staffs.

REXCO RESEARCH AND DEVELOPMENT COMPANY RESEARCH STUDENTS (with, or anticipating to have, a good honours degree in chemistry, Grad.R.I.C., or a Dip.Tech. in pure or applied chemistry) IN THE DEPARTMENT OF PURE AND APPLIED CHEMISTRY, for the study of products from the low temperature carbonization of coal—Head of the Department of Applied Chemistry, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

SCIENTIFIC OFFICER (with an honours degree in physics or physical chemistry) IN THE BIOPHYSICS SECTION, to undertake investigation of virus and antibody systems by such methods as electron-microscopy, analytical ultracentrifugation and optical analysis generally—The Secretary, Research Institute (Animal Virus Diseases), Pirbright, Surrey.

SCIENTIFIC OFFICER WITH THE DAIRY MARKETING BOARD of Southern Rhodesia, to set up and operate a central laboratory in Salisbury for the qualitative control of the Board's products, assume responsibility for laboratory control at the Board's factories, and to investigate the development of new milk products—The Secretary, Dairy Marketing Board of Southern Rhodesia, P.O. Box 587, Salisbury, Southern Rhodesia.

STUDENT TECHNICIAN (well-educated girl approximately 18 years) to assist in clinical research investigations on chests in the Surgical Unit—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

STUDENT (with good honours in a first degree in physics) IN THE DEPARTMENT OF PHYSICS, for research on the thermionic and related aspects of the direct conversion of thermal to electrical energy—The Professor of Physics, The University, Southampton.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Council for the Preservation of Rural England: Sheffield and Peak District Branch. Annual Report, May 1960. Pp. 30. (Sheffield: Council for the Preservation of Rural England, Sheffield and Peak District Branch, 1960.) [156

British Broadcasting Corporation. B.B.C. Engineering Monograph No. 30: Film Processing and After-Processing Treatment of 16-mm Films. By L. J. Wheeler. Part 1: Film-Processing Equipment in the B.B.C. Television News Service. Part 2: After-Processing Treatment of 16-mm Films. Pp. 19. (London: British Broadcasting Corporation, 1960.) 5s. [156

Central Advisory Water Committee. Sub-Committee on the Growing Demand for Water—Second Report. Pp. 5. (London: H.M. Stationery Office, 1960.) 6d. net. [206

Colonial Development Corporation. Annual Report and Statement of Accounts for year to 31.12.59. Pp. v+77. (London: H.M. Stationery Office, 1960.) 5s. net. [206

Other Countries

Ministerio de Agricultura, Bogota, D.E.-Colombia. Departamento de Investigacion Agropecuaria. Boletin de Divulgacion No. 8: Diacol Nima Variedad Mejorada de Frijol. Por C. Cardona, L. H. Camacho y S. H. Orozco. Pp. 24. (Bogota: Ministerio de Agricultura, 1959.) [36

Columbia Encyclopedia. 1959 Supplement: Record of Events. Pp. 32. (New York: Columbia University Press; London: Oxford University Press, 1960.) 16s. net. [36

Bulletin of the American Museum of Natural History. Vol. 119, Article 3: Studies on Amphisbaenids (Amphisbaenia, Reptilia). 1: A Taxonomic Revision of the Trogonophinae and a Functional Interpretation of the Amphisbaenid Adaptive Pattern. By Carl Gans. Pp. 129–204+plate 45. (New York: American Museum of Natural History, 1960.) 1.50 dollars. [36

Deutscher Wetterdienst. Deutsches Meteorologisches Jahrbuch, Gebiet der ehem. Französischen Besatzungszone, 1945–1952. Pp. xii+182. (Offenbach a.M.: Selbstverlag des Deutschen Wetterdienstes, 1960.) [36

United States Department of the Interior: Geological Survey. Bulletin 1061-F: Glacial Geology of the Mystic Lakes-Fresh Pond Area, Massachusetts. By Newton E. Chute. Pp. iii+187–216+plates 14–17. Bulletin 1072-O: Geology and Oil-Shale Resources of Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah. By W. B. Cashion. Pp. iv+793+plates 54–57. 1 dollar. Bulletin 1074-F: Geology and Uranium Occurrences in the Miller Hill Area, Carbon County, Wyoming. By James D. Vine and George E. Prichard. Pp. iv+239+plates 14–20. (Washington, D.C.: Government Printing Office, 1959.) [36

United States Department of the Interior: Geological Survey. Water-Supply Paper 1450: Quality of Surface Waters of the United States, 1956. Parts 1–4: North Atlantic Slope Basins to St. Lawrence River Basin. Prepared under the direction of S. K. Love. Pp. xv+603. Water-Supply Paper 1452: Quality of Surface Waters of the United States, 1956. Parts 7 and 8: Lower Mississippi River Basin and Western Gulf of Mexico Basins. Prepared under the direction of S. K. Love. Pp. xi+469. 1.50 dollars. Water-Supply Paper 1459-B: Restraints on Dissolved Ferrous Iron Imposed by Bicarbonate Redox Potential, and pH. By J. D. Hem. Pp. iii+33–55. 15 cents. Water-Supply Paper 1479: Geohydrologic Evaluation of Streamflow Records in the Big Wood River Basin, Idaho. By Rex O. Smith. Pp. v+68+2 plates. Water-Supply Paper 1481: Geology and Ground-Water Resources of the Winter Garden District, Texas, 1948. By Samuel F. Turner, Thomas W. Robinson, and Walter N. White. Pp. v+247+4 plates. Water-Supply Paper 1554: Surface Water Supply of the United States, 1958. Part 2-B: South Atlantic Slope and Eastern Gulf of Mexico Basins, Ogeechee River to Pearl River. Prepared under the direction of J. V. B. Wells. Pp. x+443. Water-Supply Paper 1560: Surface Water Supply of the United States, 1958. Part 6-B: Missouri River Basin below Sioux City, Iowa. Prepared under the direction of J. V. B. Wells. Pp. xi+504. (Washington, D.C.: Government Printing Office, 1960.) 2.75 dollars. [36

United States Department of the Interior: Geological Survey. Water-Supply Paper 1561: Surface Water Supply of the United States, 1958. Part 7: Lower Mississippi River Basin. Prepared under the direction of J. V. B. Wells. Pp. xi+553. 1.75 dollars. Water-Supply Paper 1562: Surface Water Supply of the United States, 1958. Part 8: Western Gulf of Mexico Basins. Prepared under the direction of J. V. B. Wells. Pp. x+472. 1.50 dollars. Water-Supply Paper 1563: Surface Water Supply of the United States, 1958. Part 9: Colorado River Basin. Prepared under the direction of J. V. B. Wells. Pp. xi+505. (Washington, D.C.: Government Printing Office, 1960.) [36

United States Department of the Interior: Geological Survey. Professional Paper 294-M: Foraminifera of the Monterey Shale and Puente Formation, Santa Ana Mountains and San Juan Capistrano Area, California. By Patsy Beckstead Smith. Pp. iii+463–495+plates 57–59. 40 cents. Professional Paper 332: Cretaceous and Tertiary Formations of the Book Cliffs, Carbon, Emery, and Grand Counties, Utah, and Garfield and Mesa Counties, Colorado. By D. Jerome Fisher, Charles E. Erdmann and John B. Reeside, Jr. Pp. iv+80+12 plates. Professional Paper 334-D: Late Paleozoic Gastropoda from Northern Alaska. By Ellis L. Yochelson and J. Thomas Dutro, Jr. Pp. iii+111–147+plates 12–14. 50 cents. Professional Paper 356-A: Oil Yield and Uranium Content of Black Shales. By Vernon E. Swanson. Pp. iii+44. 30 cents. (Washington, D.C.: Government Printing Office, 1960.) [36

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/-, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

UNDERSTANDING AND POWER

THE two aspects of science which Sir George Thomson discusses in his presidential address to the British Association for the Advancement of Science (see p. 837 of this issue) are its contribution to man's control over Nature and its contribution to our understanding of the nature of things. At the outset, Sir George firmly repudiates the idea that the contribution which science makes to our mastery of the world in which we live is the sole or even a sufficient justification for science. Without, however, examining science as one of the great human values, along with art and religion and philosophy, he defends so firmly and lucidly the value of science as a means of understanding the world in which we live that his address naturally recalls Sir Edward Appleton's address to the Association at Liverpool in 1953 on science for its own sake. Whereas, however, Sir Edward emphasized the intrinsic value of science, it is rather with the interrelations of science and technology that Sir George Thomson is concerned, and the way in which technological advance arises out of the contribution to our understanding of the physical world that science makes possible.

Science, Sir George points out, makes an approach to understanding which is the very opposite of that of religion and philosophy. It begins by studying details, often apparently trivial details, and from this study of details come concepts. Many of these do not survive, but the successful concepts, or the best of them, ~~are~~ no longer concerned with details. They penetrate deep in the heart of things and unify our thoughts over a vast area of facts, enabling men's minds to grasp certain aspects of the enormous complexity of the world. They represent an extension of the human intelligence, and often are not easy to comprehend, so that their subtleties oblige the popularizer to take care lest in simplifying he makes statements which are simply untrue.

Furthermore, Sir George maintains that concepts are discoveries as well as—indeed, more than—inventions, that they are more than an exercise or product of the human mind and represent reality. Here, where he points out that, as an exercise of the human mind, they equal the brilliance of any system of thought, philosophical or even mathematical, and when he sets science in its function of enlarging the bounds of human knowledge alongside the expression of human greatness in art and morals, he seems to come close to the line of Sir Edward Appleton's thought. It is the chance of understanding things of fundamental and permanent importance that makes the pursuit of science fascinating and worth while. This and, it might be added, the intellectual and moral discipline which it imposes on those who follow it, give science its place as one of the great human values.

Sir George Thomson, however, is more concerned in this address with the interactions of this aspect of science, as a way of finding out and understanding the world in which we live, on other aspects of life than with its value to the individual as an intellectual discipline or pursuit. In our times, technological advance, in the medical as well as in the engineering field, largely and even mainly arises out of clear understanding of the principles involved; though he reminds us that this has not always been true and that in earlier centuries advances in technology were largely empirical. To-day, discoveries are increasingly made in research laboratories and fewer by workmen on the bench, and industry in general recognizes this dependence of technology on pure science. Apart from a few industries where too little is spent on research or research is badly organized, Sir George believes the need is realized and reasonably well met.

Science itself, however, receives a great return for what it contributes to technology, and this in two ways, materially and in the realm of ideas. Indeed, though Sir George did not specifically say so, some science arises out of technology. Nevertheless, he pointed out that a modern physics laboratory could not work without instruments developed for technology and obtainable chiefly because industry needs them in large numbers, and he doubted whether academic scientists are sufficiently grateful for this return by industry. Without the resources which technology and industry have placed at his disposal, the power of the scientist to enlarge the boundaries of knowledge would be very considerably restricted, and this factor alone does not make it too easy to decide on the allocation of limited resources or whether to enter on some entirely new field.

Quite as important, however, is the influence of technology in keeping science in touch with reality. As science advances, concepts tend to become more and more abstract, and further removed from anything that can literally be touched or handled; and Sir George suggests that there is a danger that we may come to suppose that some elaborate piece of mathematics represents reality when it is only a creation of the mind, inspired indeed by physical reality, but no more like it than is a modern picture. So long as those who formulate these theories are reasonably close to those who use them, not merely in laboratories but also in industry, Sir George thinks that we are safe, and to him the most amazing thing about science and the most surprising and exciting thing about our world is the astonishing connexion between highly abstruse theoretical ideas and the matter of fact. Sir George illustrates his point by referring to a household kettle heated by electricity supplied by nuclear power; the argument for some effort in space research on the grounds of the probable benefit to telephonic communications is no more unrealistic than proposals for nuclear power would have seemed less than a generation ago.

In referring to these interactions of science and technology, Sir George joins issue with those who regard technology as intellectually a poor relation of science. To him, science without technology is incomplete and inconclusive. Systems of philosophy come and go, and it is hard to suggest criteria for their truth. When, however, conclusions deduced from precise experiments by mathematical theory lead to detailed predictions from which working machines can be designed, machines which without the theory no one would have thought of in a million years, then indeed one knows that one lives in a universe which is rational and that one has found the key to one of its rooms.

From this Sir George goes on to refer to some of the ways in which scientific knowledge has influenced and is influencing thought and the intellectual climate of the world. He believes that the quantum theory, for example, which had forced physicists, some of them very unwillingly, to believe that fundamentally the laws of physics are not statements of what must happen, but of the relative chances of a variety of alternatives, made quite a difference to the way one regards the universe, and that its consequences are still not realized by the average educated man. Yet these new ideas which science has provided, and is providing, new ideas tied closely to experience of a special character, constitute an achievement of which man may well be proud. It is surely something for beings, so utterly insignificant compared with the smallest of the stars that are scattered with reckless abandonment in the heavens, to be able to understand some at least of the principles which control their existence.

Sir George disclaimed any understanding of the relation between scientific concepts and reality, and some philosophers may well find the earlier part of his address provocative. It was not, however, the philosophy of science that he was concerned to display or the relations between science and philosophy; rather he sought to help some of those not closely concerned with science to understand something of the achievements of science in human thought, and the dependence of technological advance, or the increasing control over man's physical environment which technological achievement permits, on the advances in the fuller and deeper understanding of the physical world which science continually brings to us. "The full fruition of scientific work depends upon three things: the desire to know, the initiative to find out, and the awareness to apply"; in saying this in his tercentenary address to the Royal Society, Sir Cyril Hinshelwood recognized that scientific achievement is the result of the efforts of a small minority. Although Sir George Thomson did not attempt quite so large a canvas, his address is no less calculated to win the interest and assist the understanding of a wider audience in the work of men of science. What that small minority can achieve, either in the understanding or in the control of Nature, depends to some extent on the intellectual climate of its time, and the understanding and support it receives from the majority. The pursuit of knowledge should, as Sir Cyril implied, no longer remain the concern of the few; but, if the chronicler is to give more regular attention to the adventure and achievements of science, if the historian is to be induced to examine or record the interaction of scientific ideas with those of philosophy, politics or religion, much will depend on the determination and pertinacity, as well as the lucidity, with which men of science themselves seek to interpret the adventure of science in human understanding, no less than in extending our control of Nature to humanity in general. As Sir Cyril observed, the propagation of an idea demands the right conjunction of unknown human factors; but even when these are propitious, nothing will initiate the change save the operation of a minority, perhaps even beginning with an individual. But the majority and the individual are in mutual dependence for, except under rare conditions, the individual in isolation is impotent. To create mutual understanding and, it might be added, confidence, between the creative minority and the majority on which the minority is dependent for resources, is an essential task in science as in art; and Sir George Thomson's penetrating exposition of the relations between the two aspects of science—extension of human understanding of the world in which we live, and the enlargement of man's power of controlling the material forces and resources of that world—is best appreciated as an effective essay to that end.

IONOSPHERIC PROPAGATION OF ELECTROMAGNETIC WAVES

The Magneto-Ionic Theory and Its Applications to the Ionosphere

A Monograph. By J. A. Ratcliffe. Pp. x+206. (Cambridge: At the University Press, 1959.) 40s. net.

THE propagation of electromagnetic waves through a gaseous ionized medium in the presence of a magnetic field is a very complicated problem in its full complexity. It is fortunate that, for applications to the ionosphere, certain simplifications may be made. Thus it is rarely necessary to take explicit account of the wave character of the propagation—attention can be concentrated on the determination of the indices of refraction and of absorption. Even so, there is a great number of factors to take into account and it is extremely difficult to see how each is effective, as well as to be aware of all the different possibilities which can arise. It is therefore fortunate that one of the most skilful exponents of the subject has written this monograph with an eye always towards applications to the ionosphere.

The book is planned on a very systematic basis with the careful attention to detail which is so necessary in presenting this subject. On the other hand, the treatment is by no means purely mathematical. Indeed, special attention is devoted to discussing the physical significance of the various formulæ and approximations which are introduced.

The introductory chapter includes a historical account of the development of the subject, which is of much interest and includes a summary of the nomenclature which is used consistently throughout the book. Part I is concerned with the derivation of the equations. Both macroscopic and microscopic approaches to the problem are described in successive chapters, special attention being directed in two following chapters to the discussion of absorption.

The equations obtained are complex, and Part 2 is devoted to a detailed discussion of this interpretation. A gradual approach to the most-general case is skilfully employed so that the maximum insight into the significance of the different contributory effects can be obtained. The successive chapters deal with the graphical representation when there are no collisions, the polarization of the waves, the quasi-longitudinal and quasi-transverse approximations, the effect of collisions on the indices, some representative curves of the indices, and the group velocity.

A similar gradual approach is used in Part 3, which deals with applications to the Earth's ionosphere. Thus Chapter 12 deals with a model ionosphere with no magnetic field, to be followed by one in which the effect of a magnetic field is included. The concluding chapter of this part gives an interesting account of the nature of the motion of electrons in the ionosphere in the presence of the Earth's magnetic field.

The last part deals with some miscellaneous subjects. Chapter 15 discusses the question of whether the Lorentz term should be included in the expression for the complex refractive index and Chapter 16 examines the effect of the presence of heavy ions. In Chapter 17 the restriction otherwise maintained of dealing with a homogeneous medium is lifted and many new effects which can then arise are discussed. The final chapter compares and contrasts the propagation through the magneto-ionic medium with that through an anisotropic medium such as a crystal. An extensive bibliography is provided.

This monograph is a masterly work written by a great expert not only in the subject but also of exposition. It cannot fail to be of great value to all who are interested in the ionosphere and related subjects. Its appearance at a time when new possibilities of research in radio propagation have been opened up through the use of rocket and satellites is most opportune.

H. S. W. Massey

PROPOSALS FOR SPACE FLIGHT

The Exploration of the Solar System

By Felix Godwin. Pp. 200+10 plates. (London: Chapman and Hall, Ltd., 1960.) 35*s*. net.

THIS book represents an attempt to outline the probable development of astronautics between now and the year 2100, with many detailed accounts of possible expeditions, based on the assumption that only currently foreseeable techniques are used. The first topic discussed is the near-Earth assembly orbit, which will serve as the base for space-ships; then the problems of instrumented and manned expeditions to the Moon are reviewed. Next there is a lengthy and detailed plan for the exploration of Venus, followed by a similar one for Mars. The main text ends with a long chapter on further possibilities, such as visits to the outer planets, plasma rockets and interstellar flight. Finally, there are several appendixes, on topics such as rocket propellants, personnel, space warfare and costs, a glossary and a full index.

Although inevitably there is much that is speculative in the book, the factual detail is piled up with such convincing realism that the reader is often persuaded to suspend disbelief. Many authors of books on space flight give the unfortunate impression that to travel enthusiastically is better than to arrive, but Mr. Godwin's expeditions have a clear aim—to make thorough scientific investigations of the planets—and travelling is merely the means to an end. The author writes in the present tense, as if all the complex operations he describes were matters of routine, and for him there is no gap between the possible and the practical. This might be thought a fault, and attributed to his youth—for he wrote the book between the ages of sixteen and eighteen. But in a book about the future, there would seem to be no harm in recognizing the truth that the technological impossibilities of one generation are the commonplaces of the next. It must be emphasized, too, that the author has voluntarily limited himself to foreseeable techniques: with the development of unforeseen ones, his plans may come to seem timid rather than over-ambitious.

Mr. Godwin evidently has a wide knowledge of most aspects of space technology and physics, but there are plenty of flaws to be found among the crowded detail of the book. His schemes, though ingenious and well thought out, are sometimes out of touch with present practice: for example, solar batteries are not mentioned except in a brief paragraph on p. 124, though power supplies are often discussed earlier. He relies too much on space-flight books of the early 1950's, some of which are now seriously out of date. His use of symbols is undisciplined; for example, the symbol *a* on pp. 24 and 25 is not only undefined but has two different meanings. Pp. 74–76, explaining in detail the optimum manoeuvre for a tanker intercepting a returning space ship, seem to be erroneous: the tanker's weight could be reduced by a factor of about 3 if the transfer were made near perigee. One could go on finding fault in this way, but such flaws do not destroy the book's real merit of providing a logical and well-founded outline of the probable future exploration of the solar system. The reality will, no doubt, be different, but only because of advances not yet predictable.

D. G. King-Hele

GENERAL AND LINEAR CIRCUIT THEORY

General Circuit Theory

By Prof. Gordon Newstead. (Methuen's Monographs on Physical Subjects.) Pp. vii+144. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1959.). 15*s*. net.

THIS book is a welcome addition to Methuen's series of monographs on physical subjects. Prof. Newstead has undertaken the ambitious project of outlining a general circuit theory in 140 small pages and has succeeded to a remarkable extent.

It might have been better to have expanded the book into two volumes; one for steady-state theory and the other for transient theory. The author would then have been able to develop his generalizations at greater length and his arguments would have been easier to follow. In its present form the book is scarcely suitable for those seeking an introduction to the subject and is more suitable for experts.

The starting point of the book is the linear differential equation for two terminal networks :

$$i = \Sigma_r a_r D^r e$$

where r has zero, positive and negative integral values and $D \equiv d/dt$. The bulk of the book is confined to the treatment of the linear circuit theory following from this equation and Kirchhoff's laws. The author allows himself only ten pages in the last chapter to deal with non-linear theory, but gives here a most attractive presentation of the methods used for tackling non-linear problems. The importance of this ever-growing class of problems is scarcely underlined by such a meagre allocation of space, and it is to be hoped that another monograph from the same author will soon appear providing a generalized treatment of non-linear problems.

In the first three chapters of the present book the author develops from the above basic equation the concept of circuit components and then proceeds with the development of general network theorems and the treatment of the 4-terminal network in the steady state. There follows a chapter on "The Fourier Integral" and the treatment of network transients.

The book is mainly mathematical in character.

A. H. M. ARNOLD

CHEMICAL PHYSICS COMES OF AGE

Advances in Chemical Physics

Vol. 1. Edited by Prof. I. Prigogine. Pp. xi+414. 87*s*. Vol. 2. Edited by I. Prigogine. Pp. ix+412. 87*s*. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.)

DURING the past fifty years we have seen the development of several new branches of chemistry—physical chemistry, radiation chemistry, quantum chemistry. All of them were associated with the incursion of new physical techniques or mathematical theories, and their subsequent exploitation within the total framework of chemistry. Chemical physics is a very vigorous child, with parentage in physics and mathematics as well as in conventional chemistry. At the research-level it is well catered for by the American *Journal of Chemical Physics*, the British *Molecular Physics* and other journals elsewhere. But the time has come when no one can follow all its development. Review summaries are required. The 'baby' has come of age.

These two volumes follow the general style and format of other sets of "Advances in . . .". Each consists of a series of ten to twelve articles, written by someone working in a particular section of the field, and setting out the major developments in the preceding years. The articles are very varied in topic—from isotope effects in chemical kinetics, through the electronic description of atoms and molecules to nuclear quadrupole resonance and clathrate solutions. They also vary in length—from 15 pages on transport theory in binary liquid solutions to 116 devoted to what is probably the most complete account hitherto presented of the calculation of correlation energy in many-electron problems. Some of the essays are easy to read, such as Bright Wilson's account of the barriers to internal rotation; others, such as Kihara's on the non-additivity of intermolecular forces, are much more difficult.

Prof. Prigogine, who edits this series, has started well. His choice of authors is excellent, and the range of topics almost entirely suitable. One is tempted to say that there is now developing a rather clearer acceptance of what 'chemical physics' really is. It has been defined by no one, but has grown with the subject. It is not chemistry, because continually physical concepts and techniques are used. Nor is it physics, because the language and thought-forms of chemistry belong to it. It is an outlook—a way of looking at things—with a certain degree of austerity in its discipline (as befits physics) and a satisfaction with understanding a phenomenon, even when you cannot completely calculate it (as befits chemistry). It makes unashamed use of mathematics, yet the mathematics is never the *raison d'être*. There are as yet practically no university chairs in it; but its arrival (so well documented in these annual volumes) has probably made as much difference to chemistry as any development since the atomic theory. Long may we continue to look for convenient summaries of its progress, similar to these present ones.

C. A. COULSON

MOLECULAR GEOMETRY

The Determination of Molecular Structure

By P. J. Wheatley. Pp. vii+263. (Oxford: Clarendon Press; London: Oxford University Press, 1959.) 35*s*. net.

A DISCONCERTING modern trend which this book serves to underline is the increasingly divergent scientific outlooks of the workers in different branches of chemistry. They tend even to attach different meanings to the words they use. For many decades past the classical organic chemist has used the expression 'molecular structure' to denote the arrangement of atoms in molecules and the manner in which they are linked. Mr. Wheatley uses the term in the more precise sense of configuration and molecular dimensions. From this point of view he is no doubt justified in his reference to the "uncertainty attached to many chemical arguments" and in saying that "nowadays an appeal is almost always made to the more reliable physico-chemical methods". But the traditional chemical methods of determining molecular constitution are by no means obsolete, and there is no immediate prospect that they will soon be superseded.

To the theoretical chemist it may well be true that "the object of any scientific experimentation is the elimination of further experimentation". This is another respect in which the author's attitude is very different from those who pursue other branches of the science.

Mr. Wheatley's book gives a brief and interesting survey of modern physical methods used in determining the sizes and shapes of molecules. There are a section on spectroscopic methods (excluding ultra violet absorption), a considerable section on diffraction methods (mainly X-ray diffraction of crystals but including also electron and neutron diffraction and a third section on miscellaneous methods, including dipole moments and nuclear magnetic resonance. The approach is theoretical rather than practical but care is taken to indicate the types of information that can be obtained by the application of the methods discussed. At the end of each chapter are useful references to more extensive publications on the subjects under discussion. J. W. Cook

GENETICS OF CONTINUOUS VARIATION

Introduction to Quantitative Genetics

By D. S. Falconer. Pp. ix+365. (Edinburgh and London: Oliver and Boyd, Ltd., 1960.) 35s. net.

THE genetical study of continuous variation has had a somewhat chequered career. To Darwin this was the variation that mattered above all, and it was the variation to which Galton and later Pearson devoted their unsuccessful efforts to work out the principles of heredity. To the early Mendelians, however, it was, one feels, a puzzle and even a nuisance, intractable by their techniques and a source of acid dispute. True, the basis for understanding its determination and properties was laid down during this period; but its experimental study was so much more tedious and its theory so much more mathematical that for several decades it just failed to hold its interest in the face of the more classical type of genetical study. Now the situation has changed again. The significance of continuous variation in wild populations and its key importance for plant and animal breeding are fully recognized, and the past fifteen years or so have seen a tremendous growth in its genetic study. Its problems and perhaps even more its analytical techniques may still set it apart as a somewhat specialized branch of genetics, but it is as essential to an appreciation of the science at one end as cell chemistry, deoxyribonucleic acid and gene structure are at the other.

Dr. Falconer has now given us a text-book of, as he terms it, "Quantitative Genetics", and we are indebted to him for it. It is a noteworthy book in several ways. To most biologists it will read more like a text-book of physics than like the type of biological literature with which they are familiar, so much is mathematics an integral part of the structure. Yet we should be grateful that the mathematics is never oppressively advanced or complex—a virtue which will be acknowledged the more readily by those who have attempted other texts in this field. Within its ambit it covers the ground admirably, and its length serves only to indicate the amount of ground to be covered. The behaviour of genes in populations, variation, heritability, selection, inbreeding and heterosis, particularly as they appear in animal experiments, are all dealt with lucidly as well as carefully: indeed in places, as where family selection is analysed and discussed, the treatment is of a notably high order. Occasionally a laxness of expression creeps in, as where it is said that the "partition of (phenotypic) variance into genotypic and environmental components formulates the problem of . . . the relative importance of genotype and environment in determining the phenotypic value"—surely one of the oldest *non-sequitur* in the history of genetics. At times, too, the argument is more than a little tendentious; but these periodical blemishes can weigh only lightly in the balance against the generally consistent quality of the book.

The risk of a book such as "Quantitative Genetics" lies elsewhere, in its very success in presenting the mathematically analytical approach. Mathematics has a charm of its own, in the clarity, generality and finality with which its conclusions emerge. These, however, can never be sounder than the evidence, postulates and concepts from which they are derived, and the charm becomes meretricious if it blinds us to the limitations of the situations, the complexities of the relations or the uncertainty of the premisses we are exploring. Dr. Falconer, for example, spends little time on linkage: he largely contents himself with reiterating the charge that mathematics has shown it cannot have much importance in relation to selection while ignoring the experimental evidence that it is in fact not so lightly to be dismissed. He discusses correlated response to selection wholly in terms of pleiotropy, which is easy to handle by correlation technique, but overlooks the cases where linkage supplies, to say the least, a much more satisfactory interpretation of the experimental results. He argues for a simple relation between heterozygosity and fitness but barely mentions the self-fertilizing plants which show that this relation must itself be the product of natural selection in the past. He states that the genes governing number of bristles in *Drosophila* show no dominance, and bolsters his contention that this character is selectively neutral by postulating hypothetical pleiotropic effects of these genes while supporting his view by reference to evidence which is at least as readily interpretable in the opposite way. In justice to Dr. Falconer it must be said that most of these opinions are to be found in the final chapter, which he himself describes as setting out his own views on controversial topics. This is a praiseworthy warning, for indeed whatever disagreement we may feel with these final sections should never be allowed to blind us to the great value of the other nine-tenths of the book, or to the debt we owe Dr. Falconer for so ably presenting the subject, especially as it appears to the animal geneticist, for the benefit of all our students. Kenneth Mather

THE YELLOW FEVER MOSQUITO

Aëdes aegypti (L)

The Yellow Fever Mosquito—Its Life History, Bionomics and Structure. By Sir S. Rickard Christophers. Pp. xii+739. (Cambridge: At the University Press, 1960.) 75s. net.

THE yellow fever mosquito is a most appropriate subject for a large treatise. Of all mosquitoes it is that most easily maintained in culture in the laboratory. Its most characteristic breeding site is the small tree-hole containing an ounce or two of water, very liable to dry up. The eggs stranded under these conditions can withstand desiccation for many months and hatch in a few minutes when immersed in water; abundantly fed, they reach the adult state in a few days. It is therefore a most valuable experimental animal upon which much of our knowledge of the physiology of mosquitoes in general has been based. It has been extensively used as a test object for insecticides and repellents.

Few insects have suffered more at the hands of taxonomists than this mosquito. It is now generally known as *Aëdes aegypti* Linnæus 1762. It may or may not be the insect briefly described by Linnæus under that name—but after so many tiresome changes it is to be hoped that the name will stick. *Aedes aegypti* occurs throughout the entire tropical belt around the globe, and extends for a variable distance into the subtropics. Throughout most of its range it is a domestic insect, rarely breeding more than a few yards from human habitations. It was incriminated by Reed and his colleagues (1900) as the carrier of urban yellow fever; it also carries the virus of dengue fever. It is therefore an insect of great importance to mankind.

The effective control of *Aedes aegypti* in Havana and Panama, with the elimination of yellow fever, gave promise that the disease could be eradicated from the New World. But the attempt at eradication by the Rockefeller Foundation brought to light the existence of a sylvan form of the disease maintained by other mosquitoes in monkeys and other mammals in the jungle and spreading only occasionally to man, and so to his domestic mosquito. The same epidemiological pattern has been found in tropical Africa; and rural forms (genetic strains) of *Aedes aegypti* have been recognized which can also be involved in the transmission of the rural disease.

As the years have passed the subject of yellow fever and its main carrier has become ever more complicated. It will be a great boon to have this erudite and practical treatise on hand, dealing as it does with all aspects of the morphology, physiology, biology and control of *Aedes aegypti* (much of the morphology being original), written by an author who has been an authority on mosquitoes since he was a member of the Malaria Commission of 1899–1902, combining a sense of history with a good account of the most modern work, and beautifully produced. It will not be difficult to find small omissions of recent work, but it is to be doubted whether any other author could have written such a well-proportioned survey of this many-sided subject. It was a wise and generous decision of the Rockefeller Foundation to make possible the publication of this book.

V. B. WIGGLESWORTH

EMBRYOS OF BIRDS

The Avian Embryo

Structural and Functional Development. By Prof. Alexis L. Romanoff. Pp. xvi+1305. (New York and London: The Macmillan Company, 1960.) 210s.

SOME ten years ago, Prof. Romanoff, who holds the chair of chemical embryology at Cornell University, published in collaboration with his wife a massive compendium on the avian egg. He has now proceeded to a detailed consideration of the embryo within the egg. Embryos of the domestic fowl have been perhaps more widely and thoroughly studied than those of any other vertebrate. Romanoff's monograph is certainly the most complete that yet exists in this field. Moreover it covers the embryo not only of the fowl but also those of all other birds in so far as they have been studied. It is therefore an invaluable work of reference, and there can be no embryologist who does not feel a debt of gratitude to the author for the enormous labour which must have gone to its compilation.

Romanoff states that in the preparation of this book it was necessary to make a critical study of more than 7,000 original publications, about two-thirds of which were written in languages other than English. Of these only some 2,700 are cited in the text; but that is already a much more extensive bibliography than is available elsewhere. Moreover, the list of references is at the same time an author index, giving reference to the page of the text in which the work referred to is discussed. One perhaps slightly odd feature of the bibliography is that no mention is made of the other recent monographic works on the chick, such as Hamilton and Hamburger's revision of Lillie's book, the Willier-Weiss-Hamburger "Analysis of Development" or my own "Epigenetics of Birds". On the other hand, the references to original publications give evidence of truly catholic reading, and will be found particularly valuable by English-speaking readers to whom the contributions published in other languages may not be so easily available.

The first three chapters cover the reproductive cells (70 pages), fertilization and fertility (40 pages), and early morphogenesis (about 95 pages). In the last-named chapter it is particularly gratifying to see full accounts of the work of the real pioneers of the modern period of our knowledge of gastrulation and associated processes in the chick, such as Gräper, Wetzel and Pasteels, which in some of the recent American monographs has tended to be somewhat neglected in favour of more recent American work. The experimental studies on these stages has also been very well reviewed. It is perhaps noteworthy that Romanoff does not use, and so far as I can make out, does not even mention the conventional numbered stages into which the development of the chick embryo has been divided, for example by Hamburger and Hamilton. Personally, I find the use of such stage numbers an unnecessary impediment to ease of understanding. If one refers to an embryo as in the long streak stage, the head process stage, or the three somites stage, everyone knows immediately what is meant, whereas reference to stage 13 conveys nothing except to the expert and saves only a minimal amount of breath or printer's ink. However, many embryologists appear at the present time to favour the use of numbered stages, and it would perhaps have been valuable if Romanoff had at least listed them.

After these three introductory chapters there follow more than 900 pages devoted to the description of the development of the various organ systems, including the extra-embryonic membranes. It is clearly impossible to review these in detail; it can only be said that a vast body of information is here assembled together and that the choice and arrangement of materials show evidence of a good critical insight. A subject index of more than 60 pages in addition to the bibliography author-index make it possible for the reader to find his way about. The book also contains some 440 illustrations which comprise in all more than 2,250 separate drawings. In spite of the size of the book these have had to be reproduced on a comparatively small scale, but they have been re-drawn in a simple style so that nearly all of them remain quite clear even after reduction.

Both in the wealth of detail it includes and in the balance and fairness of its account, Romanoff's book is far in advance of any previous monograph on the bird embryo. It will certainly remain the standard work of reference in this field for many years to come.

C. H. WADDINGTON

ASPECTS OF PLANT NUTRITION

Nutrition of the Legumes

Proceedings of the University of Nottingham Fifth Easter School in Agricultural Science, 1958. Edited by Prof. E. G. Hallsworth. Pp. x+360. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 55s.

Utilization of Nitrogen and its Compounds by Plants

Symposia of the Society for Experimental Biology, No. 13. Edited by H. K. Porter. Pp. vii+385. (Cambridge: At the University Press, 1959. Published for the Company of Biologists on behalf of the Society for Experimental Biology.) 50s. net.

THIS is an age of conferences, and both the Society for Experimental Biology and the Agricultural Department of the University of Nottingham can claim a high degree of success for those they organize in their respective fields of interest. In 1958 the topics of the Symposium of the Society for Experimental Biology and of the University of Nottingham Fifth Easter School in Agricultural Science overlapped considerably, for in a discussion on the nutrition of legumes, the subject of the latter, the uptake and utilization of nitrogen, the subject of the former, must obviously demand a leading, though by no means exclusive, part.

In the Nottingham Easter School the various aspects of legume nutrition were well covered by the twenty-four papers provided by the various contributors. These papers were classified in five groups: the plant component, the rhizobial component, the symbiotic system, biochemical aspects and field aspects. The papers in the first group, apart from one on the classification of the Leguminosae by Prof. Tutin, were concerned with mineral nutrition, particular attention being given to micronutrients and aluminium. Among the second group were contributions on the classification of *Rhizobia*, the physiology of nodule formation, the survival of the root nodule bacteria outside the host plant and a general consideration of the symbiotic fixation of nitrogen in the Leguminosae. The third group of papers was largely concerned with factors affecting the uptake of nitrogen by legumes and factors affecting nodulation, but included in this group was a paper by Dr. G. Bond on symbiotic fixation of nitrogen by eight genera of angiosperms outside the Leguminosae. The biochemical aspects considered in the fourth group were nitrogen fixation, the transport of amino-acids, and the effect of iron deficiency on amino-acid metabolism in the yellow lupin. The papers concerned with field aspects dealt with a rather miscellaneous assortment of topics ranging from the tolerance of lucerne to excess manganese and copper deficiency in the field to the growth of a clover sward.

In the Symposium of the Society for Experimental Biology the emphasis was mainly biochemical, as was to be expected when the theme was the utilization of nitrogen. The course of nitrate reduction and the enzymes concerned in it, various aspects of the metabolism of amino-acids, including their assimilation and utilization, the biosynthesis of amide and peptide bonds, the formation of alkaloids, and the relation of nucleic acids to plant growth and development, were among the subjects of the twenty papers contributed to the Symposium.

The papers presented at both these conferences varied considerably in respect to the amount of original unpublished information contained in them. It would perhaps be best to regard them as essays giving an up-to-date account of the respective subjects with which they dealt, written by experts actively working in their various fields. As such they provide a wealth of information on the nutrition of the Leguminosae and the utilization of nitrogen by plants in general.

The esteem in which these conferences are held and the value placed on them by the participants is indicated by the number of overseas visitors taking part. In the Nottingham School 40 per cent, and in the Society for Experimental Biology Symposium 50 per cent of the papers were given by workers abroad who came from Australia and New Zealand, Canada and the United States, Belgium, Holland, Denmark, Finland, Germany and the U.S.S.R. WALTER STILES

PARASITIC HELMINTHS

Medical Helminthology

By Dr. J. M. Watson. Pp. xi+487. (London: Baillière, Tindall and Cox, Ltd., 1960.) 84s.

TO summarize, in a convenient form, all the work that has been done in the past half-century on the human diseases caused by helminths is not an easy task; and when an author includes, as Watson does, references to diseases caused in other animals by these parasitic worms, the task is greater still. Watson has, however, had long experience of his subject. He was senior helminthologist to the Wellcome Laboratories in London, served as a member of the World Health Organization's Expert Committee on Parasitic Diseases and has been professor of zoology and of parasitology and bacteriology in the University of Baghdad. The book he now gives us is based on lectures he gave at the American University of Beirut, and the manuscript of it has been checked by English, Canadian and American experts whose names are household words in the field of parasitology.

Part I of the book is a general introduction to the subject, which reviews the comparatively brief history of helminthology and discusses the zoological position of parasitic helminths, their relations with their hosts and the geographical distribution of the important species which infect man. In the bulk of the book (Part 2) the author gives an account of the helminths themselves, arranging these, not, as most text-books on this subject do, according to their zoological position, but according to the tissues which they attack. This is, the author thinks, clinically more convenient and no doubt many will agree. Others will prefer the zoological plan, which at least has the merit of bringing together the types of lesions caused by nematodes, cestodes and trematodes, respectively. The third part of the book discusses the diagnosis, treatment and prevention of helminth infections, and appendixes provide a bibliography, all too short, some may think, of key references to the vast literature, a valuable chapter on the rules of zoological nomenclature and another, which research workers will find useful, on the helminth infections of common laboratory animals. In his final chapter the author gives, among other facts, notes on the rapid recent advances in our knowledge of vectors and anthelmintics.

It is not possible, in a brief review, to discuss detail in a book as extensive as this one and, in any event, the criticism of detail is best left to the teacher or the research worker who uses the book and advises students about it. But a word must be said in praise of the 62 figures, most of which are made up of several individual line drawings, among which are silhouettes of parasitic helminths which give their natural size, a useful feature which appears in other books, but not to the extent to which it is here employed. The production of the book must also be praised; it is well printed, in clear type, in parallel columns on a large page and, unlike some very heavy text-books on this subject, it is delightfully light.
G. LAPAGE

PLANNING FOR THE CHANGING WORLD POPULATION

Our Developing World

By Prof. L. Dudley Stamp. Pp. 195. (London: Faber and Faber, Ltd., 1960.) 21s. net.

PROF. DUDLEY STAMP gave the Patten Foundation Lectures at the University of Indiana in 1950. These lectures were expanded and published in 1952 by the Indiana University Press and the American Geographical Society under the title "Land for Tomorrow", and were revised for the English edition "Our Undeveloped World", published in 1953.

Rapidly changing world populations, land-use values and food supply, urbanization, and new developments in farming, in mechanization of agriculture and in plant and animal genetics during the past seven or eight years have made further revision necessary, and "Our Developing World" now appears as a new book emphasizing the same fundamental point of view of the author on the ever-increasing pressure of population on land resources and incorporating, where appropriate, much material from the two earlier books, but also bringing new thought to the problems of under-developed lands.

At the present rate of increase, world population will be doubled in less than forty years. This problem and its related one of planning land use are considered on the world-level, the national level with extremes of wealth in some countries and poverty in others, the regional level and local level. Farming is rapidly becoming a specialized industry. The proportion of population engaged in farming is decreasing almost all over the world, and while the movement is generally away from subsistence farming to commercial agriculture it must not be assumed that increasing industrialization and decreasing agriculture are necessarily the panacea for all ills associated with under-development.

Increasing urbanization is a pressing problem, and growth of cities cannot easily be limited. Efforts should be directed towards improving the urban environment as part of a correct land-use programme. The need for mapping the present distribution of population is as important as that for mapping the use of land, and a Commission has been set up by the International Geographical Union for the study of this problem. The geographical distribution of pests and diseases in man, animals and crops is another contributory study to population and land-use problems.

Prof. Dudley Stamp's conclusions are that world starvation is not just around the corner, that the population of the Earth could be increased to many times its present number without starvation provided man-made barriers are broken down and food is produced efficiently by a comparatively small number of specialist farmers.
M. K. MILNE

CONTINUITY IN A SMALL PACIFIC ISLAND

Social Change in Tikopia

Re-Study of a Polynesian Community after a Generation. By Raymond Firth. Pp. 360+8 plates. (London: George Allen and Unwin, Ltd., 1959.) 45s. net.

TIKOPIA is an isolated speck of land seven miles in circumference with a population of fewer than 2,000 souls; it is one of the smallest of the small islands on the periphery of the British Solomon Islands Protectorate, of which entity it has been politically since 1898 a remote outlying fragment. The nearest land is another islet, Anuta, 70 miles to the north-east; the nearest administrative officer of the Protectorate resides at Vanikoro in the Santa Cruz Group, 130 miles away; it is 500 miles distant from the Solomon Islands proper.

This dot in the Pacific Ocean is inhabited by a community of Polynesians left behind during the great migrations that led the main branches of the race on to Samoa and Tonga, the Ellice and Cook Islands and Tahiti, to Hawaii in the north, New Zealand in the south and Easter Island in the far east of the Pacific. Cut off since those migrations from the centres of Polynesian life, the people of Tikopia and of the other islets in the Solomon Islands' "Polynesian Fringe" have continued to live in isolation as they had always lived; even in the first half of this century they were seldom visited more than about once a year by a Mission ship or a government officer. Before the Second World War, practically no Tikopians ever left their island (except perhaps for a temporary sojourn in Anuta) to return with new ideas from the outside world of other Pacific islands, for a paternal if distant Government wisely forbade recruiting-vessels to take them away to work elsewhere.

Tikopia was therefore the perfect subject for a detailed anthropological study; and in 1929 Prof. Raymond Firth concluded a long and solitary residence with this small, homogeneous and hitherto unchanged community; the principal findings of his study were published as a substantial volume in 1936 under the title "We, the Tikopia". After an interval of twenty-three years he decided to re-investigate the Tikopians (on this occasion in the company of a colleague) partly "to throw some further light on the analysis of the dynamics of small-scale integral social systems", but more particularly to ascertain what had happened to these hitherto sheltered islanders in a period that had seen, owing largely to a world war, such drastic changes in other parts of the Pacific.

What did he find? The first and most obvious impression was the sad destruction wrought by a hurricane shortly before his return, with its resultant grave reduction of foodstuffs and threat of famine. He then found, as he pursued his investigations, that the War had left Tikopia alone since, luckily for its people, it was off the line of the Solomon Islands campaign. The Tikopians, he says, "were spared the traumatic experience of most other islands; neither the Japanese nor the Americans established a base there".

But he also found that a few of the islanders had, after the War, gone to work in the Solomon Islands proper; that the people's geographical notions, previously more or less confined to Anuta and perhaps Vanikoro, had consequently received a modest expansion, that Christianity as taught by the Anglican Melanesian Mission had increased its majority over paganism, that money was beginning to co-exist with barter.

When Prof. Firth first resided in Tikopia, the men of the island presented a striking appearance of a bizarre and unique kind; tall, slim and well-built, they grew their hair as long as possible and bleached it with applications of lime to a golden shade, so that at a distance they seemed to be maned like lions. This was still the case when I myself visited the island more than a decade later, just before war came to the Pacific. On his return, Firth found that most of the younger men were wearing their hair short, and that some of the canoes that came out to meet him were paddled by exclusively female crews, "a striking cultural novelty".

Tikopia is too distant from any Government centre and too small for direct administration, even if this were thought to be suitable. Thus, the traditional local forms of autonomy have had the chance to survive; and Prof. Firth thinks that, even with increasing contact with the Government, the power of the chiefs is likely to grow so long as the Government accepts their authority. "With the clearer emergence of the Tikopian Chief as a secular power, recognition of him as such by the Government is likely to consolidate his general status".

Some artists—Tintoretto, for example—work on a vast canvas; others choose the technique of the miniature. Prof. Firth, in his two major books on the Tikopians, belongs to the latter class. He has devoted an appreciable period of his life to the study of a tiny community—1,200 souls during his first stay, 1,700 on his return—and he has dealt with it in the utmost detail. He has done well to do so, for Tikopia is not only, as he points out, "a highly structural society" but it is also a homogeneous one, saved by its geographical isolation from the drastic and sometimes disastrous changes that the Second World War has wrought in other primitive communities. He has, by this full account of his return to the scene of his former studies, conferred a benefit on all students of the Pacific. H. C. Luke

FACT AND OPINION

The Anatomy of Judgment

An Investigation into the Processes of Perception and Reasoning. By Dr. M. L. Johnson Abercrombie. Pp. 156+7 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1960.) 25s. net.

The author of this short book is a zoologist who has been much concerned with the selection and training of medical students. As a university teacher, she had become increasingly sceptical about the effects of an ordinary scientific education upon the capacity to think, and was therefore led to embark upon a most courageous experiment in education. This, essentially, was a free discussion class in which a dozen or so students were tactfully prevailed upon to scrutinize their own processes of observation and inference. For example, a discussion built around the incidence of 'observer error' in the interpretation of radiographs served to bring out the role of hidden inferences in the reporting of 'facts'. Other discussions were concerned with the meanings of words (for example, the word 'normal' as used in biology or medicine), with the rationale of classification and the evaluation of evidence. These classes were certainly not meant to provide formal instruction in logic or scientific method. Rather was it hoped that the participants, by gaining insight into their own preconceptions, would gradually attain a more original and genuinely objective approach to scientific issues. Although it is difficult to be sure, there is reason to believe that the new method achieved a very fair measure of success.

Although mainly concerned with cognitive issues, Dr. Johnson Abercrombie clearly finds it essential to devote some consideration to factors of temperament. Indeed she has gone out of her way to learn something of the techniques of modern psychotherapy and traces a most interesting parallel between her discussion classes and group psychotherapy. In both settings, discussion of topics apparently impersonal may serve to uncover insecurities at a deeper level. It follows, therefore, that educational experiments of the kind Dr. Johnson Abercrombie describes are not to be undertaken lightly. None the less, if we are to make the best of scientific education, it seems essential that we should discover ways to liberate the student from the security of his accepted patterns of opinion and thought. Dr. Johnson Abercrombie's work is at least a first step in this direction and, after all, *c'est le premier pas qui coute*.

Dr. Johnson Abercrombie's experience has stimulated her to inquire seriously into the psychology of perception and judgment and to attempt to place her findings within a broader psychological context. Indeed, the first part of her book provides a useful review of modern work in this field, with particular reference to the parts played by attitudes and experience in governing perceptual activity. Although her account is quite well done, it cannot perhaps be said to add anything to the numerous accounts of the subject already available. The value of this book lies above all in the description given of a fascinating real-life experiment and in its very real implications for the theory and practice of education.

O. L. Zangwill

FRANCIS BACON WITHOUT HIS BACKGROUND

Francis Bacon

The First Statesman of Science. By J. G. Crowther. Pp. xv+362+7 plates. (London: The Cresset Press, 1960.) 35s. net.

This big book falls into two parts. The first, "For Mankind", is an attempt to estimate Bacon's scientific achievement. The second part, "For Himself", offers a biography of the statesman. The suggestion here, that Bacon was in politics for private ends, is unfortunate, and does not really represent Crowther's view. For he has written a full and sympathetic study of Bacon's public career, which can be read with pleasure and is, in my judgment, the more successful portion of the book.

Of the first part it is not possible to speak so favourably. The character and the greatness of Bacon's reform of knowledge can only be brought out by a strictly historical approach. Before he could clear the path for an active philosophy of Nature, Bacon had to break the fetters of the past. These, in his view, were a Christian tradition which had belied its promise by sinking into resignation; a Greek tradition which had been entangled with Christianity by both the Scholastics and the Neo-Platonists and had made it still more helpless in the face of Nature; a magical and alchemical tradition which had kept alive the dream of a conquest of Nature but was vitiated by imposture, obscurantism and vain-glory; and a rhetorical and literary culture divorced from the manual arts. How Bacon fought and routed these doughty adversaries is a story until recently very imperfectly understood; but it was brilliantly elucidated four years ago by Prof. Paolo Rossi, of Milan, in his "Francesco Bacone: della magia alla scienza". Crowther is not alone among British scholars in ignoring Rossi's book; but he has done so at his peril. It is the only large-scale advance in Baconian studies since Spedding and Ellis.

Crowther's approach is unsystematic and unhistorical. He makes no serious attempt to describe the corpus of Baconian writings, to characterize the items, to date them, or even to list them completely. He does not seek to place them in their context in contemporary European culture. His method is to bring out of the Baconian hat one topic after another, illustrating it by quotation or free paraphrase but never indicating its source. To check him on any point would involve an endless chase. The chief aim of his study is to direct attention to any advance in modern science which can plausibly be regarded as a late flowering of some Baconian seed of thought. This, though not valueless, is a treacherous game. It is not what Pavlov or Sherrington did in the twentieth century that makes Bacon great. It is what Bacon himself did in the seventeenth. This the reader will not find in Crowther's book, for it can only be exhibited against a background which he does not supply.

B. FARRINGTON

BRIDGING THE GAP BETWEEN SCIENCE AND CHRISTIANITY

The Spiritual Crisis of the Scientific Age

By G. D. Yarnold. Pp. 207. (London: George Allen and Unwin, Ltd., 1959. Published for the Sir Halley Stewart Trust.) 18s. net.

BY and large, Mr. Yarnold's book could be described as a dissertation upon the theme of General Smuts's presidential address to the British Association at its centenary meeting, that man's material progress has outstripped his moral and spiritual advance and that advances there are imperative if man is to regain control over events. Dismissing as irrelevant any idea of a conflict between Christianity and science, Mr. Yarnold seeks to indicate what that relationship could be in the modern world and its bearing on the far-reaching crisis, essentially spiritual in character, through which the world is passing, largely because of its inability to assimilate new scientific knowledge and to direct rightly the new technical skills. In effect, the book consists of three essays, the first of which discusses the crisis of understanding which arises in considering the order of Nature, the second the crisis of belief which confronts us in considering scientific presuppositions and some of the central doctrines of the Christian faith, and the third the crisis of living involved in the ethical and moral problems of the nuclear age.

These three aspects are linked by the logical connexion between knowledge, belief and practical activity and the underlying insistence that the danger confronting civilization to-day arises primarily from the refusal to confront spiritual issues. Mr. Yarnold writes reasonably but persuasively. He suggests in his first essay that to bridge the gap between the sciences and Christian theology we need ask no more than the acceptance of three simple integrative principles: the external world is not self-existent, but is created by God; in studying the external world by the method of the sciences, the human mind makes contact with the divine mind—thus discovery and revolution are two aspects of the same encounter; and the fundamental laws of Nature are what they are because God has so ordered the world which He has created. In his second essay he presents his reasons for believing that in its essentials the Christian tradition has been preserved with commendable accuracy, and while he recognizes the difficulties which the modern scientific outlook places in the way of full Christian belief, he himself holds that faith with intelligence as well as with conviction.

Even those who are unable to go all the way with Mr. Yarnold in these interpretations of the world of Nature and of the Christian faith may well agree with him in much that he writes about the crisis of living. No argument as to how far the ethical standards for which he pleads can be truly described as Christian ethics can invalidate a penetrating analysis of the bearing of respect for human personality and the values which characterize the teaching of Christ on the problems of living that arise in the world to-day. The acuteness of such problems is largely due to our failure to notice the human problems created by technology until those problems have become unmanageable. It is not the emergence of entirely new moral problems but the extraordinarily rapid increase in the power which the new knowledge has placed at man's disposal: man's power has outgrown his moral capabilities.

On many of the varied aspects of the problems that arise in this situation Mr. Yarnold writes with insight and sanity, and this essay could well be read with profit by many who might be disinclined to follow him in the two preceding essays. Particularly on the industrial society he is trenchant and displays the critical issues, and on nuclear power and defence he has words which might well be pondered by some of the advocates of unilateral action who are inclined to overlook a government's responsibility to protect the lives and property of its nationals. Mr. Yarnold may not carry all his readers with him in his allegiance to Christianity, but he should at least be sure of their support in the moving appeal of this essay to bring all the moral and spiritual resources at our disposal to combat unprincipled private personal gain and human injustice which to-day technical knowledge and skill have often enabled to flourish on an unprecedented scale. Mr. Yarnold has at the least focused attention on some of the fundamental issues of our time as well as on the relations between the natural sciences and the Christian faith with dignity, sincerity and scholarship.

R. BRIGHTMAN

NEW HORIZONS IN CHEMISTRY*

By Sir ALEXANDER TODD, F.R.S.

ORGANIC chemistry is one of the most remarkable of all the sciences, and is usually regarded by the layman as one of the most abstruse and remote from everyday life and thought. This view is, perhaps, based on its content of jargon and its use of abbreviated molecular formulæ as a kind of hieroglyphic script. It is difficult to believe, however, that a science can properly be described as abstruse which permeates almost every material aspect of modern civilization, which stands as the bridge which links the physical with the biological sciences, and which is, perhaps, the biggest of the sciences in its factual content and in the number of its adherents. Organic chemistry is, perhaps, the most logical of the sciences, and in its history of about 150 years it has suffered fewer theoretical upsets than other sciences. It is a remarkable fact that the whole towering edifice of the subject rests essentially on three basic concepts propounded in the third quarter of the nineteenth century, namely, the concept of fixed combining power of valence due to Frankland, the Kekulé–Couper theory of the tetravalency of carbon and the capacity of carbon atoms to join together into chains and rings, and the theory of the tetrahedral carbon atom due to van't Hoff and Le Bel which gave us stereochemistry. All these concepts were purely empirical, but they have stood the test of time, and on them the whole of modern organic chemistry rests; advances in theory have occurred since they were first enunciated, but these have been essentially refinements giving more precise meaning to them and have in no way upset or destroyed their validity. I doubt whether the same claim could be made of any other science.

There have been two definitions of organic chemistry. Historically, the first, due to Berzelius, was "the chemistry of substances found in living matter". The second, commonly ascribed to Gmelin, appeared first about fifty years later when more was known about the peculiarities of the substances found in living matter and was simply "the chemistry of the carbon compounds". Each of these definitions is valid; but neither is wholly satisfactory, since the first is too restricted and the second is in certain respects too general. A very large number of known carbon compounds are of purely synthetic origin and do not, so far as we are aware, occur in living matter; but it is undoubtedly true that the study of substances which are found in living organisms has provided most of the major stimuli to the advance of organic chemistry throughout its history, and there is little reason to believe that this will not continue to be the case. After all, it was Pasteur's work on the tartaric acids from wine that led to the van't Hoff–Le Bel theory, the anthraquinone dyestuffs stem from Graebe and Liebermann's work on alizarin from madder root, and work on polymerization and plastics goes back to the studies of Harries on natural rubber. Many other examples could be quoted, but I shall mention only one other because it is probably not very well known. It was the work of Windaus on the isomeric sterols that influenced Hückel to develop his theoretical studies on stereoisomerism in fused ring systems and through this developed in the fulness of time a realization of the deep significance of conformational analysis in reduced ring systems—beginning with Hassel and developed by Barton and others—and with it the concept of a new dynamic aspect of stereochemistry which has in recent years exerted a profound influence over a very large area of organic chemistry.

The direct study of substances present in living matter—broadly described as natural products—in the sense of their structural elucidation and total synthesis, has been a dominant feature of organic chemistry only during the twentieth century. That it was not so during the past century can be readily understood, for without an extensive knowledge of carbon chemistry, the relatively complex natural products could not be successfully investigated. The nineteenth century was indeed essentially the period during which the necessary facts of carbon chemistry and the techniques of experiment were developed to the point at which natural product chemistry could be tackled with real prospect of success. This is not to say that natural products were wholly neglected in the nineteenth century; the medical importance of many of them ensured that some attention was paid to them, and, indeed, it was through such work that physiological chemistry and, in due course, biochemistry developed. To-day, with the development of natural product chemistry, it is interesting to see how the demarcation between organic chemistry and biochemistry is again becoming blurred—and with considerable advantage to both sciences.

Not only science as a whole, but also individual sciences, tend to advance irregularly on a broad front, and during any one phase of development there are always individual investigators who stand apart and who break new ground or who see new vistas or horizons not apparent to others at the time. For this reason it is difficult—especially with recent events—to put precise dates to changes in scientific patterns. But in broad terms it seems to me that during the first thirty years or so of the present century most organic chemists dealing with natural products were preoccupied almost entirely with the structure of compounds, while the biochemists were interested essentially with their function. During this period the organic chemists developed their methods of degradation and synthesis to a high degree of perfection and, aided by the introduction of new physical methods of analysis, they have taken them to the point at which the synthesis of molecules as complex as cholesterol, strychnine, chlorophyll, and a number of the coenzymes, has been realized. But since the mid-thirties, slowly at first, but later with increasing rapidity, interest has been moving to a study of structure in relation to function among natural products. It is this which has taken organic chemistry much closer to biology than it has ever been before. Equally, of course, it is the increasing realization that function must be considered in relation to structure that is bringing the biochemists closer to their organic chemical colleagues, to the advantage of both. The way in which organic chemical, biochemical and biophysical studies interact and illumine one another has been one of the

---

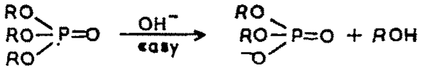
[*] Substance of a Royal Society Tercentenary Lecture delivered on July 20.

features of recent scientific advances in a variety of fields of biological interest, and it seems to me that it might be fitting to try to illustrate some of the new vistas that are opening up by giving a very brief outline of what has been developing in a few fields apparently diverse from a biological point of view, but which have a common chemical thread. It would be possible to choose a series of random topics to illustrate new horizons; but it is perhaps more instructive to choose a small group where the chemical background is common, and I confess that it is also more interesting to me to choose one where the common background is one with which I myself have been associated, namely, the chemistry of the organic phosphates.

It has long been known that organic phosphates are invariable constituents of living organisms and that they have a variety of roles involving energy transfer and the facilitation of both synthetic and degradative processes in biological systems. Just how or why they do so and why phosphate should be found in such complex molecules as, for example, the nucleic acids and phospholipids, has been very much less clear. Until quite recently, organic chemists had paid very little attention to the synthesis or to the study of the chemical behaviour of organic phosphates, and in the absence of knowledge on these points much careful biochemical work remained without a satisfactory explanation.

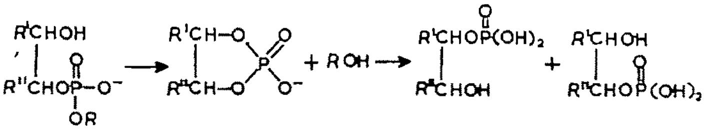
My own interest in this field was aroused just over twenty years ago. I had been introduced to the study of vitamin structure by the late Prof. G. Barger, and this at a time when the relation of several of the B group of vitamins to the so-called nucleotide co-enzymes was emerging and the features which these latter had in common with breakdown products of the nucleic acids was becoming clear. The chemistry of the nucleotides was at this time in a rather rudimentary state and I began a series of investigations aimed at the clarification of this field by synthetic methods, including as a necessary part of it a study of the neglected field of phosphorylation and the study of organic phosphates. Over the years, through the efforts of many devoted and enthusiastic colleagues, we were able to make substantial progress in our general field of endeavour, but I propose to mention here only three features of the work which has been carried out. Each of them is really quite a simple and straightforward piece of phosphate chemistry, but each has a relevance to much wider problems which stand in the forefront of modern organic chemistry and biochemistry. I shall deal with them in turn, endeavouring to show in each instance their importance.

(1) *Hydrolysis of phosphates.* The neutral triesters of phosphoric acid are readily hydrolysed by alkali to the diesters; but the latter are normally resistant to further hydrolysis by alkali, presumably because the formal negative charge on the anion hinders approach of the negative hydroxyl anion to the phosphorus atom.



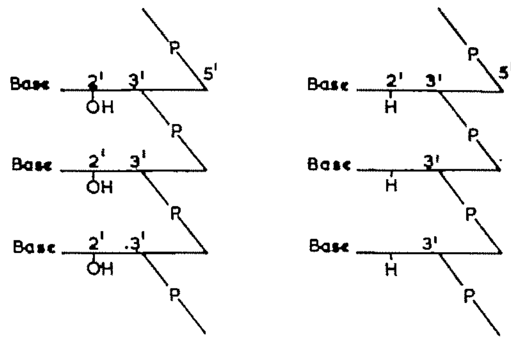
$$(RO)_3P{=}O \xrightarrow[\text{easy}]{OH^-} (RO)_2(^-O)P{=}O + ROH$$

There is, however, one type of phosphodiester which does not show this resistance and which is, indeed, very easily hydrolysed by alkali. The characteristic feature of this type is that one of the esterifying groups bears a *cis*-hydroxyl in the α-position.



In such cases the spatial proximity of the hydroxyl group permits attack on phosphorus despite the negative charge on the anion, and we get very easy hydrolysis *via* a cyclic intermediate, the phosphoric acid residue invariably remaining attached to the glycol residue. Equally, of course, and for the same reason, phosphotriesters containing a *cis*-α-hydroxyl are even more easily hydrolysed than those which do not.

The recognition of these properties of organic phosphates was, in fact, the key to the understanding of the structure of the nucleic acids. The two types of nucleic acid—the ribonucleic acids and the deoxyribonucleic acids—are poly-diesters of phosphoric acid consisting of a large number of nucleosides joined together by phosphodiester linkages. These nucleosides are, in the case of ribonucleic acid, ribosides and, in the case of deoxyribonucleic acid, deoxyribosides, of heterocyclic bases. The conclusion that the nucleic acids are linear polyesters with a recurring 3′ : 5′-internucleotidic linkage, as propounded by Brown and Todd in 1951, rests essentially on their recognition that the behaviour of ribonucleic acid towards hydrolytic agents is that of a phosphodiester containing *cis*-α-hydroxyl groups, whereas deoxyribonucleic acids have the stability of a normal phosphodiester.

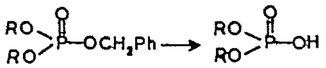


Ribonucleic Acid Deoxyribonucleic Acid

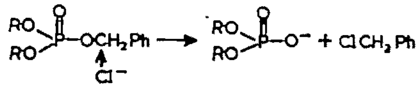
The recognition of the chemical structure of the nucleic acids paved the way for the brilliant biophysical and biochemical achievements of recent years in furthering our understanding of the key position occupied in all living matter by these substances and of the nature of the genes and viruses; and through these achievements there is opening out a wide vista of problems where the organic chemist must play his part—the reasons for specificity in polynucleotides and the determination of nucleotide sequence, the mechanism of protein synthesis and the use of template mechanisms, and the fascinating, if still distant, goal of the synthesis of specific polynucleotides.

Before leaving the subject of hydrolysis of phosphate esters of glycols, it is worthy of note that this same structural feature is characteristic of the phospholipids. Investigations on these important substances based on an understanding of phosphate chemistry by Brown and others is now leading slowly to a clarification of the apparently confused chemical and biochemical literature stemming from earlier investigations.

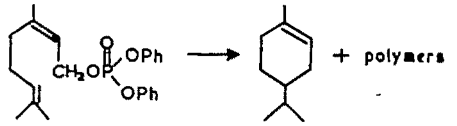
(2) *Anionic debenzylation of phosphates.* In the course of synthetic studies on organic phosphates and polyphosphates it was found necessary at times to be able to remove one benzyl group from a phosphotriester to yield a diester without recourse either to hydrolysis with alkali or acid or to hydrogenolysis, that is, to bring about the simple change:



In such phosphotriesters the CH$_2$ of the benzyl group is strongly electrophilic (electron-deficient), the influence of the phenyl group being reinforced by that of the phosphorus atom. It is thus readily attacked and removed by anions, debenzylation being thereby effected.

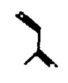


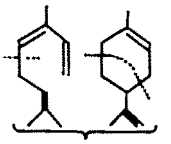
It is not, indeed, necessary to use an actual anion to bring about this reaction, although it is usually convenient to do so in the laboratory. Such compounds as tertiary bases are also effective because of their nucleophilic properties. Nor is the reaction confined to benzyl groups; allyl groups are equally easily removed and, provided that the other two groups *R* in the triester are such (for example, phenyl) as to make the anion $(RO)_2\overset{O}{\overset{\|}{P}}$—O$^-$ very stable, even alkyl groups can be readily removed by anionic fission. An example of considerable interest in connexion with the relevance of these observations to the function of phosphates as biosynthetic intermediates is the observation of my former colleague, Dr. Atherton, that geranyl diphenyl phosphate, in which the nucleophilic olefinic group is, or can be, spatially close to the phosphate group, undergoes cyclization (and also more complex polymerization) with very great ease.

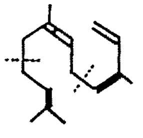


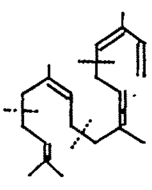
Organic chemists have long been fascinated by the structural relationships between many natural products and have assumed that compounds of one class, for example, terpenoids or alkaloids, are produced in different organisms by essentially similar synthetic processes. Interest in such topics has grown steadily since the early theory of alkaloid biogenesis from amino-acids due to Robinson, and his synthesis of the alkaloid tropinone from simple intermediates in dilute aqueous solution at room temperature under *p*H conditions similar to those commonly obtaining in biological systems. Biogenetic theories of this nature were based on chemical structural relationships and did not purport to set out in detail the precise mechanism of biosynthesis, and it was, perhaps, the failure to realize this which led to their neglect by some biologists and their too uncritical use by some chemists. But properly used, these theories have been, and still are, of immense value in the determination of structure of natural products. During the past twenty years or so the increasing availability of isotopes, both non-radioactive and radioactive, and the development of methods for incorporating them into organic compounds and following the fate of 'labelled' atoms in biological systems, has led to a joint effort by organic chemists and biochemists to elucidate the actual course of biosynthesis of complex molecules in Nature. In this field beautiful work has been carried out by many workers—by Schoenheimer, whose early pioneering work with nitrogen isotopes showed the way, and later by Bloch, Cornforth, Lynen, Shemin, Birch, and others—and in several fields we have now a good deal of precise information available. It should be emphasized that, while this new work has been gradually revealing the course of biosynthetic processes, it has also served to vindicate the organic chemist's use of biogenetic theory in his structural studies. I should like to say something about the mechanism of the biosynthetic pathways to the terpenoid and steroid groups of natural products, since this provides a particularly striking example of the relation between the 'biogenesis' of the organic chemists and 'biosynthesis', and also indicates, again through a consideration of phosphate chemistry, a broad field of further endeavour.

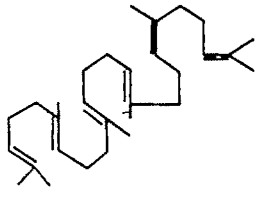
The name terpenoid is applied generally to a large family of natural products of which the simplest members, the terpenes of formula $C_{10}H_{16}$, are common constituents of the essential oils of plants. More complex members include the sesquiterpenes, $C_{15}H_{24}$, the diterpenes, $C_{20}H_{32}$, and the triterpenes, $C_{30}H_{48}$, together with related alcohols, acids, etc. Closely related to them in structure are the carotenoids and the steroids. It was Ruzicka who emphasized the biogenetic relationship of the terpenoids and showed that, so far as their carbon skeleton was concerned, they could, in general, be regarded as made up to 2, 3, 4 or 6 units of isoprene joined most commonly head to tail.

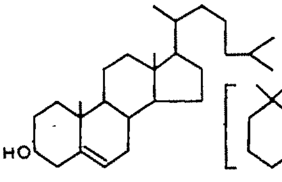

Isoprene


Terpenes

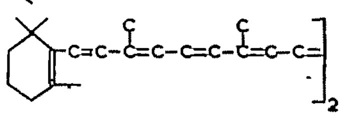

Sesquiterpene


Diterpene


Squalene



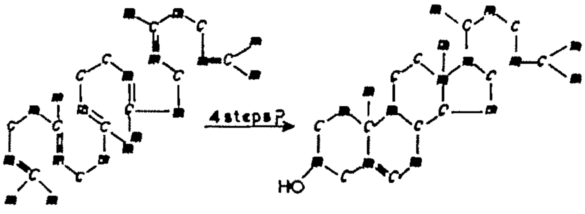
Cholesterol



β-Carotene

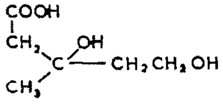
The basis of the isoprene rule can be readily appreciated from the sample formulæ given, and it has been of enormous value in chemical work. The relationship of the steroids to the other terpenoids is, perhaps, not quite so obvious from the formulæ, although it was first postulated just about thirty years ago on biogenetic grounds. The isoprene rule does not purport to portray the biosynthetic mechanism, although it certainly suggests that, even if isoprene itself is unlikely to be the synthetic intermediate in Nature, some closely related substance is likely to be involved.

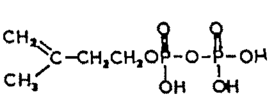
The unravelling of the actual biosynthetic pathway to the terpenoids and the steroids is one of the outstanding achievements of recent years. True, there are some details still to be clarified; but, thanks largely to the magnificent work of Bloch, Cornforth, Lynen and their colleagues, the general picture is now clear. I do not propose to discuss the development of their work in detail, but will try to give a brief general outline. It really begins with the finding that the cholesterol molecule, and also the triterpene squalene, can be built up in living organisms from acetic acid—this was demonstrated by the administration of isotopically labelled acetic acid and elegant degradative studies on the cholesterol produced. Thus, we know that in the rat the cholesterol produced has the structure shown below, in which *m* represents a carbon atom from the CH_3 group of acetic acid, and *c* a carbon atom from the COOH group. It was next found that squalene is an intermediate in the synthesis of cholesterol, that is, that it is quantitatively converted to cholesterol by the rat. This conversion proceeds in several steps beginning with the formation of lanosterol—although all the intermediate steps have not been unequivocally fixed as yet.



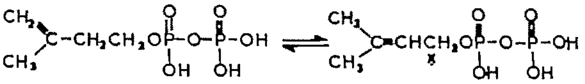
Squalene Cholesterol

So far so good—but what goes on between acetic acid and squalene? What is the hypothetical 'active isoprene unit'? It is now known that acetic acid is first converted in several steps to the six-carbon compound, mevalonic acid, and that this seems to be converted, through its phosphate ester, to *iso*pentenyl pyrophosphate, which has been isolated from biological systems and identified by analysis and synthesis. *Iso*pentenyl pyrophosphate is, in fact, the active isoprene, and from it stem the terpenoids, the steroids, the carotenoid pigments, and rubber.


Mevalonic Acid

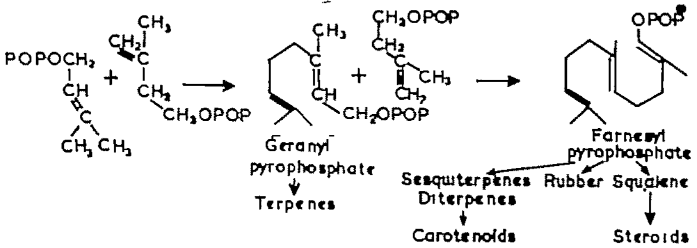

*Iso*pentenyl Pyrophosphate

The mechanism of synthesis from *iso*pentenyl pyrophosphate is readily understood from our knowledge of the fission of benzyl and allyl esters of the phosphoric acids by anions and other nucleophilic reagents. *Iso*pentenyl pyrophosphate (I) can, like other similarly constituted compounds, isomerize to ββ-dimethylallyl pyrophosphate (II)—and, indeed, the two isomers may exist in equilibrium.

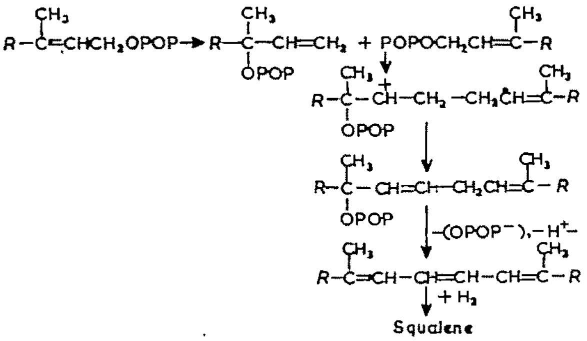

I II

In form II we have an allyl ester capable of attack at the asterisked carbon by a nucleophile (assuming that the ionization of the pyrophosphate residue is sufficiently depressed so that approach of the nucleophile is not inhibited), and in form I the unsaturated *iso*pentenyl group provides a nucleophilic centre. Reaction between the two forms will therefore occur precisely as in the case of geranyl diphenyl phosphate studied by Atherton.

In this way, from two molecules of 'active isoprene' we obtain geranyl pyrophosphate, from this, with another molecule, farnesyl pyrophosphate, and hence, by various routes, the whole range of observed natural products. It should be noted that such intermediates as farnesyl pyrophosphate have, in fact, been isolated and that it is possible, by using an appropriate enzyme system from rubber trees, to make a product indistinguishable from natural rubber starting with synthetic *iso*pentenyl pyrophosphate.

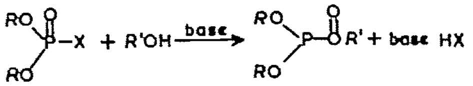


It is noteworthy that the conversion of farnesyl pyrophosphate to squalene involves a doubling of the molecule, since the latter is symmetrical; the same is true of the conversion of the diterpene intermediate to give carotenoids. As has been pointed out by Cornforth, this is readily explained by the so-called farnesol-nerolidol isomerization of the pyrophosphates followed by the same type of nucleophilic fission as before.

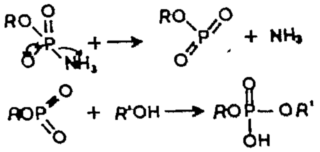


There are still points of detail to be settled in this fascinating story; but the broad picture is there, and from it opens out a new picture of synthetic mechanisms in Nature. Not only can one now begin to picture other biosynthetic processes involving phosphate intermediates, but, as I have already stressed, the essential validity of the biogenetic concepts of the structural chemist receives, through this elegant work, a striking confirmation.

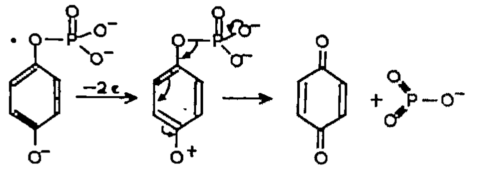
(3) *Oxidative phosphorylation*. Extensive research on the synthesis of phosphates and polyphosphates has led to the development of a variety of phosphorylation methods which fall essentially into two groups. In the first group fall those methods normally based on agents which can be regarded as derived from diesters of phosphoric acid and which proceed by expulsion of an anion.



In methods of the second group, to which some of the most powerful procedures belong, the active agent usually derives from a monoester of phosphoric acid, and instead of an anion a neutral molecule is expelled—for example, in the phosphoramidate carbodi-imide and imidoyl phosphate methods and in oxidative procedures. Much evidence exists for our view that in these cases the active agent in the phosphorylation is the hypothetical monomeric metaphosphate $ROPO_2$, which reacts vigorously with alcohols to give phosphates and with phosphate anions to yield pyrophosphates;

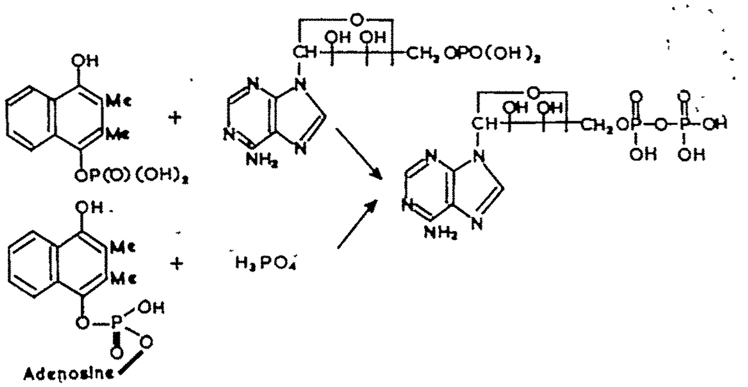


In the case illustrated—the phosphoramidate method—the 'activation' of the reagent is brought about by protonation. But the same effect could be produced by withdrawal of an electron; this is, in fact, the principle of phosphorylation procedures based on oxidation. One in which we have been particularly interested involves quinol phosphates as reagents. Quinol phosphates in presence of oxidizing agents such as bromine, ceric sulphate, or quinones, transfer their phosphate, yielding, at the same time, the corresponding quinone. Thus:

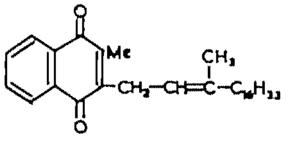


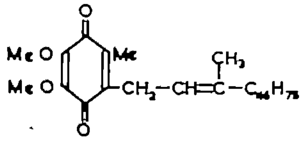
You will notice that we formulate this reaction as producing monomeric metaphosphate. This is supported by a considerable body of evidence. In the first place, the phosphorylation which occurs is a result of the oxidation and is not due to hydrolysis. Quinol phosphates are very resistant to hydrolysis and do not break down in absence of oxygen. Again, although quinol phosphates and their monoesters both undergo this reaction readily with concomitant phosphorylation, quinol phosphate diesters (which cannot yield metaphosphate without hydrolysis) do not, even in presence of reagents as powerful as ceric sulphate. Finally, if quinol phosphates are oxidized in aqueous solution in presence of phosphate anions, phosphorylation occurs to produce pyrophosphate, whereas if oxidized in dimethylformamide in the absence of phosphate considerable amounts of trimeric metaphosphate and only a little pyrophosphate are produced.

These results are of great interest in connexion with the biological problem of oxidative phosphorylation in the respiratory chain, particularly since, in the laboratory, we have been able to show that, for example, adenosine diphosphate can be synthesized either from a quinol phosphate and adenylic acid, or from a quinol ester of adenylic acid and phosphate anion by bromine oxidation.



It is difficult to believe that there is no connexion between these observations and the occurrence of vitamin K derivatives and the ubiquinones or coenzymes *Q* in systems where oxidative phosphorylation occurs and the participation of which is strongly suggested by available biochemical evidence.

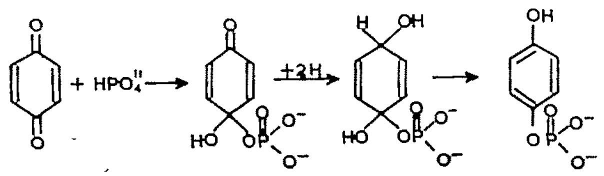

Vitamin K


Ubiquinone (Q_{10})

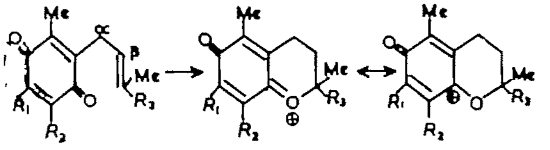
We suggest that these substances are involved in oxidative phosphorylation as the phosphates of their reduced (that is, hydroquinone) forms.

Although this suggestion readily explains the production of adenosine triphosphate through intervention of these natural quinones as their reduced phosphates, there still remains the problem of how these phosphates are produced from the quinones and phosphate anion so that the whole system can work continuously. It is unlikely that reduction of the quinone to the quinol occurs followed by phosphorylation; this could scarcely be done with phosphate anion, and introduction of a 'high energy' phosphorylating entity to bring it about would seem to make the whole process slightly absurd from a biological point of view.

One theoretically possible method would be a simple reductive phosphorylation of the type shown below; but it must be confessed that, despite many attempts, we have as yet been unable to demonstrate any such reaction in benzoquinones or naphthoquinones under many different conditions.



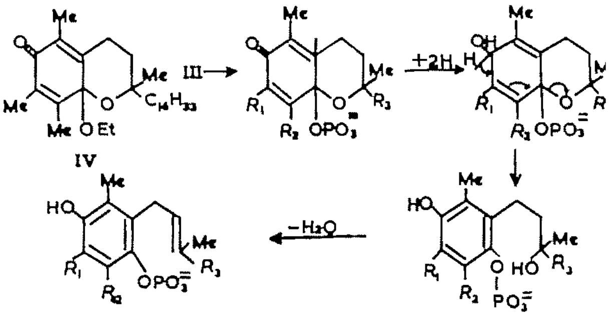
There is, however, another possibility which should be mentioned and which is, indeed, under investigation by Dr. V. M. Clark in Cambridge now. If one examines the structure of vitamin K and the ubiquinones, it is noteworthy that each quinone ring is tetrasubstituted and that each has a trisubstituted double bond in the position β : γ to the quinone ring. If H+ were added to the β-position, a tertiary carbonium ion would be produced which should react with the oxygen of the adjacent carbonyl group to produce the cation III.



III

Evidence for the transient existence of anions of this type already exists in the related vitamin E group, where the substance (IV) has been isolated from oxidation of α-tocopherol with ferric chloride in ethanol. Attack on (III) by phosphate, followed by reduction, should yield the desired quinol phosphate.

If such a scheme can be realized in the laboratory, then it would provide a completely rational picture of the participation of these complex natural quinones in biological oxidative phosphorylation.



I have tried to exemplify, by talking about these aspects of the chemistry of organic phosphates, some of the ways in which advancing organic chemistry is helping at once to clarify certain biological problems and to open up new vistas of potential progress. But I should not like it to be thought that these are the only examples I could have chosen, nor that it is only through the field of biological studies that new vistas are to be found. This is far from true, as could be shown by considering, for example, some of the brilliant recent studies in hydrocarbon transformation and polymerization. But my own research interests have lain largely on the biological side of organic chemistry and I hope, therefore, that I shall be forgiven if I have chosen my illustrations from it.

GEOMAGNETIC STORMS AND THE SPACE AROUND THE EARTH*

By PROF. SYDNEY CHAPMAN, F.R.S.
High Altitude Observatory, Boulder, Colorado

'MAGNETIC storm' is the name long ago given to magnetic disturbance or irregular activity in its more extreme forms. The study of geomagnetic disturbance began in the eighteenth century, with Graham's observations of the compass needle. These were made by eye with a microscope. Eye observation was later improved by use of a moving spot of light on a scale, reflected from a lamp by a mirror attached to a needle. This method made serious demands on the time of the observers, and gave very incomplete information. Yet it was used as late as the first International Polar Year, 1882–83, although in 1846 Airy had introduced photographic observing at Greenwich Observatory. Through the inventions of Gauss, and his influence and that of Humboldt, magnetic observatories for the observation of all three magnetic elements were instituted in increasing numbers from about 1840 onwards. Sabine notably advanced our knowledge of magnetic disturbance by his studies based on the records of the British Colonial Observatories at St. Helena, Toronto and Hobarton. His contribution was largely to the 'morphology' of magnetic disturbance—concerning the distribution and changes of the disturbing magnetic field over the surface of the Earth. Later principal studies in this field were made by Moos in 1910, by Chapman in 1918, and from 1952 onwards by Sugiura and Chapman.

Sabine, Lamont and others contributed also to our knowledge of the time distribution of the occurrence of magnetic disturbance. Soon after Schwabe in 1851 recognized the sunspot cycle, they showed that it is manifested also by magnetic activity. Later, the tendency to a 27-day recurrence was discovered and investigated in different ways, especially by Broun, Maunder, Chree, Stagg and Bartels. It was interpreted as indicating the emission of corpuscular streams from particular areas on the rotating Sun. These streams produce magnetic storms (or less activity) when they impinge on the Earth. Greaves and Newton showed that the greatest storms do not show this tendency towards a 27-day recurrence. They are found to be often associable with solar flares. These are believed to involve the ejection of limited clouds of gas. The time-interval between flares and their associated magnetic storms indicates a speed of travel of the cloud of about 1,000 km./sec. There is some indication that the gas in the continuing streams may travel rather more slowly.

How solar streams and clouds are ejected is still unknown. Scant visual evidence that they are ejected comes from photographs of the edge of the Sun. Solar radio later indicated the rise of gas in the Sun's atmosphere, with speeds that would lead to escape. The streams may be generally invisible because of practically complete ionization of their main constituents, atomic hydrogen and helium. But the hypothesis of causation of magnetic storms by corpuscular flux from the Sun was a reasonable inference without such evidence. Even now the solar sources of corpuscular 'streams' have not been certainly identified.

---

* Substance of three University of London Special Lectures delivered at Queen Mary College during June 1–3.

Birkeland attempted a physical theory of magnetic storms and the associated phenomenon of the aurora polaris. He ascribed them to streams of solar electrons. From model experiments he inferred that the geomagnetic field would deflect them polewards, and that this might account for the existence of the auroral zones and other auroral features. Størmer developed Birkeland's ideas mathematically. He considered almost exclusively the motions of single charged particles influenced only by the geomagnetic field. Schuster and others directed attention to the importance of electrostatic forces between the particles in a stream of charges all of the same sign, such as Birkeland and Størmer contemplated. They urged that such streams could not reach the Earth in sufficient density, because the mutual repulsion of the particles would disperse them widely during their travel.

Størmer did consider the combined action of his particles in one respect, namely, as regards the geomagnetic field caused by the electric current associated with their motion partially surrounding the Earth. He connected this field with the reduction of the Earth's horizontal force during geomagnetic storms. This reduction is one of the most notable features of such storms. Though the suggested electric current was not a complete ring, it came to be linked with the name 'ring current'. The existence of a ring current was postulated by Schmidt on purely geomagnetic evidence, without any proposal as to the location or origin or detailed nature of the ring. Størmer's ring current was not a ring. It was situated far from the Earth (at a distance comparable with that of the Moon). It would greatly alter the field in a manner inconsistent with its own presence there. Further, it could not have the supposed current intensity and yet be composed of charges of one sign only.

Over a period of decades, Størmer studied the paths of single particles in a dipole magnetic field. The intended explanation of auroral phenomena had little success, but his work proved highly valuable in connexion with cosmic rays—a phenomenon unknown when his work began.

Lindemann (later Lord Cherwell) added an important constructive suggestion to a justified destructive criticism of a one-sign stream theory proposed by Chapman in 1918 to explain magnetic storms. The suggestion was that the cause of magnetic storms and auroras is a stream or cloud of neutral but ionized gas. Chapman and Ferraro from 1929 onwards tried with some success to develop an inductive theory of the events that would follow the impact of such gas upon the Earth. In this speculative subject there is natural scope for a variety of views as to the significance of their results. To Hulburt a few years ago they seemed to be "of merely historical interest", whereas according to some other authors the Chapman–Ferraro work has "dominated the discussion" of magnetic storm theory for some decades.

The chief conclusions reached were that the geomagnetic field would 'carve a hollow' in the stream, and that electric currents would flow over the surface of this hollow, mainly on the sunward side of the Earth. These currents shield the volume of the stream from the Earth's magnetic field. Also in the parts of the hollow space nearer the equatorial plane they enhance the Earth's field. This is a notable feature observed at and near the commencement of magnetic storms. Such a current continues as long as the flux, and will vary in intensity with the density and speed of the stream particles. It is conveyed by the different motions of the opposite charges, protons and electrons, near the surface of the hollow. The charges are deflected when they enter the very non-uniform magnetic field in the boundary region bordering on the hollow. The particles are turned back less or more directly, according as their approach is farther from or nearer to the line from the Sun to the centre of the Earth.

Simple approximate relations were found between the first-phase increase of horizontal magnetic force in a storm, the density of kinetic energy of the stream, and its distance of closest approach to the Earth. It became clear that the electromagnetic phenomena that produce magnetic storms and auroras take place within a few Earth radii—of order 3 to 10—from the Earth's centre. This scale is much less than that envisaged in Størmer's theory, or in cosmic rays, which are guided by the Earth's field through a much greater region surrounding the Earth. In a later idealized treatment of a problem on the initial approach of a solar stream, Chapman and Ferraro estimated the limits of density and momentum that determine whether the Størmer simple theory is applicable. They showed that for a stream that can exert any appreciable magnetic effect the mutual influence of opposite charges is important.

They tried also to infer the further, main, development of a magnetic storm, but were unable to overcome the mathematical difficulties involved. They made only a tentative suggestion as to how a ring current could begin to grow. The value of this suggestion is still uncertain. Assuming that in some way a ring current is formed, they studied its stability. They conceived the current as toroidal in form: and the particles, positive and negative, as moving with slightly different speeds around the geomagnetic axis, in planes parallel to the geomagnetic equatorial plane.

In 1957 Singer described a different conception of the motion and distribution of the energetic particles in the space around the Earth—in a region of the scale above mentioned. He pictured the particles as moving around and along the Earth's dipole lines of force, to and fro between mirror points in high latitudes, where they attain their lowest levels. This motion would be combined with a slower drift around the Earth. This drift is eastward for electrons, westward for protons. It seemed obvious that this would supply the inferred westward ring current. This was later proved by Dessler and Parker and by Akasofu, but the cause of the electric current proved to be less obvious than at first appeared.

Singer's conception, and the Chapman–Ferraro scale of the phenomena, were confirmed by the discovery and investigation of the Van Allen belts that surround the Earth. The inner, minor, belt seems to be due to the decay of upward-flying neutrons generated in the Earth's atmosphere by cosmic rays. The outer, major, belt is generally but not universally believed to be fed by the solar streams and clouds. The process by which they are trapped by the Earth's magnetic field is still not clear. The outer belt has been found to vary considerably during the year or two in which it has been studied. U.S.S.R. and U.S. cosmic rockets have confirmed irregularities in the magnetic field in the region of the outer belt, which demonstrate the presence of a ring current.

The particles of the belts are very energetic—of order 100 MeV. for the protons and 600 keV. for the electrons. The density of these protons is extremely low—of order 10^{-4} to 10^{-3} per cm.^{3}. The electrons are more numerous. The protons and electrons are gradually lost, the protons mainly by charge exchange at the lower levels they reach, especially near the mirror points. Thus the continuance of the belts requires continual replacement by new energetic particles.

Although corpuscular theories of magnetic storms and auroras found wide acceptance, they were not without critics and rivals. One of the latter tried to explain the geophysical phenomena by specially intense ultra-violet emissions from the Sun. Inadequacies and counter arguments prevented these theories from making much headway. Corpuscular theories, on the contrary, gained important direct support in 1950 from a spectrum obtained by Meinel of an aurora nearly overhead. It showed lines of atomic hydrogen much displaced towards the ultraviolet. This was interpreted as a Doppler effect indicating the downflow of hydrogen atoms with a speed of order 3,000 km./sec. It was naturally inferred that the atoms reached auroral latitudes as protons—guided by the geomagnetic field—and there gained an electron during their descent through our atmosphere. The speed, 3,000 km./sec., was thrice that deduced from travel-time delays between great flares and their succeeding magnetic storms. The discrepancy had already been noted in another connexion. This was the speed necessary for particles coming from outside, if they were to penetrate to the observed lower levels of auroral luminosity.

Further evidence has since been obtained that both protons and electrons do penetrate to these and indeed to much lower levels. This was first shown in the years 1952–53 by the rockoon studies made by Van Allen and his colleagues in latitudes up to more than 80°. The rockoons, fired in the day-time, carried cosmic ray recorders up to heights of 80 km. or more. In latitudes from about 62° to 75°, they showed that, besides cosmic rays, other less energetic agents added to the record. These agents were later interpreted as X-rays, of average energy about 30 keV. (but running up to 100 keV.). These X-rays were explained as Bremsstrahlungen generated by a small minority of electrons (about 0·1 per cent) in close impact with the nuclei of atmospheric atoms and molecules. The great majority of these electrons were stopped at higher, auroral levels of order 100 km. The flux of electrons appeared to be continual, not confined to great auroral occasions. The rockoon launchings, made in years of moderate solar activity, did not coincide with such occasions.

More recently rocket and balloon studies at night, during notable auroras, have disclosed the entry at such times of protons as well as X-rays generated by electrons. They have been detected down to levels as low as 30 km. during strong overhead auroras, by Winckler and his colleagues. This suggests that at such times electrons and protons enter the atmosphere in special abundance, and with speeds much greater than those inferred by Meinel.

The strongest features of magnetic storms as observed at the Earth's surface are recorded in and near the latitudes where the auroras then occur. These latitudes are below those, 65°–68°, of the 'auroral zone', the zone of most frequent auroral visibility. The magnetic records indicate the presence of strong electric currents along these abnormal auroral latitudes. The intense current is limited laterally, and is therefore called an electrojet. The current circuit is completed mainly in higher latitudes over the polar cap, but also over the great middle belt of the Earth between the northern and southern auroral latitudes. These currents flow in our atmosphere: they are more often westward than eastward, corresponding to 'negative' rather than 'positive' polar magnetic 'bays'. The former occur during late evening to early post-dawn hours, the latter during the afternoon and early post-sunset hours. They and the part of the storm field associated with them seem to develop in impulsive bursts, with quieter intervals between. They are closely associated with striking phases of the aurora during magnetic storms.

The morphology of the aurora is complex. The great increase in visual and instrumental auroral observation during the International Geophysical Year is adding, and will add further, greatly to our knowledge of the extent and changes of the aurora in association with magnetic, solar and other phenomena. At present there is a diversity of theories of the auroral luminosity and the electric currents linked with it. Almost all involve the now proved entry of electrons and protons into our ionosphere from beyond. They come ultimately from the Sun, but some theorists consider that before descent to auroral levels they may spend some time as denizens of the Van Allen belts. Some theories envisage the participation of solar magnetic fields transported from the Sun by the solar streams and clouds. Such fields could hold, among the particles travelling more directly, others of much higher energy and speed, spiralling around the magnetic field lines in the stream or cloud. Hoyle and Dungey attributed importance to two neutral points in the combined geomagnetic and transported solar fields. They suggested that such points may be a means whereby solar particles may enter the atmosphere with added energy and penetration. Other theorists attach importance to atmospheric winds in connexion with auroral luminosity and movements, and with the generation—by dynamo action—of the polar magnetic disturbance currents. Martyn associated the acceleration of particles entering the atmosphere with electrostatic potential differences across the section of a ring current of the type envisaged by Chapman and Ferraro. He also explained the impulsion of the polar disturbance currents by these potential differences, supposed transferred along the lines of force to auroral levels.

A new theory of auroral morphology and of the magnetic disturbance currents, by Akasofu and Chapman, is now nearing partial completion. One novel feature of the theory is the attribution of importance to neutral *lines* in the magnetic field around the Earth. These lines, mainly lying on the night side of the Earth, are associated specially with the combination of the ring current and corpuscular flux fields with the Earth's main field. Subsidiary hypotheses are involved, without present proof, to explain several complicated features of the phenomena observed.

Until recently most auroral and storm theories based on solar streams and clouds ignored the possible permanent presence of gas in interplanetary space and in the region around the Earth where the ring current and corpuscular flux current are believed to flow. The magnetic changes associated with these currents were supposed to be transmitted to the Earth's surface as if *in vacuo*. The radio phenomena of whistlers, elucidated by Eckersley and Storey, indicated the presence of electrons in at least part of the region. Parker for a time concluded that this would almost prevent the fields of the ring current and corpuscular flux current from affecting the Earth's surface field. Controversy with Hines finally led to agreement that this bar to transmission was misconceived. But the transmission will be by hydromagnetic waves rather than purely by electromagnetic waves. Chapman in recent years has inferred that the Sun's coronal atmosphere extends up to and beyond the Earth, and that this interplanetary gas is very hot even up to the Earth's distance. He has further concluded that, if so, the Earth's atmosphere could be enormously more extensive than formerly supposed. This would imply that the Van Allen belts lie relatively low in our atmosphere. But the atmospheric gas in their region, though far more dense than the energetic gas of the belts themselves, would probably be too rare to have much influence on the development of magnetic storms and auroras.

OBITUARIES

Prof. Charles Singer

DR. CHARLES SINGER, the eminent historian of medicine, science and technology, died at his beautiful home, 'Kilmarth', near Par, Cornwall, on June 10, in his eighty-fourth year.

A son of the distinguished Hebrew scholar, the Rev. Simeon Singer, minister of the West End Synagogue, Charles Singer was born in Camberwell, on November 2, 1876, and was educated at the City of London School. At the age of seventeen he became a medical student at University College, London. But the delights of biology were at first too strong, and after a year he turned to the study of zoology and botany under Weldon and F. W. Oliver, respectively. After two years of these studies, he was by a chance invited to enter for a scholarship at Magdalen College, Oxford. His success resulted in his spending three years at that College, studying zoology under Weldon (now transferred to Oxford) and under E. S. Goodrich, for both of whom he retained an immense admiration. In 1899 he graduated B.A. at Oxford, and then returned to London to continue his medical studies at St. Mary's Hospital, Paddington.

Singer qualified M.R.C.S., L.R.C.P. in 1903, and at once departed to Abyssinia as the medical officer to a survey expedition to that country. The result was his first paper (1904) on some unusual clinical conditions. Back in Britain, he filled various resident posts to fit himself for a clinical career, and graduated B.M., B.Ch. at Oxford in 1905. He then had an extensive period in a post in the Government Hospital at Singapore. After his return to England, he became physician to the Dreadnought Hospital and concurrently registrar to the Cancer Hospital in Fulham Road. In the latter post he did much clinical research and laboratory research alone and in collaboration with S. B. Schryver. In 1913 he described a nematode worm in a gastric carcinoma in a rat. He discovered it in the same week in which Fibiger published the researches for which he received a Nobel Prize.

Charles Singer had entered the field of the history of medicine in 1911. He took a prominent part in the early proceedings of the History Section of the Royal Society of Medicine, established in 1912. Osler was its first president, and just before the outbreak of the First World War he offered Singer a post at Oxford, the duties of which were to be mainly historical. Singer's tenure of this post was interrupted by the War, during which he served, mainly at Malta and Salonika, with the rank of captain in the R.A.M.C. But before he was commissioned early in the War he had time to establish, with the help of his wife, Dorothea Waley Singer, whom he had married in 1910, a History of Science Room in the Radcliffe Camera, which is still remembered.

After the War, Singer was invited in 1920 to lecture on the history of medicine at University College, London, and for a short time he continued to hold both the London and the Oxford posts. With his resignation from Oxford there began the most prolific period of his life. In 1930 the University of London conferred on him the title of professor, and he became professor emeritus on his retirement in 1942. In 1930 and again in 1932 he acted as visiting professor at the University of California, Berkeley, where he lectured to enthusiastic audiences. In 1934 he removed his residence to the house near Par, in Cornwall, which was to be his home during the remainder of his long life. Many friends from all over the world remember with pleasure and regret the hospitality so generously extended to them at 'Kilmarth'.

Until he was more than fifty, Singer's interests lay mainly in the history of medicine. In that field he published in rapid sequence several works which opened new ground and led to further study by others. His "Early English Magic and Medicine" (1920) was probably the first serious study of Anglo-Saxon medicine since Cockayne. To the history of anatomy he contributed two important books on medieval anatomical texts (1924–25), and in the latter year there appeared his "Evolution of Anatomy", the substance of his FitzPatrick Lectures. This work was virtually the only history of anatomy in English. The close of this book with Harvey indicated the limit of Singer's serious interest in the history of medicine. Apart from ephemeral writings, none of his original work on the history of medicine dealt with events after the Restoration. He was deeply interested in Greek and Roman medicine, in the medicine of the Dark Ages, and in the history of syphilis. His important paper on the herbal in antiquity was published in 1927. His early medical period closed in 1928 with the publication of his "Short History of Medicine".

Singer's interest in the history of science was at first confined largely to biology and the history of microscopy. The first volume of his "Studies in the History and Method of Science" (1917) contained papers by him which were medical rather than scientific; but the second volume (1921) contained his very important study of Greek biology, and also his paper on the invention of the first optical apparatus. Thereafter he published (1922) his useful little book on "Greek Biology and Greek Medicine". After that, occasional papers on biological and scientific subjects began to appear, and in 1931 he published—as a result of his American lectures—his "Short History of Biology", one of his best books, which he afterwards revised twice.

After this, it was ten years before Singer published another important book. In the intervening period he had spent nearly a year in the United States, had removed to Cornwall, and had written many articles and reviews. He had also played a prominent part in the foundation of the Society for the Protection of Science and Learning, for he was deeply saddened by what happened to European scholars before the outbreak of the Second World War. He had also been reading widely in the literature of science, and the result was his "Short History of Science", published in 1941. This work was much read because it covered the whole field to 1900 within reasonable compass; it introduced a new approach and was easily understood. Towards the end of the War he worked on the "Tabulae anatomicae sex" of Vesalius, and later he completed the philological aspects in collaboration with Prof. Chaim Rabin. This work was published in 1946 as "A Prelude to Modern Science".

In the closing years of the War, Singer was asked by Mr. Derek Spence to write the history of the alum trade; Mr. Spence's well-known firm, dating back to 1855, contributed much to the later history of that trade. For Singer this was a new departure, and he devoted several years of enthusiastic work to this effort. The result was the fine folio volume, "The Earliest Chemical Industry", published in 1948.

Singer next turned to three medical projects which had long been in his mind. The first was the completion, in collaboration with his old friend, Prof. J. H. G. Gratton, of a definitive text of the Anglo-Saxon work known as the "Lacnunga". This work was published in 1952, as also was the second of these projects, a translation of the seventh book of the "Fabrica" of Vesalius.

The need for an authoritative work on the history of technology had long been understood by Singer, and after the publication of his work on the alum trade he devoted much time to the planning of a co-operative work on this subject. The drawing up of these detailed plans for five large volumes must be considered as one of Singer's finest pieces of work. It gave him scope for the use and display of his vast knowledge of men and books, and for the extensive correspondence in which he delighted. Although he had associated editors, chief of whom was the late Dr. E. J. Holmyard, Singer played the main part in the planning and editing of this work. The first volume was published in 1954, and the fourth and fifth volumes in 1958. During its publication he completed and published his last original medical work, his annotated translation of "Galen on Anatomical Procedures" (1956).

In 1922 Singer was awarded a D.Litt. at Oxford for his thesis on the manuscripts dealing with St. Hildegard of Bingen. He already had the Oxford D.M. (1911), and in 1936 that University conferred on him the honorary degree of D.Sc. He became a Fellow of the Royal College of Physicians in 1917. Later in life he became a Fellow of University College, London, an Honorary Fellow of the Royal Society of Medicine, and an Honorary Fellow of his old college, Magdalen, at Oxford. He delivered the L. T. Hobhouse Memorial Trust Lecture in 1951, and the Lloyd Roberts Lecture in 1954. He was president of the History of Medicine Section of the Royal Society of Medicine during 1920–22, and first president of the British Society for the History of Science (1946–48). He was also president of two International Congresses held in London (History of Medicine, 1922; and History of Science, 1931). In 1947 he was president of the International Union for the History of Science. He was awarded the Osler Medal and the George Sarton Medal. In 1953 Singer was the recipient of a large work containing historical essays written in his honour ("Science Medicine and History", 2 vols.; London, 1953).

Singer was by inclination and training a biologist, and to the end of his life he rather regretted that he had not taken up this subject as a profession. When the King's School at Canterbury was evacuated to the west of England early in the Second World War, he was induced to take over the teaching of practical biology. For this purpose he had a room in his house fitted out as a laboratory, and during most of the War he taught in it pupils attending that and another school. It gave him great satisfaction that he consistently obtained a very high standard of passes. In botany, Singer was especially interested in the succulents, and in front of his desk there stood a thriving array of these plants.

Charles Singer will be remembered as much for the encouragement which he gave to others as for his own numerous and important contributions to his subjects. His large correspondence testified to the advice which he gave. But his inspiration and encouragement flowed most easily in his conversation. Those who knew him well appreciated that, despite his learning, his humanity was perhaps the outstanding feature of his character. He had a rich fund of humour, and he could talk simply to the unlearned about subjects which were by no means simple. His studies in the local history and customs of Cornwall were unpublished, and were probably known to very few except his Cornish neighbours.

E. ASHWORTH UNDERWOOD

Dr. Geoffrey Builder

THE sudden death of Geoffrey Builder at the early age of fifty-four has deprived the University of Sydney of an original and sympathetic teacher of physics and Australia of a scientist of international reputation. Born in Western Australia, he was educated at Guildford Grammar School, the Perth Technical College and the University of Western Australia. After graduating in 1928 he joined the Watheroo Magnetic Observatory of the Carnegie Institution of Washington and was responsible for developing a radio technique for the rapid transmission of geophysical data to Washington.

In 1931 Builder commenced work under me at King's College, London, on the exploration of the ionosphere, in which researches he was largely responsible for the discovery of the magneto-ionic splitting of pulse radio echoes and the quantitative verification of ionospheric double refraction which had been predicted by a theory of mine. During July 1932–May 1933 he was a member of the British Radio Expedition to Tromsø, in North Norway, organized by the Royal Society as part of Britain's contribution to the work of the Second International Polar Year. It was this expedition which discovered the phenomenon of the polar radio 'black-out', associated with magnetic storm and auroral activity.

After obtaining the London degree of Ph.D., and becoming a Fellow of the Institute of Physics, Builder joined the Australian Radio Research Board in the latter part of 1933. He then played an important part in developing the Board's new experimental techniques for ionospheric exploration and collaborated with the late A. L. Green in researches on the polarization of long radio waves and on the suppression of fading.

Towards the end of 1934 he joined Amalgamated Wireless (Australasia), Ltd., to take charge of its small group of research laboratories. Under his energetic and skilful direction this group developed rapidly until, at the time of his departure for the Army in 1941, it had grown into an effective organization with more than fifty members of staff. Many well-known Australian radio-physicists and engineers owe their selection and early professional training to the shrewd judgment and scientific and administrative capacity which he exercised during this period as chief of research.

While a major at Army Headquarters during part of the Second World War, Builder acted as adviser on radar, and later engaged in defence production as general manager of Airzone, Ltd. After the War he worked as a consultant and founded two electrical engineering companies. During part of this time he was able to give valuable assistance to the Department of Physics of the University of Sydney in coping with its excessive load of teaching. In 1949 he was appointed to the permanent staff of the Department as a senior lecturer and devoted himself largely to giving lectures on electricity and to the duties of the lecturer-in-charge of second-year physics.

As a member of the Faculty of Science he was very active in proposing various reforms and successful in getting many of them adopted. In recent years he developed an interest in the theory of relativity and gave much time and thought to resolving the famous clock paradox of the special theory. These researches were carried out with his usual thoroughness and acumen and, although at times they brought him into conflict with well-known theoreticians, one of his last papers[1] appears to have settled the controversy by showing that "the clock paradox . . . arose solely out of the elementary mistake of utilizing, in a single calculation, quantities expressed in the measures of two different reference systems". Such versatility and depth are not often found among the younger generation of physicists.

Builder's great interest in the welfare of his students, both collectively and individually, and his exceptional combination of technical, commercial and academic experience made him one of the most successful of teachers and a constant source of wise counsel to his academic colleagues.

EDWARD V. APPLETON

Georges Claude

Avec Georges Claude (décédé le 23 Mai) vient de disparaître un des derniers pionniers, inventeurs. ingénieurs, savants, qui ont permis la révolution industrielle qui précéda la Première Guerre Mondiale. Ingénieur débutant, Georges Claude s'intéresse à l'acétylène, rendu accessible par la fabrication au four électrique du carbure de calcium ; en 1896, il crée l'industrie de l'acétylène dissous et permet l'essor de la soudure autogène, du découpage au chalumeau : les techniques de la construction mécanique sont immédiatement transformées.

Claude se préoccupe alors du prix de revient de l'oxygène, non pas tant pour abaisser le prix de la soudure au chalumeau que pour son application à la production des hautes températures. Avant la fin du siècle dernier, il envisage la possibilité de fabriquer le carbure de calcium dans un four à charbon soufflé à l'oxygène ! Ses efforts sont couronnés de succès et la détente avec travail extérieur, qu'il industrialise dès 1902, est universellement utilisée. En 1910, il démontre dans les aciéries belges d'Ougrée la possibilité d'économies substantielles en sidérurgie par l'emploi de l'oxygène. Depuis la fin de la Deuxième Guerre Mondiale, ses prévisions ont été très largement justifiées ; l'avenir montrera, nous en sommes convaincus, que la production du carbure de calcium au four soufflé à l'oxygène n'était pas davantage une utopie.

Claude s'intéresse également aux gaz rares de l'air et réalise la production industrielle de l'argon, du néon, du krypton et du xénon. L'éclairage à incandescence s'en trouve transformé et ces travaux ont conduit à l'éclairage par fluorescence dont nous jouissons maintenant.

Au cours de la Première Guerre Mondiale, Georges Claude s'attaque à la synthèse de l'ammoniaque ; aux 250 atmosphères du Prof. F. Haber, il oppose audacieusement les 1,000 atmosphères auxquelles il prétend travailler, et il y réussit. Son procédé est encore employé et l'on peut dire que les procédés Casale ou Fauser ne sont qu'un compromis raisonnable entre les pressions déjà courantes du temps de Haber et les hyperpressions dont Claude a rendu possible l'emploi.

Du domaine des hyperpressions, son imagination créatrice entraîne Georges Claude vers l'emploi des pressions réduites. Passionné des grands problèmes qui dominent l'avenir du monde, il voit là un moyen d'utiliser l'inépuisable réservoir d'énergie que constituent les océans par la différence de température entre les couches superficielles et les couches profondes de l'eau. Dans une première installation, il réussit à entraîner une dynamo de 60 kW. par une turbine mue par de la vapeur à faible pression qui se condense au contact d'eau froide. La différence de température n'est que de 20° C. ; l'eau de la Meuse lui sert de source froide, et il prend comme source chaude cette même eau servant à refroidir les tuyères du haut-fourneau.

Georges Claude s'engage alors tout seul dans l'expérimentation industrielle. A Cuba, après trois tentatives, il immerge dans le fond de l'océan un tube de deux mètres de diamètre et de plus de deux mille mètres de long. Il réussit à faire fonctionner son turbogénérateur et peut éclairer la station expérimentale qu'il a construite de ses deniers. Une nouvelle tentative pour atteindre une échelle industrielle (2,000 kW.) échoue par suite de l'hostilité des éléments, déchaînés contre un inventeur génial. La fortune considérable gagnée par Georges Claude ne lui a pas permis de mener à bien, tout seul, l'audacieuse expérience de captation de l'énergie thermique des mers.

---

[1] *Amer. J. Phys.*, 27, 656 (1959).

Le succès de l'opération *Pluto* durant la Deuxième Guerre Mondiale, les projets actuels de pipe-lines traversant la Méditerranée sont le fruit de la tentative de l'inventeur français. Au moment où s'estompent les espoirs trop optimistes fondés sur la conquête rapide de l'énergie nucléaire à bon marché, on ne peut pas s'empêcher d'une certaine mélancolie en considérant qu'un effort beaucoup moins onéreux aurait pu réussir à nous mettre en possession d'une énergie équivalente et ne présentant pas les mêmes dangers.

Avec le recul des années, l'oeuvre de Georges Claude prend tout son relief : il fut, dans toute l'acception du terme, un véritable créateur dont le génie inventif a généreusement servi son pays et la civilisation oxydentale. J. CATHALA

NEWS and VIEWS

Mathematics at Oxford : Dr. Graham Higman, F.R.S.

DR. GRAHAM HIGMAN, who has recently been appointed to the Waynflete chair of pure mathematics in the University of Oxford, in succession to the late Prof. J. H. C. Whitehead, is a Balliol man who, apart from a brief sojourn in Cambridge, has divided his academic life between Oxford and Manchester. After the Second World War, he joined the mathematical staff of the University of Manchester as a founder member of the algebra school which has flourished there since that time. He remained in Manchester until 1955, when he accepted a readership in Oxford. As a pupil of J. H. C. Whitehead, he first worked on a problem of topological origin. In his hands it soon became algebraical, and in the rest of his career he has devoted himself entirely to the 'pure' theory of groups, especially infinite groups. To this theory he has made deep and influential contributions. Lately he has turned his attention to the border country of group-theory and logic, in which he has proved a theorem of great interest on the insolubility of certain group-theoretic problems. Dr. Higman was elected a Fellow of the Royal Society in 1958.

Seismology in New Zealand : Dr. F. F. Evison

DR. F. F. EVISON has been appointed superintendent of the Seismological Observatory, Wellington, New Zealand (Department of Scientific and Industrial Research), in succession to Mr. R. C. Hayes (*Nature*, 187, 24 ; 1960). Dr. Evison was educated at West Christchurch High School and the Victoria University of Wellington, graduating in mathematics and physics. In 1947 he went to the Imperial College of Science and Technology, London, as a research student under Prof. J. McG. Bruckshaw, where he developed the technique of experimental seismology in which a transducer is used for generating seismic pulses in the ground. After returning to New Zealand in 1950 to join the Geophysical Survey, he brought this technique to bear on a variety of seismic propagation problems. He also made a study of deformations of strata in coal-mines. In 1956 the Nuffield Foundation awarded Dr. Evison a Dominion Travelling Fellowship in the Natural Sciences, which took him for a year to the Department of Geodesy and Geophysics, Cambridge. Dr. Evison and his colleagues produced the first geophysical evidence that the Antarctic ice-cap is underlain by a continental crust. They have recently extended the work, which depends on dispersive earthquake waves recorded in Antarctica, to obtain crustal thicknesses over the greater part of Antarctica and the surrounding oceans. The Seismological Observatory, Wellington, operates the Antarctic seismograph stations at Scott Base and Hallett, and also stations at Samoa and Raoul Island, as well as the network within New Zealand itself.

The Russian Earth Satellite 1960λ

A SIGNIFICANT milestone on the road to space flight was passed on August 20, when, for the first time, living animals were successfully brought back to earth after being in orbit in space, aboard the second Russian space-ship satellite. This satellite, which weighed 4,600 kgm., was launched at about 08h. 45m. U.T. on August 19, and entered a nearly circular orbit, inclined at an angle of 65·0° to the equator. Its height varied between 306 km. at perigee and 340 km. at apogee, and the period of revolution was 90·7 min. The satellite, also known as *Sputnik* 5, was designated 1960λ1, and was accompanied in orbit by its final-stage rocket (1960λ2). The living creatures in the satellite included two dogs, 40 mice (21 black and 19 white) and 2 rats ; there were 15 phials containing *Drosophila* and 12 with the alga *Chlorella* ; seeds of maize and many other plants, cancerous cells, and a variety of micro-organisms. The satellite also carried a radio transmitter having a frequency of 19·995 Mc./s., and instruments for measuring the composition of cosmic rays and the intensity of solar X-ray and ultra-violet radiation. It is stated that the pulse and rate of respiration of the dogs were measured and their behaviour observed by television, the information being stored and telemetered back to earth. On the eighteenth revolution of the satellite its velocity was reduced by a retro-rocket and it descended through the atmosphere ; all the animals and biological specimens are reported as being recovered in good condition.

Research and Development in Industry

DR. E. J. SOLVAY'S presidential address to the Society of Chemical Industry at Bristol on July 5 reviews the evolution of the chemical industry, and more particularly the part which research has played in the development of the industry. He also stressed the need for more men in scientific research and for the more effective use of such highly trained man-power (*Chem. and Indust.*, 976 ; July 30). Urging a real co-ordination of research programmes on an international scale as the result of agreement freely negotiated between companies interested in the same activities, Dr. Solvay was thus endorsing a plea which Viscount Chandos had made earlier in the year to the British Electrical Power Convention. Lord Chandos, who delivered the Messel Medal address to the Society of Chemical Industry on May 6 (*Chem. and Indust.*, 1037; August 13), did not in that address renew this plea; but, dealing with research and finance in industry, suggested that statements that research and development effort in Britain are too small are misleading. He put expenditure in Great Britain on research and development in 1959 at about £450 million, of which the Government financed one third of that carried out by private industry; about 27 per cent of the total is in the hands of Government and nationalized industry and performed by them. Lord Chandos believes that more attention should be given to the wider implications of this huge research and development effort. Man's ability to create wealth is increasing much faster than is generally appreciated, and we must be prepared to take some risks to ensure that our means of exchange should increase in a planned and calculated way parallel with the new wealth.

Arctic Institute of North America

THE Arctic Institute is inviting applications from research scientists interested in arctic and subarctic North America and in Antarctica. The aims of the Institute's grant-in-aid programme, which last year numbered thirty-five awards ranging in value from 400 to 10,000 dollars, are to support the work of experienced field-scientists and to introduce other competent researchers to polar science. The Institute favours no particular scientific disciplines, but appraises proposals on their individual merit. Grants are usually made for a one-year period. Opportunities for field research in arctic Alaska and Canada have widened considerably since the International Geophysical Year. The Institute can now assist research workers in obtaining laboratory facilities and field-stations for many kinds of work. For example, the Office of Naval Research's Arctic Research Laboratory at Point Barrow, Alaska, offers laboratory facilities for work in oceanography, sea-ice, ecology, geology and soil science, and arctic climatology. The Institute is establishing this year two stations on Devon Island, N.W.T., for glaciological, marine biological and meteorological studies. Opportunities exist at stations on the Ellesmere Island Ice Shelf and Ice Island *T*-3 for work in glaciology, sea-ice, oceanography, and marine biology. The Institute maintains one small glacier station and is associated with another on the northern slope of Brooks Range in Alaska. The Arctic Institute also invites proposals for support of field-research in Antarctica. Applications must be submitted a full year in advance of an antarctic field-season. Further information about the programme and application forms can be obtained from the Arctic Institute of North America, 3485 University Street, Montreal 2, P.Q., or 1530 P Street N.W., Washington, D.C. Applications for grants for 1961 should be sent in before November 1, 1960.

Boris Kidrich Institute of Nuclear Sciences

VOLUME 10 (March 1960) of the *Bulletin* of the Boris Kidrich Institute of Nuclear Sciences at Vinca, near Belgrade, contains twenty-five articles and one laboratory note contributed by members of the physics, physical chemistry, applied mathematics, electronics and radiobiology laboratories of the Institute. Continuing their work on the development of three basic methods—coincidence, 4π and solid-angle methods—for the absolute measurement of beta activity, V. Urošević and co-workers describe techniques and methods developed for the primary standardization of gold-198. The results obtained agreed with measurements made at Harwell on four gold foils to within the limits of the estimated error (2–6 per cent). New apparatus described include a thorium fission chamber, a low-pressure expansion cloud-chamber, and a high-resolution binary and decade counting unit. Nine papers deal with radiobiological topics. The brief news report included in Volume 10 records that during 1959 more than sixty scientists from other research centres visited the Institute. Eight delegations, including representatives of the International Atomic Energy Agency, Poland, France, the U.S.S.R., Cambodia, United Arab Republics, and Ethiopia, were received. A joint meeting of Polish and Yugoslav physicists to discuss beta- and gamma-spectroscopy was held at the Institute during September, a symposium on analytical chemistry during October and a symposium on solid state physics and chemistry during December. The construction of an experimental reactor of 6·5 MW. (2 per cent enriched uranium and heavy water), delivered by the U.S.S.R. in accordance with an agreement between Yugoslavia and the U.S.S.R., was completed, and the reactor, which first became critical on October 28, began to operate officially on December 28.

Geological Research in the Northern Highlands of Scotland

THE past fifteen years have witnessed active development of geological research in the Northern Highlands, with many younger workers added to those of the pre-war period. The new (third) edition of the "Handbook of Regional Geology" on "Scotland: The Northern Highlands", by Dr. J. Phemister, lists more than 150 references additional to those in the original printing of the second edition in 1948 (H.M.S.O. 5*s*. net). The great majority of these concern detailed researches on the structure, metamorphic history and correlation of the Lewisian and Moine metamorphic rocks; but in view of the active controversies centred on the interpretation of much of this work at the present time, it was not deemed profitable to attempt a complete summary and assessment of it in the present edition. The bulk of the 1948 text is reprinted without modification, additional paragraphs directing attention to more recent publications. By this means the Handbook will serve as a comprehensive and unbiased guide in this field of research until such time as the main controversies are resolved and we can welcome a definitive fourth edition.

National Museum of Wales

THE Department of Zoology at the National Museum of Wales, Cardiff, has recently arranged an exhibit to illustrate the interchange of animal species between Wales and some of the Commonwealth countries. For centuries the Merchant Navy has played an important part in this, for animals of different types such as insects, small mammals and lizards as well as plants have been transferred to new parts of the world. Accidental or deliberate importation has led to a mingling of once characteristic types for any particular country. Thus, the British winter-moth is spreading in Canada, the North American grey squirrel flourishes in Wales and other parts of Great Britain, and the British house sparrow is common in New Zealand. The exhibit at Cardiff is grouped around a model of the old Cardiff-registered cargo vessel *Tredegar Hall* and shows a striking series of insects, spiders, molluscs, reptiles and other creatures accidentally landed at the chief seaports of South Wales from overseas.

Ethionine and Plant Growth Systems

It has already been ascertained that ethionine is an antimetabolite of methionine and that it has growth stimulatory and morphogenetic effects on excised roots of tomato grown in sterile media. R. L. Lowther and W. G. Boll (*Canad. J. Bot.*, 38, 437; 1960) have now reported on the effects of ethionine on six different plant growth systems, for example, growth of lateral buds on decapitated dwarf beans, the rooting of excised, etiolated bean hypocotyls, expansion of leaf disks, and so on. It was noted that the pretreatment of sections of etiolated pea shoots with manganese lowered or prevented the stimulatory effect of ethionine. A considerable amount of new observations on various growth effects is set out in some detail. According to the nature of the growth system, ethionine stimulates the effect of auxins or 'antiauxins'. Some relationships between the known effects of ethionine and theories of auxin action, and its possible significance as an inhibitor of adaptive enzyme synthesis, are indicated.

Translations of Soviet Science into English

The Israel Programme for Scientific Translations has been inaugurated to provide English translations of recent and important Russian books in all branches of science. The programme was initiated by the National Science Foundation, Washington, which supports the programme and selects the material to be translated (Soviet Science in English Catalogue, 1960. Pp. 24. Jerusalem: Program for Science Translations, 1960). The first issue of a catalogue of works translated under this programme lists books which will be available some time before December 1960. The books are photo-offset reproductions of originals typed on IBM electric typewriters and are usually bound in cloth boards with dust jackets.

New Filmstrips

To their series of natural-history filmstrips, Educational Productions, Ltd., of East Ardsley, Wakefield, Yorkshire, has added four more which will be well received by school-teachers. One contains a series of frames describing common plants and animals of the hedgerow and will be specially suitable for junior schools; a second is of the same type but takes its examples from woodlands. The third, "Flowers of the Marsh and Pool", is of more use for botany scholars in secondary schools and includes some of the rarer plants as well as the more common. The fourth strip contains some excellent photographs of British and foreign butterflies and is the forerunner of a similar strip which will deal with moths. Each strip is accompanied by explanatory teaching notes.

Ramsay Memorial Fellowships

The Ramsay Memorial Fellowships Trustees have made the following awards of new fellowships in chemistry for the year 1960–61: Mr. Alan Bewick, a general fellowship at the University of Durham; a Glasgow Fellowship to Dr. D. G. Watson at the University of Cambridge; a New Zealand Fellowship to Mr. G. A. Rodley at University College, London; Spanish Fellowships to Mr. José García Contreras, Miss María Covadonga Rodríguez Pascual and Mr. Salvador Oliver Moscardó, all at Rothamsted Experimental Station; a United States Fellowship to Mr. Herbert L. Strauss at the University of Oxford. The Trustees have renewed the following fellowships for the same year to: Dr. P. J. T. Tait (General Fellowship) at the University of Aberdeen; Dr. W. G. Paterson (Canadian Fellowship) at the University of Oxford; Dr. T. Anno (Japanese Fellowship) at University College, London; Mr. F. Baltá Calleja (Spanish Fellowship) at the University of Bristol.

Announcements

Mr. N. Elson has joined Cossor Communications Co., Ltd., as technical director. Educated at Trinity College, Cambridge, Mr. Elson was employed during the Second World War at the Radar Research Development Establishment, Malvern (formerly the Air Defence Experimental Establishment, Christchurch), where he made notable contributions to the development of the wave-guide. Following a period of research on radio wave propagation at the Cavendish Laboratory and in New Zealand, Mr. Elson was engaged on work on guided weapon systems at Ferranti, Ltd., and has been, for the past six years, in charge of the research and development activities of the Racal Engineering and Instrument Companies as chief scientist.

The Physics of Fluids, published by the American Institute of Physics, 335 East 45 Street, New York 17, N.Y., hitherto published bimonthly, will be published monthly, starting in 1961 with volume 4. It is hoped by this means to speed up publication of research on the structure, statistical mechanics and general physics of gases, liquids, plasmas, and other fluids.

The Chemical Society, London, has issued "Handbook for Chemical Society Authors" (Special Publication No. 14), 6*s*. to Fellows, 21*s*. to non-Fellows (post paid). Although primarily intended for authors preparing material for publication by the Chemical Society, the 224-page well-bound volume contains sections on nomenclature and symbols which are of general interest.

Messrs. Johnson, Matthey and Co., Ltd., Hatton Garden, London, E.C.1, have issued a publication, "Products of the Rare Earth Group", recording the properties of the pure rare earth metals and their oxides. The firm can supply the metals in ingots, rods, and sometimes wires, in various states of purity at much lower cost than hitherto.

A conference on Nuclear Physics is being arranged by the Institute of Physics and the Physical Society and will be held in the Department of Natural Philosophy, University of Glasgow, during September 14 and 15. Sessions will be devoted to electron and photon interactions with nuclei at energies below meson threshold; strange particle physics; interactions involving pi- and mu-mesons; nuclear forces and interactions between lightest nuclei ($A < 4$); experimental techniques. The Rutherford Lecture will be given by Prof. C. F. Powell during the meeting; he will speak on "Studies of Nuclear Disintegrations at Very High Energies".

NEW CHEMICAL LABORATORIES IN THE UNIVERSITY OF SYDNEY

By Prof. R. J. W. LE FEVRE, F.R.S.

CHEMISTRY has been studied in the University of Sydney for 108 years. It began in the early 1850's in basement rooms of what is now the Sydney Grammar School, and was transferred to permanent laboratories in the main buildings of the University as soon as these were ready, about 1858. The foundation professor was the Hon. J. Smith, member of the Legislative Council, who went to Sydney from Aberdeen. Under Archibald Liversidge, Smith's successor, chemistry expanded and moved in 1883 to new premises, to which additions were gradually made through the period 1885–1945. Some details of this history appear in *Chemistry and Industry*, 415 (1951), 736 (1953).

The late Mrs. Brightie Phillips presented to the University of Sydney a sum of £100,000 "on the sole condition that it is to be used for the building of a first wing of a new Chemistry School, and in the hope that it will stimulate other donors". Subsequent grants from the Federal and New South Wales State Governments made the planning of a new building a practical proposition. The late Mr. J. J. Cahill, premier of New South Wales, formally commemorated the beginning of construction by unveiling a plaque on October 18, 1956. The project was completed last year, and chemistry is now installed in its fourth location in the University.

Mr. Cahill's successor in the premiership, the Right Hon. R. J. Heffron, visited the new Chemistry School on June 28, 1960, where he addressed a gathering of University Senate and staff members, benefactors, research workers and senior students, the occasion being "a function to mark the opening of the New Chemistry School".

Mr. Heffron traced the history of the present School from its origins in 1851, spoke in terms of appreciation and congratulation of its development, achievements and status, enlarged on the general importance of chemical industry to the State of New South Wales, and outlined the financial responsibilities which his Government has towards universities and education.

Undergraduate classes were not suspended, and the Premier, with other guests, visited the laboratories where students were working to the normal time-table.

The new building is in a contemporary style, contrasting with the older Victorian Gothic buildings of the University, the earliest of which were the work of the mid-nineteenth century architect, Edmund Blacket. Construction was completed toward the end of 1959; but the building has been progressively occupied as portions were finished. Some 146,000 sq. ft. of floor area are provided. The ultimate cost is about £A.1,500,000.

The plan of the building is roughly 'T'-shaped, lying north-west to south-east. The head of the 'T' is a five-storey block 70 ft. by 240 ft., housing all the undergraduate laboratories, service rooms, stores, boiler room, plant room, compressors, liquid-air machine, etc. The wing seen in Fig. 1 behind the main entrance canopy is largely devoted to research laboratories and staff offices. In line with the front door is another wing containing research laboratories, and leading to the foyers of the lecture theatre block. This contains two lecture theatres, each seating 370, and two others, each seating 170. These, in pairs, are placed back to back, with preparation rooms in between. Store-rooms, undergraduates' reading and

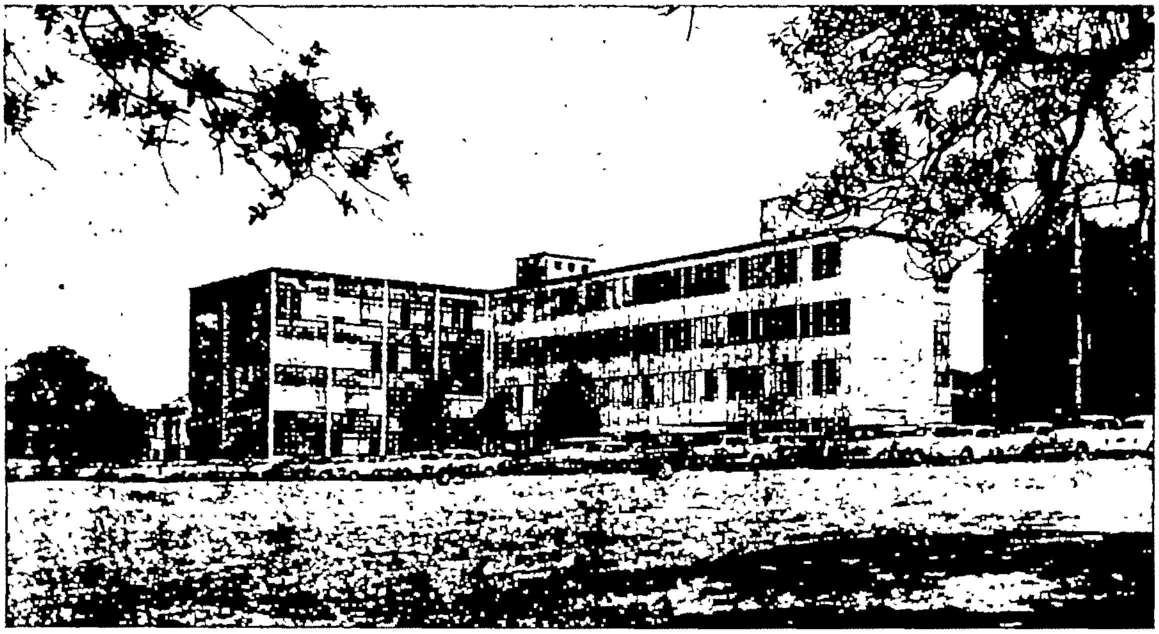


Fig. 1. New chemical laboratories in the University of Sydney as seen from the north

writing room, and a 'kitchen' (making possible the serving of refreshments after public lectures, conferences, etc.) are also in this block. The four theatres themselves are windowless, relying on artificial light and mechanical ventilation.

Features of the building are that all external walls are free of pipes and other extrusions. The roofs slope downwards to the centre lines of each block, along which run a series of vertical ducts containing all rainwater, chemical waste and service pipes, together with fume cupboard and ventilation trunking. Services generally provided include gas, electricity (two- and three-phase a.c. and d.c.), hot and cold water, compressed air, and steam. Outlets for most of these are very generously distributed to ensure maximum future flexibility. Because of the height of the site, water pressure is boosted by compressed air to give a constant 20 lb. per sq. in. on the top floor.

Pleasant features of the completed building are two courtyards to the rear. Here seats have been built and enclose small plots in which shade trees are now being planted. The courtyards are paved with precast concrete slabs, and contain the only explicit luxuries in the whole scheme—two ornamental fountains, and a pair of Italian mosaic tile designs around large supporting pillars, immediately outside the lower lecture theatre block.

Tilden spoke of Liversidge's building as "serving for the present needs of the colony, though in all probability large additions will be necessary before long. About 200 students work in the laboratories . . .". The New Chemistry School in 1960 serves the present needs of some 2,500 undergraduates and about 100 staff and research students. These numbers are expected to increase rapidly; Tilden's remark may soon have to be made again.

PLANT PATHOLOGY IN THE BRITISH COMMONWEALTH

EVERY five years the Commonwealth Mycological Institute organizes a conference on plant diseases which is attended by official delegates from Commonwealth countries, observers from such bodies as the Food and Agriculture Organization, and invited visitors. Similar conferences on insect pests of plants are arranged by the Commonwealth Entomological Institute, the sister institute within the Commonwealth Agricultural Bureaux. This year the two conferences were held in succeeding weeks, and the final day of the Seventh Commonwealth Entomological Conference was devoted to two joint sessions at which agricultural entomologists and plant pathologists discussed topics of common interest. In the morning, developments in the study of plant viruses and their insect vectors with special reference to their bearing on control were considered, and in the afternoon the link between research work and its application in the field of plant protection was reviewed in a series of papers from Canada, the United Kingdom, Kenya and Nigeria.

On the evening of the same day the delegates to the two conferences attended a reception given by the Government at Lancaster House, where they were received and addressed by Lord Hailsham, Minister for Science.

The Sixth Commonwealth Mycological Conference was opened by A. Perera, of Ceylon, chairman of the Executive Council of the Commonwealth Agricultural Bureaux, at the London School of Hygiene and Tropical Medicine, on the morning of July 15, and this was followed by the first plenary session, at which J. C. F. Hopkins, director of the Commonwealth Mycological Institute, reported on the work of the Institute since the previous Conference, a period of expansion marked by the occupation in 1955 of a spacious new building, increase in staff, and an extension of the services offered to plant pathologists and others.

One duty of the delegates is always to review the working of the Institute and to make such recommendations as they may think fit for the next quinquennium. To aid them in this task, and to lay a foundation for their next day's visitation to the Institute at Kew, the papers given during the remainder of the first day dealt largely with different aspects of the Institute's activities.

The primary function of the Institute was to provide an information service, and its main abstract journal, the ***Review of Applied Mycology***, which surveys the world literature on plant pathology, is now in its thirty-ninth year. The exact size and extent of the literature of plant pathology are uncertain. The annual output is perhaps 5,000 items derived over the years from 2,000 current publications, but many of these items are popular and ephemeral. The 3,070 abstracts in the 1958 volume of the *Review* came from 530 different journals, 59 books, and 71 reports—a total of 660 publications—and an analysis of a series of volumes since 1925 suggested that while the scatter of papers is broadening more papers are being noticed from a few major journals. Similarly, the language scatter is on the increase, but while the proportion in French is definitely on the decline, that in Japanese, Chinese, and especially Russian is on the increase; the amount in English now stands at 60 per cent, to which another 10 per cent can be added for papers in languages other than English which have English summaries. With regard to types of disease, the number of papers on bacterial diseases is on the increase but their proportion (5 per cent) seems to be slightly less than it was; those on virus diseases have increased from 6 per cent in 1925 to 18 per cent in 1958. Papers on fungal infections have remained remarkably constant for the past thirty years at about 60 per cent of the total, and thus account for the importance of the Institute's identification service and the help it gives in cataloguing fungi from different parts of the world, especially the tropics. During 1958–59, some 4,000 identifications were made and the Institute's herbarium (Herb.I.M.I.) now comprises more than eighty thousand specimens. There are, however, still many taxonomic uncertainties, and M. B. Ellis, the Institute's chief mycologist, emphasized the benefits which accrue from working visits of both experienced and less experienced taxonomists to each others' herbaria. The herbarium is supplemented or complemented by a collection of living cultures which constitutes the main section of the United Kingdom national collection of fungi, and the curator, H. A. Dade, indicated some of the collection's many contacts and uses. The most recent addition to the Institute's resources is a bacteriological laboratory for the study of plant pathogenic bacteria.

Two-thirds of the world's population is undernourished. The losses of crops from disease are immense. According to E. Hainsworth, preventable losses from crop diseases in Kenya account for one-tenth of the entire agricultural output. In other words, he estimated that one quarter of this loss could be economically prevented by spraying or dusting with fungicides, one quarter by the use of disease-resistant plant varieties, and rather more than one half by the use of seed dressings and the preplanting treatment of seeds. For other diseases no control measures may be available, or the increase in costs from applying an efficacious control would not be commensurate with the increased monetary value of the crop. For example, as J. W. Blencowe and A. L. Wharton of the West African Cocoa Research Institute indicated, though the absolute loss of crop of cacao caused by black pod disease (*Phytophthora palmivora*) in southern Ghana and Ashanti is of the order of 23 and 16 per cent, respectively, and must represent a cash loss of several million pounds, the application of fungicidal sprays is not at present economically justified. The economics of control are, however, under experimental study.

Such data offered to the Conference give clues to modern trends in plant pathology. Up to the First World War may be considered to have been the age of the pathogen. Plant pathology was undertaken by mycologists. Emphasis then shifted to the diseased plant both in relation to the pathogen and the totality of the environment, physical, social, and economic. Plant pathology became a profession. In human medicine, increasing attention is being paid to public health, to the prevention rather than to the cure of disease, and it now seems that this attitude is also gaining ground among plant pathologists. It may be recalled that just over a century ago the Rev. Miles Joseph Berkeley, one of the founders of plant pathology, began his famous series of articles on vegetable pathology in the *Gardeners' Chronicle* with an account of the plant in a state of health. The wheel is turning full circle.

During three days of the reading of papers, some thirty contributions were made by nearly forty different authors on half a dozen main topics, all of current interest.

Throughout the world, and in diverse crops, root rots are being intensively studied. Losses in annual crops can be serious, but the problem of root rots in plantation crops and in forest trees is in many countries particularly acute. I. A. S. Gibson and N. A. Goodchild dealt with *Armillaria mellea* root rot of tea in Kenya, a paper by A. Riggenbach covered white root disease (caused by *Fomes lignosus*) and its control in *Hevea* rubber in Ceylon and R. A. Fox reported on the same disease in Malaya. These tropical examples were followed by a review by J. S. Murray (Forestry Commission) of the increasingly serious depredations caused by *Fomes annosus* among conifers in the United Kingdom. Two further papers, by D. A. Perry (Empire Cotton Growing Corporation) on a *Fusarium* wilt of cotton in Uganda and by C. D. Blake on a banana root rot in New South Wales, provided interesting examples of root rot complexes in the etiology of which nematodes play an important part; successful control of the banana disease being by disinfesting planting material by hot-water treatment and planting in virgin areas or areas which have not carried bananas for at least five years. Such results, and the recognition of nematodes as vectors of some plant viruses, led to resolutions being adopted at the final plenary session for increased emphasis not only on investigations of root rots but also on studies of nematodes, and the desirability of including an introduction to nematology in the training of plant pathologists.

Seed pathology and seed-health testing were comprehensively reviewed at another session by Mary Noble (Scotland), P. Neergaard (Denmark), and J. de Tempe (Netherlands), the three authors of an annotated list of seed-borne pathogens prepared on behalf of the International Seed Testing Association and published by the Commonwealth Mycological Institute in 1958. All concerned with plant introductions are now aware of the extreme importance of being able to rely on any certificates of freedom of 'seed' from disease or disease-inducing organisms which the export or import regulations of their own or other countries may require, but much still remains to be done in devising reliable tests and in ensuring uniformity in their use. These papers and the discussion which followed resulted in another Conference resolution urging the improvement of seed certification schemes, and the production of seed in areas where the incidence of potentially dangerous seed-borne diseases is at a minimum—a resolution particularly appropriate to the eve of the forthcoming 'World Seed Year' being sponsored by the Food and Agriculture Organization.

The elucidation of epidemiological problems in connexion with plant diseases is dependent on reliable procedures for assessing their incidence, so that data obtained by different observers in different areas at different times shall be comparable. Further, rational and economical control measures are also often dependent on the forecasting of disease outbreaks. E. C. Large (United Kingdom Ministry of Agriculture's Plant Pathology Laboratory) gave a lucid survey of these aspects of the annual outbreaks of potato blight in England during the past twenty years where, due to the close co-operation between the meteorological service and the Ministry, the conditions which determine the progress and severity of potato blight are now better understood than in any other country, and regional forecasting is becoming increasingly accurate. In another interesting paper, L. Ogilvie and I. G. Thorpe (United Kingdom) outlined the co-operative investigation in Western Europe and North Africa of the annual spread of black rust of wheat (*Puccinia graminis*), outbreaks of which in the south and west of England in mid- to late summer have been shown to originate in North Africa in the early spring. At another session, breeding for rust resistance was reviewed in papers from the United Kingdom and New South Wales.

Virus diseases, diseases of various tropical crops, and fungicides were dealt with in a further series of papers and discussions. During the Conference a whole-day visit was made to the John Innes Institute on the occasion of the British Mycological Society's annual plant pathology field meeting, and during the week after the conference opportunities were made for the delegates to visit a number of research stations and laboratories.

G. C. Ainsworth

INTRACELLULAR LOCALIZATION OF ENZYMES

A COLLOQUIUM on "Intracellular Localization of Enzymes" was held in Louvain on June 17–18 under the auspices of the Centre Interuniversitaire de Recherches Enzymologiques. The meeting was organized in a similar fashion to that held last year by the same centre on "Specificity in Protein Biogenesis" (see *Nature*, 184, 1198; 1959). A limited number of papers were read by invited speakers and plenty of time was allowed for discussion. In order to favour an informal exchange of ideas, it was decided not to publish the proceedings of the colloquium. The interest of the meeting was enhanced by the participation of a number of foreign guests to an international symposium organized earlier in the week at the Cancer Institute of Louvain, under the Cell Biology Programme of Unesco, on the subject of "Cell Biology and Growth Inhibition". In addition, the sessions were attended by more than a hundred workers from various Belgian laboratories and by a few visitors from abroad.

The meeting was opened by A. Claude (Brussels), who gave an account of the history of cell fractionation and reported his own recent electron-microscope observations on the cytoplasmic granules of kidney tubules. In the past few years, non-mitochondrial granules have been described under a variety of names in a number of different tissues. Their main characteristic is that they are limited by a single membrane and do not contain cristæ, but their size and internal structure may vary considerably from one tissue to the other and even within the same tissue. Claude proposed the general name of 'cytosomes' for these organelles, and put forward the hypothesis that they may represent various functional states of the same entity, possibly related to lysosomes.

The same theme was discussed later by other speakers, namely, S. J. Holt (London), A. B. Novikoff (New York) and H. Beaufay (Louvain). With respect to liver tissue, the two former speakers both showed excellent evidence, based upon cytochemical staining results and further supported by electron-microscope observations, indicating that acid phosphatase is essentially localized within granules arranged along the bile canaliculi, and previously described under the name of peribiliary or pericanalicular dense bodies. Beaufay reported on recent experimental results obtained with several density-gradient centrifugal systems of high resolution and confirming the association of acid phosphatase with numerous other acid hydrolases, as embodied in the lysosome concept. In agreement with the other speakers, he found numerous pericanalicular dense bodies in purified preparations of lysosomes. However, these preparations also contain a second biochemical component, namely, the granules containing uricase, catalase and D-amino-acid oxidase, which are different from lysosomes, as well as a second morphological component, the so-called 'microbodies', which differ from the pericanalicular dense bodies by the absence of ferritin-like grains and the presence of an internal multi-membranous or crystalloid core. Beaufay suggested that these microbodies might represent the uricase-bearing granules, which are known to contain little or no iron. But evidence to the contrary was produced by Novikoff, who found that the liver of rats injected with bilirubin becomes loaded very rapidly with granules containing acid phosphatase as well as with typical microbodies, which appear to be positive for acid phosphatase in a cytochemical staining test adapted to the electron microscope. It was decided that this point required further elucidation.

A serious discrepancy between biochemical and cytochemical staining results was discussed in detail by Holt, who showed that in fixed rat liver, kidney and several other tissues, esterase, an enzyme known to sediment quantitatively with the microsomes in liver homogenates, shows exactly the same localization as acid phosphatase when revealed by staining techniques. It was also shown, however, that esterase is removed selectively from sections of unfixed frozen-dried tissues by immersion in isotonic sucrose. The possibility thus exists that esterase may be loosely attached to the surface of lysosomes in the cells and be eluted from this site and secondarily adsorbed on the microsomes upon homogenization.

A great deal of attention was also paid to the role of lysosomes in cytolysis and in the accumulation of waste products, as well as to their relationship with pinocytosis vacuoles or phagosomes. Novikoff produced evidence, based on the simultaneous histochemical detection of acid phosphatase and of foreign material taken up by cells, as well as on electron-microscope observations, which strongly suggests that lysosomes may be involved in all these processes. Beaufay reported the results of experiments of P. Jacques, in which the biochemical properties of lysosomes and phagosomes were found to be very similar in many respects, though not identical. In the discussion which followed, it was agreed that the uptake of foreign material by engulfing processes may be followed by intracellular digestion and even possibly excretion of residues, and that a number of the vacuoles and bodies observed morphologically as well as the phagosomes and lysosomes may be part of a general system involved in these phenomena. The exact identification of the granules implicated and of their role will, however, require a great deal of additional work. This session was closed by the presentation of a remarkable film on pinocytosis in tissue cultures by H. Lettré (Heidelberg).

The necessity for correlating biochemical results with accurate cytological data was emphasized by C. Allard (Montreal), who showed that feeding azo-dyes to rats causes striking changes in the cellular composition of the liver. Bile duct and connective tissue cells proliferate considerably while the proportion of parenchymal cells decreases. Allard reported further that homogenates originating almost exclusively from parenchymal cells can be prepared at all stages of this transformation by pressing the liver through a mesh which retains the connective, vascular and ductular framework of the organ. Enzymic studies performed on these homogenates

(*Continued on page* 858)

BRITISH ASSOCIATION MEETING IN CARDIFF

THE TWO ASPECTS OF SCIENCE*

By Sir GEORGE THOMSON, F.R.S.

President of the British Association

SCIENCE is already valued for what it can do to increase man's control over Nature, and feared for what some of its consequences may be. Some would have us consider these consequences as the sole justification of science. This view, or something very like it, is the official attitude in Marxist countries, and there are many in Great Britain and in the United States who would be horrified to be told they were Marxists but who without any explicit statement do in fact act and speak as if they thought the same. But this view is too limited. There is a second aspect; it is this.

Science aims at understanding the nature of things: in this it is at one with religion and philosophy. But its approach is the opposite. These last try to gain knowledge of the whole, in one case by an awareness of the Deity, intuitive or revealed, in the other by building with words a system of thought which can account for fundamentals. Science starts from the other end. It begins by studying details, often apparently trivial details but things which are queer and appeal to human curiosity. Things like black rocks which attract iron or rubbed amber which makes chaff fly.

This has been more successful than one could have expected. It is a method difficult to defend *a priori*—it has often been made fun of. Swift ridiculed the philosophers of Laputa who studied how to make sunshine from cucumbers. But the method works.

From the study of details such as these come *concepts*. These concepts, or some of them, show vitality and take charge, as characters in fiction are said by authors to do. They are the bases for hypotheses and 'laws', they are the things that get names—mass, energy, temperature, entropy, wave-length, charge, electrons, quantum numbers, to take some examples from my own subject.

Some do not survive: caloric, phlogiston. Others are deposed from their independence and become vassals of the more successful, as mass has of energy or valency of electronic structure.

But the successful concepts—or the best of them—are not concerned with details any more; they penetrate deep in the heart of things. Electrons, for example, are regarded as present in all ordinary matter, and in any attempt to explain the behaviour of matter, physical, chemical or ultimately biological, one is, if one goes deep enough, forced back on to them. At present they stand as a fundamental concept, but even if, as is quite possible, they ultimately come under some still more general idea, the concept of an electron will still be used, as mass is in mechanics.

It unifies our thoughts over a vast area of facts. Thus there is excellent reason for believing that the whole of chemistry is explicable in terms of electrons and the wave functions which describe their location. This is an enormous simplification of thought, even if the mathematics are too difficult to work out in most cases. It does not much matter from this point of view that test-tubes are cheaper than electronic computers if you really want to know the answer to a practical question.

Scientific concepts enable certain aspects of the enormous complexity of the world to be handled by men's minds. They are suggested mostly by experiment but partly by mathematics, and controlled by the need that they should not lead to illogical consequences.

These concepts represent an extension of the human intelligence. They are not easy; many have subtleties which, for example, oblige the popularizer to take anxious care lest in trying to simplify he make statements which are simply untrue. Some are more fundamental than others, but even those which turn out to be only rough pictures of what really happens often retain their usefulness. They are sketches as compared with finished pictures, and if details are not needed a sketch is often clearer.

Concepts are discoveries as well as, indeed more than, inventions. They have more in common with the discovery of America than with the invention of the spinning jenny or of the electronic computer. Some at least have been forced on unwilling minds by hard facts and have resisted many attempts to displace them. I am thinking more especially of the quantum theory.

Not merely are they an exercise of the human mind which equals the brilliance of any system of thought, philosophical or even mathematical, but they represent reality.

The nature of the relationship is to me a mystery, but they are certainly not merely the product of the human mind.

---

* Presidential Address delivered in Cardiff on August 31 and published in the September issue of *The Advancement of Science*.

Science is a pyramid based on many varied facts, topped with a crown of ideas reaching to the skies. These are its fruit but can change without affecting its stability. I sometimes think that in philosophy the pyramid is the other way up!

What we want as scientists—I am sure in this I speak for the great majority—is that the world should realize that we are not interested merely in making possible new drugs, television sets, or weapons, though all these are important, but in enlarging the bounds of human knowledge.

The greatness of the human race is indeed many-sided. Thus in the world of art there is a difference between the ability to compose or interpret a great piece of music and that which makes possible a great novel or a great picture. Yet all are evidence of greatness and worthy of the name. Still more so is moral greatness. "There is one glory of the sun and another glory of the moon and another glory of the stars."

I have no desire to exalt our profession unduly, but surely the ability to understand, even to a limited extent, the world around him is one of the powers of which man has good right to be proud. Indeed it seems to be the one which most divides him from the animals. The lark's song, the heroism of a plover luring an enemy away from her young, the cat who was seen to attack a grizzly in defence of her kittens—these, if taken at their face value, are notable even by human standards, but I am not aware (though I speak with great diffidence) of any creature which even appears to be trying to discover any general principles.

The chance of understanding things of fundamental and permanent importance is what makes the pursuit of science fascinating and worth while.

These two aspects of science do not in fact conflict. The best way to make advances in technology, whether on the medical or the engineering side, turns out to be to understand the principles. This is quite a recent discovery—indeed it has probably only recently become true. It would not have been much use, for example, to man in the stone age, or even a few hundred years ago, to try to understand the principles of tanning with no basic knowledge of chemistry to guide him. He did better by trial and error. Even the steam engine was developed with little knowledge of the determining principles, though the best scientific minds of the day were much interested, and the thought they gave it advanced science by discovering thermodynamics.

Electrical engineering was the first important activity to be developed from the start on scientific principles, and even here Edison did great things on a decidedly sketchy knowledge. But increasingly more discoveries are made in research laboratories and fewer by workmen on the bench. This is what one might expect. As fundamental principles get known it is possible to use their consequences intelligently. Often these consequences are too complicated to be calculated, but knowledge of the principles is an enormous help by showing in a general way what is likely to happen.

Then of course there are the modern technologies which derive directly from some important new basic discovery, such as electronics and nuclear energy.

This dependence of technology on pure science is now pretty generally recognized by industry. The more progressive industries maintain research laboratories which both make use of the basic discoveries made in the universities and elsewhere, and contribute their own. These laboratories may be owned and operated by individual firms, or be co-operative efforts of an industry in the form of research associations substantially helped by Government. There are black spots of course—industries which spend too little on research or organize it badly—but broadly speaking the need is realized and reasonably well met.

Pure science receives a great return for what it contributes to technology, and this in two ways, materially and in the realm of ideas. Consider first the material return; a modern physics laboratory could not work without instruments developed for technology and obtainable cheaply because industry needs them in large numbers. Take just two examples out of many. The use of high vacua—and how important this is—has been enormously facilitated by the needs first of the electric light industry and then of the manufacturers of radio valves. Again, the complicated electronic devices which crowd every physics research laboratory would be impossible without the cheap components of all kinds manufactured originally for radio and now for television. For this return by industry I sometimes think we academic scientists are not as grateful as we ought to be.

The other influence of technology is more subtle but as important. As science advances, concepts tend to become more and more abstract, further from anything that can literally be touched or handled. To take a simple case, energy is more abstract than mass which it replaces. In the higher flights of theoretical physics abstraction goes much further. Is there not a danger that one may lose touch with reality, and end up by supposing that some elaborate piece of mathematics represents reality when it is only a creation of the mind, inspired indeed by physical reality but no more like it than is a modern picture? I think we are safe so long as the people who make these theories are reasonably close to those who use them, not merely in laboratories but also in industry.

A theory which involves detailed consideration of the behaviour of particles less than a millionth of a millionth of an inch across would have seemed to Swift too absurd to be even worth ridicule. Yet one cannot regard it as a pipe dream when it leads to the great reactors of Calder Hall or Chapelcross. To me, the most amazing thing about science, and the most surprising and exciting fact about our world, is this astonishing connexion between highly abstruse theoretical ideas and the matter of fact, in this case the housewife boiling her kettle with power from nuclei. This surely adds an immense thrill to discovery. I have no sympathy with those who regard technology as intellectually a poor relation of science. To me science without technology is incomplete and inconclusive. Systems of philosophy come and go; some are perhaps true but who can tell? But when conclusions deduced from precise experiments by mathematical theory lead to detailed predictions from which working machines can be designed, machines which without the theory no one would have thought of in a million years, then indeed one knows that one lives in a universe which is rational, and that one has found the key to one of its rooms.

In speaking to you to stress the importance of the idealistic—almost the spiritual—side of science, I am hoping that my words may reach others not here who are brought less closely into contact with it than are most of you.

May I remind you of a few of the ways in which scientific knowledge has influenced and is influencing thought and the intellectual climate of the world? First and most obvious is the idea of evolution, that things change consistently and pass through successive stages, whether they are mice or stars. That living creatures in particular not only go through individual changes, but also that in the flow of generations changes come over the race, or over a part of it, and that these changes lead to profound differences like those which distinguish men from molluscs. In the year of the centenary of the "Origin of Species" just past, you have heard the profound consequences of this idea described much better than I can.

In the course of my life the quantum theory has produced a revolution in physics comparable with that produced in biology by Darwin. We have been forced, some of us very unwillingly, to believe that at bottom the laws of physics are not statements of what *must* happen, but of the relative chances of a variety of alternatives. That the determinism of the planets, for example, occurs merely because planets are enormous on the atomic scale and their distance from the Sun very large, and that the "Nautical Almanack" would be impossible if the solar system was reduced to the scale of a molecule. Certainty comes with a massive body; or if the bodies are small, one must have very many of them so that the laws of statistics can manufacture near certainty out of highly uncertain events, as they do in life insurance.

This makes quite a difference to the way one regards the world, and I think its consequences are still not realized by the average educated man, though it has been accepted by the majority of physicists for thirty years. It shows for one thing how dangerous it is to extrapolate, to attribute—in this case—to the very small the kind of behaviour that is common sense when one talks of objects of large or ordinary size. That, for example, if a particle crosses a flat screen with two holes in it, it must have gone through one to the exclusion of the other. This is not true of an electron.

The quantum theory stresses another point which is fundamental to the modern view of physics—the importance of the observer. An experiment to be of any use must be observed. True, the immediate observer may be a photographic plate which forms a latent image to be developed and examined later, but there must be something. In other words, the scientist can only learn about the world through his senses. Theories are meant to unify sensations and in this sense explain them, but on these sensations they ultimately rest.

The observer first received proper attention in the theory of relativity. So long as there was supposed to be an aether, there was a privileged observer, or class of observers, those at rest with respect to it. Without it all are on the same footing, and equally entitled to be considered. Now relativity asserts that the laws can be stated so as to be the same in form for all; no privilege is allowed.

But relativistic observers, those rather strange creatures who go about with clocks and measuring rods making signals, are not supposed to alter what they observe. The quantum observer does. Or more precisely, the circumstances that attend observation, for example the light that is required, alter what is observed and in a manner which cannot be determined even after the observation has been made. In consequence the knowledge that can be acquired is limited, because each observation upsets something else one would like to know. This was the first real hint that there are definite limits to scientific knowledge, limits not dependent on human patience or ingenuity. The argument depends, as all physicists know, on the finite size of Planck's quantum of action, but a very similar conclusion might have been reached before the quantum theory was thought of.

I think it is curious that physics remained deterministic in philosophy so long as it did. The power of accurate prediction in all systems diminishes with time. Even for the planets, those most orderly of creatures, a "Nautical Almanack" drawn up for the year 10,000 would be appreciably less accurate than one for next year. When one is interested in individual atoms this loss of accuracy can be enormous and catastrophic. Quite apart from any quantum considerations, even if one knew the positions and velocity of every molecule of a small sample of gas at one instant, one could not predict the path of a special molecule distinguished, for example, by being radioactive; one could not find, let us say, where it would first hit a wall of the vessel holding the gas. Even supposing every gaseous collision fully determinate, a small error in an original measurement mounts up, as Max Born has pointed out, with enormous speed. In a small fraction of a second all the detailed information is useless, and one can only treat the motion as one of diffusion to which only a probability answer is possible. So when time is taken into account one gets much the same result even if Planck's constant were many orders of magnitude less than it is. This kind of virtual indeterminacy is inherent in Maxwell's kinetic theory. It sets as real a limit to certain kinds of human knowledge, even given any thinkable extension of human skill, as does the quantum theory. The circumstances to which it applies are almost certainly of more human importance. The further ahead a prediction is made the less certain it becomes, and beyond a certain rough limit all that can be affirmed is a probability, often over a wide range of possibilities. It is an interesting question, for example, what is the best that could ever possibly be done in the long-range forecasting of weather. Can, say, a prediction of the weather on a particular day ten years hence ever have any validity?

Yet in some respects atoms behave in a surprisingly straightforward way. They pile together almost like spheres, like tennis balls in fact. They are slightly compressible and their distances depend a bit on chemical relationship; but one can place them in order in molecules and still more definitely in crystals. The work which is being done by the group at Cambridge under Perutz and Kendrew is a striking example of this. They have located most of the 10,000 atoms in the vastly complicated molecule of hæmoglobin, the first protein for which this has been done.

Single rows of atoms, and occasionally individual atoms, can actually be seen in the electron microscope. They seem as real, and almost as commonplace, as grains of sand.

In contrast to this matter-of-fact behaviour of atoms, the electrons are strange fairy-like creatures. They have no particular place; even when part of an atom, one can at best assign them a region in which they are most likely to be found. Unless they have an unusual amount of energy they cannot be assigned a definite path. Even their approximate behaviour is queer and to treat them properly requires highly abstract mathematics.

They can be created out of the energy of radiation but only in pairs with positive and negative charges, and the positive one soon dies in a suicide pact with another negative. In the same way, protons and antiprotons can be created and disappear. Certainly other kinds of elementary particles also have their anti-particles.

I should like to conclude by referring to two ideas of a somewhat more speculative character which may prove of importance in general thought.

The first is the relation between mass, energy and matter. In conventional mechanics, mass is the primary property of matter, even more so perhaps than extension since it is more constant. Now, as is well known, the theory of relativity made it probable that mass is energy considered from another point of view. This is expressed by Einstein's famous equation $E = mc^2$. Thus if energy is added to, or taken from, an otherwise closed system, the mass of the system will increase or decrease, as the case may be, though it takes a lot of energy to make much difference to the mass. Einstein's conclusion has been abundantly confirmed by the discovery of nuclear energy and other experiments in nuclear physics. Further, as I have just said, energy can be transformed into pairs of particles of opposite sign. It began to look as if matter is just another name for energy.

It may seem paradoxical to equate energy with the property, mass, that measures inertia, but remember that in Newtonian mechanics the bullet penetrates because of its inertia, which makes it continue in its state of motion. However, mass is only one property of matter, and perhaps not even the most important. There are indications, rather slight perhaps, but not to be ignored, that matter is *not* just another name for energy. The study of the many curious particles which have been found in cosmic rays and later produced in the giant so-called 'atom-smashers' has shown the persistence of certain features in spite of the bewildering number of spontaneous changes which these particles undergo. Two groups of these particles have appeared such that the net number in each group remains always the same, and this in contrast to a third group for which there is no such constancy. By the phrase 'net number' is meant the difference, in each case, between the numbers of the 'ordinary' particles and of the anti-particles. Thus electrons are members of one group called 'leptons', to which neutrinos also belong. In reckoning the net number of electrons, one subtracts the number of positrons from the number of ordinary electrons. Thus the creation of an electron-positron pair does not alter the net number. The rule states that no interaction between particles of any kind, including the photons of radiant energy and the mesons of the cosmic rays, can alter the *sum* of the *net numbers* of the three kinds of particles, electrons, neutrinos and μ mesons, which count as leptons. A similar rule holds for the class of particles, protons, neutrons, and some others, which rank as 'baryons'. Leptons can never change into baryons or reversely.

This seems a hint that underlying matter are two classes of entity, each of which indeed can appear in several different forms associated with various amounts of mass, sometimes electrically charged and sometimes not, but yet fundamentally the same. Matter is, I think, more than merely mass or energy. A neutrino has zero rest mass but yet is an entity. A piece of ordinary matter is made up of leptons and baryons in fixed numbers.

The mass of an atom at rest is a form of energy, but matter may be something extra.

This leads to one more instance, my last, of broad ideas derived from physics. It is one of the strangest facts of Nature that she is so fond of whole numbers. The mere existence of large classes of individuals identical in each class such as electrons, protons, atoms of fluorine, molecules of ethyl alcohol and many more is surprising enough. One might expect a continuous gradation of sizes, weights and charges. But it is not so. On the smallest scale only certain types of particles exist. The next most complicated things, atoms, are built of integral numbers of electrons, protons and neutrons. The numbers are fundamental and characteristic. An atom of carbon is a pattern based on the number six, there are six electrons, six protons and six, seven, or eight neutrons according to which of the three kinds of carbon atom it happens to be.

This is such a commonplace of science that one is apt to take it for granted. But surely this, and similar facts about other atoms, are most startling if one thinks. Further, the details of the pattern made by the electrons depend on another set of small integers, the quantum numbers. We cannot say yet whether this is also true of the arrangement of protons and neutrons in the nucleus, but there are indications that it may be. We are getting back to one of the earliest scientific ideas. Pythagoras taught that whole numbers are supreme.

It is worth notice that the masses of the atoms, even reckoned at rest and in the lowest energy state, show only rough regularities. The energy of formation and the mass representing it are variable, and though energy is sometimes divided into units, there is here a continuous variation, for the unit is $h\nu$ and ν can have any value. Yet even here we have units in a sense, and all photons of the same frequency have the same energy.

Molecules, again, are composed each of an integral number of atoms. It is true that at the moment of a reaction it may be difficult to say which atoms belong to a molecule or even if the concept of molecule is valid; but few would deny its importance in general. It is a concept which, though it owes something to the desire of the human mind to simplify, yet arises almost inevitably from Nature. If the Martians are competent chemists they will, sometimes at least, think in terms of molecules.

Rather the same can be said of the concept of a cell. Living matter is generally speaking cellular, and the cells that compose a given kind of tissue are mostly pretty much alike in size and shape. Even the organisms that they form tend, at least, to fall into species each containing very many similar individuals. In many cases also the component parts of an individual are multiplied, for example, scales or leaves.

While the 'atomicity' of electrons is perfect in the sense that each is in principle indistinguishable from any other, and the possibility of exchange without resulting difference is built into the theory, the atomicity of members of a species, of cells, and even of molecules is less rigid; but concepts embodying it are highly useful and represent something real in the world.

At present one can only speculate as to how far the complete atomicity of the elementary particle causes the partial atomicity one sees in biology, or for that matter in astronomy. If it is not a sufficient explanation, then we must look even deeper than the elementary particles for this principle of atomicity, which would make it very fundamental indeed.

I have tried here in a very discursive fashion to remind you of a few of the ways in which science has provided, and is providing, new ideas tied closely to experience, though often experience of a special character. These ideas constitute an achievement of which man may well be proud. It is surely something for beings, so utterly insignificant compared with the smallest of the stars that are scattered with reckless abandonment in the heavens, to be able to understand some at least of the principles which control their existence and enable us to perceive them.

To see these principles as applying equally on Earth, as manifest in the most varied phenomena; in the motions of the tides, in the blue of the sky, in the lightning flash, and in the falling apple; to prove our understanding by creating, on however small a scale, compositions of our own which use these principles in new ways of our own devising; to be beginning to see some light on the nature of living matter and how living forms can transmit themselves to descendants; all these are worth while and worthy to rank with the achievement of sculpture, of music or of literature.

Science is not merely the control but also the understanding of Nature. Its two aspects must be held in equal honour.

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

STELLAR MOTIONS

STELLAR motions relative to the Sun are resolved into tangential and radial components. The former appear as proper motions and are seen as displacements of the direction in which the stars are seen. These proper motions, as Dr. R. v. d. R. Woolley in his presidential address to Section A (Mathematics and Physics) points out, are measured by comparisons between new and old catalogues of star positions determined by meridian instruments, and by comparison of new and old photographic plates. They can only be converted into linear velocities in km. per sec. if the star's distance is known. The radial component of a star's motion is directly observed in km. per sec. through the Doppler shifts in the star's spectral lines. Only in the case of the nearest stars can the distance be measured by the direct trigonometric method. In the case of a moving star cluster such as the Hyades, an independent method exists, as the observations of proper motion and radial velocity are consistent within the errors of measurement with the hypothesis that the motion of the cluster stars is equal and parallel. The geometry of this motion permits a determination of each star's distance. Recent measures conducted at the Royal Greenwich Observatory indicate that the dispersion in the velocities of these cluster stars is less than 0·5 km./sec., the total motion relative to the Sun being about 44 km./sec. The permanence of this motion raises interesting questions.

When the velocities of the nearby stars are resolved into three components along rectangular axes, pointing towards the centre of the Galaxy, the pole of the galactic plane and a third axis (tangential to galactic rotation), it is found that the distribution of velocities in each co-ordinate is more or less Gaussian and inferences may be drawn from the three velocity dispersions, which are unequal. Relaxation of the stellar velocities is incomplete. Discussion of the motion perpendicular to the galactic plane leads to a determination of the average density (due to stars, dust and gas) in the solar neighbourhood.

Stellar motions exhibit a number of cases in which stars apparently wide apart in the sky share a common motion. When this can be established, the distances of the stars concerned can be found, even if the stars are too far away for a reliable determination of trigonometric parallax. Some important cases occur, as has been shown recently by Dr. Eggen, of the Royal Greenwich Observatory. A further case of stellar motion is that of the Cepheid variables. These are all too far away to show measurable trigonometric parallaxes, but the average motion relative to the Sun and its dispersion can be found from radial velocities alone. The distances can be found from the period–luminosity relation, apart from a constant multiplier. This constant multiplier can be chosen to make the average proper motion agree with the average radial velocity. The result is a determination of the zero point of the period–luminosity relation among Cepheid variables. This determines the distance of the Large Magellanic Cloud and indeed of all objects including extra galactic nebulæ which contain Cepheid variables.

CHEMISTRY IS NOT ENOUGH

DR. JAMES TAYLOR reminds us in his presidential address to Section B (Chemistry) that for better or for worse we are living in a society which is based physically on Western science and technology. This has inescapable consequences for the scientist.

To the everyday world science is only a means to an end and not an end to itself. Science is not enough. Chemistry is not enough. Modern societies are pre-occupied with efforts to improve their material conditions. The means which are used depend on the application of scientific knowledge. Only scientists have the necessary training for establishing and using the technologies required to exploit recent major discoveries and those likely to arise in the future. It is clear that they will be brought more and more into technology, and thus into industry, the vehicle by which mankind exploits science for his own ends. It is certain that Huxley's view "that the chief aim of the scientist should be to increase material knowledge rather than human convenience" cannot prevail in modern society, which will be forced to deploy its scientists in a manner conducive to fulfilling its objectives.

The scientist must come down from his ivory tower and play a full part in developing the 'good life'; not merely as a narrow specialist supplying the data of invention, but also in the whole complex of problems which confront us. To prosper we must have an adequate supply of new discoveries and ideas to provide for future progress. In the future such discoveries are only likely to come from the professionally trained scientist and, particularly, the 'academically trained' individual. The laboratory discovery, however, is only one event in a long train which culminates in successful manufacture, and the follow-up involves applied research, development and chemical engineering, in all of which the chemist plays an important and growing part.

While formerly chemical industry was directed by men of non-scientific education, nowadays their place has largely been taken by men with scientific education. Equally important, such men have achieved, in considerable numbers, general and administrative responsibility in financial, commercial, sales and personnel positions throughout the chemical industry, and thus for the first time the scientist is in the position to fashion the ends as well as the means. Scientists are also making an increasing contribution in work study, operational research, analysis of requirements and the study of overheads. In its widest sense the scientists' contribution to industry can be regarded as a philosophy of approach: it is the application of a particular mental attitude which can be shared alike by the scientist, the financier, the salesman and, in the final analysis, the workman.

The scientist and chemist makes his initial contribution via pure science then via technology and industry. He has accepted technology and industry, but finally in the wider world of politics and affairs, where as yet he has neither been accepted nor indeed applied himself, he must deliberately reach out and become an active force. This is his destiny; to this end he was born.

PLEISTOCENE HISTORY OF THE IRISH SEA

TO-DAY—as in earlier interglacial periods—the Irish Sea forms a water-barrier separating Ireland from Britain. But during the Pleistocene glaciations its basin was a broad dry valley down the floor of which ice from Scotland advanced southwards. It was with this in mind that Mr. G. F. Mitchell (Trinity College, Dublin) opened his presidential address to Section C (Geology).

During a later phase of the last (Weichsel) glaciation, ice pressed up against the mountains of Wicklow and of Wales, and the corresponding deposits can be readily recognized on both sides of the Irish Sea. At the same time a lobe of ice advanced down the Cheshire Plain, discharging its melt-waters into the Severn valley; layers of mud in the melt-water gravels have a radiocarbon age of 42,000 years. At Chelford a deposit of mud, which lies below the deposits of this ice-lobe and contains wood of spruce, pine and birch, has a radiocarbon age of 57,000 years. This mud should thus belong to an interstadial stage within the last glaciation. Nothing is known of the early stages of the Weichsel glaciation in the Irish Sea basin.

A freshwater deposit at Ardcavan in Wexford is assigned to the last (Eem) interglacial period. It indicates temperate conditions and a sea-level no higher than that of to-day. In England also the deposits of corresponding age at Cambridge, Ipswich, London and Selsey all lie close to modern sea-level, and give no positive evidence of a high sea-level around the British Isles during this interglacial period.

During the preceding (Saale) glaciation ice advanced as far as Hoxne in East Anglia, where it deposited Gipping boulder clay on top of the famous interglacial deposit. There was a corresponding advance down the Irish Sea, from the floor of which the ice incorporated marine clays and shells. A calcareous shelly boulder clay (easily recognized in many localities) can be traced as far as Cork in Ireland and Fremington in Devon. This advance was preceded and succeeded by local phases in which ice from the mountains of Ireland and of Wales descended into the Irish Sea valley.

The preceding (Holstein) interglacial period saw the Irish Sea standing perhaps 100 ft. above its present level, and its shores covered by evergreen forest. At Kilbeg, Waterford, trees such as fir, spruce, pine, yew, rhododendron and box were dominant, and the deciduous trees were poorly represented. In Barnstaple Bay the beach deposits below the Fremington boulder clay rise to 60 ft. above present sea-level, while still greater heights are recorded in eastern England at Kirmington and the Nar valley.

In the Weichsel and the Saale glaciations ice advanced far south in eastern England and in the Irish Sea. In the Elster glaciation ice reached the Thames valley, and there must have been a corresponding advance in the west. The younger (Holstein) beach of the Irish Sea contains far-travelled erratics, the transport of which is usually attributed to floating ice. But the glacial seas had their shores far to the south and at much lower levels, and only an ice-sheet of Elster age could have carried these erratics to the levels at which they are now found around the Irish Sea. The Giant's Rock near Porthleven in Cornwall and the erratics of the Cork coast indicate the limits of advance.

For the preceding (Cromer) interglacial period we have no record of the vegetation. But a widely distributed shore-platform shows that the Irish Sea must have stood for a considerable time about 20 ft. above its present level. The beds at St. Erth and the Red Crag shells in secondary position in the Isle of Man and in Wicklow show that there must have been still earlier marine periods in the basin.

When the ice of the last glaciation retreated up the Irish Sea it deposited three large moraines. The first runs from Wexford to the Lleyn Peninsula about 320 ft. below modern sea-level, the second from Wicklow to the same point 270 ft. down, and the third from north Dublin to the Isle of Man and thence to England at the same depth. The first moraine may have been quickly drowned by the rising waters of the postglacial sea, but the second and third probably persisted for some time, and provided routes for the postglacial migration of plants and animals into Ireland. If the link between Ireland and the Isle of Man was severed before—but only a short time before—the link between the Isle of Man and Britain, then many of the puzzling features of the modern flora and fauna of the Isle of Man find ready explanation.

TROPICAL CLIMATES AND BIOLOGY

In his presidential address to Section D (Zoology), Dr. G. S. Carter took as his subject a comparison between the results of tropical and temperate biology, emphasizing especially work in the tropics which has given results not to be expected from our knowledge of temperate biology. As an introduction to his address, he gave a short account of the climatic conditions in the tropics that seem most likely to be biologically important, especially the less-marked seasonal rhythms of tropical climates, and the greater importance of variations in the amount and type of the rainfall in determining the nature of environments.

His first example of biological work in the tropics that has given results unlike those of similar work in temperate regions was investigation of the conditions of life in shallow and stagnant tropical swamps. The waters of such swamps are always markedly and sometimes almost completely de-oxygenated, even close to the surface. This is due to several conditions resulting from the tropical climate and not present in similar temperate waters. Of these conditions the most important are protection from wind disturbance by thick plant growth above the water, absence of overturn in the warm tropical nights, and rapid absorption of any oxygen that reaches the water in the chemical and biological processes of decay at the high temperatures. The faunas of tropical swamps are variously adapted to these conditions. The swamps are the habitat of most of the known air-breathing species of fishes, and the invertebrates show many different kinds of adaptation to life in a de-oxygenated environment.

The distribution of sulphur compounds in African lakes gives a second example of unexpected results in tropical biology. In Lake Victoria and other lakes the sulphur content of the water is very low. But when the mud at the bottom of the lake is examined, it is found that its content of sulphur is extremely high to depths of at least 10–15 m., and, surprisingly, that the sulphur in the mud is almost all in organic compounds. It seems that the fauna absorbs sulphur compounds from the water, which thus becomes denuded of sulphur; the sulphur in their bodies is carried down to the mud when they die; and—this is the surprising feature—the sulphur compounds so brought into the mud do not break down even in the thousands of years needed for the deposition of 10 m. of mud. Sulphur can be returned from the mud to the water only if it is absorbed by the roots of the aquatic plants, which contain a normal concentration of sulphur. No similar situation is known in temperate waters.

The control of seasonal rhythms of breeding and migration in the many tropical environments that are nearly invariable in climate throughout the year is a problem not met with in temperate biology. In equatorial rain-forests the only significant seasonal climatic change is in rainfall, and even in rainfall the variation is more in amount than in frequency, for rain falls at intervals of not more than a few days at any time of the year. Yet even in these environments most species show seasonal periodicity of breeding, and many migrate to other regions at definite times of the year. How these periodicities are controlled and especially whether endogenous rhythms play any part in their control was considered.

Finally, the means by which small mammals are able to maintain their water-balance in desert environments was discussed, and, in conclusion, a plea was made for more work in the wide and still largely unexplored field of tropical biology.

WELSH EMIGRATION OVERSEAS

Prof. E. G. Bowen, being head of the Department of Geography and Anthropology at the University College of Wales, Aberystwyth, could scarcely have chosen a more apt subject for his presidential address to Section E (Geography) than "Welsh Emigration Overseas". As he points out, Wales has made a very substantial contribution for its size to the peopling of new territories overseas.

In the main, Welsh emigrants have left their homes seeking employment similar to that which they were accustomed to in Wales. They became farmers, miners, quarry workers and tinplate workers in the New World and in Africa; while in earlier times others had left the homeland in search of religious or political freedom. At present, the majority of Welsh people overseas are engaged in commercial, administrative or educational work. In recent years, the historians have gathered together a considerable amount of information regarding Welsh emigration to individual countries, but no one has yet attempted an overall picture, or examined the matter from a strictly geographical point of view. All this has been made possible by plotting the data assembled at Dolgellau by the Society of Welsh People in Dispersion (Undeb y Cymry ar Wasgar). The overall picture brings out most of the points mentioned above.

Special attention has been directed to the Welsh communities in those countries, such as the United States of America and the Argentine, which lie outside the British Commonwealth. The famous Welsh Colony on the banks of the Chubut River in Patagonia is studied in some detail, and much new evidence is made available concerning the preparations made for the great adventure in the middle of the past century, and the extent to which the Welsh emigrants were misled before they left their native land, concerning the geographical conditions they were going to find in their new homeland in the South Atlantic.

MONETARY THOUGHT AND MONETARY POLICY IN ENGLAND

THE purpose of Prof. R. S. Sayers's presidential address to Section F (Economics) is to review the theoretical approach to the problems of monetary policy, in the light of changes in the institutional and political environment. It is confined to questions of internal policy: the theory is that of a closed system.

Since 1800 all policy has been based on a broad quantity theory approach: a simple supply-and-demand analysis, in which money is regarded as basically different from other commodities. Although the abstract sense of money, as the unit of account, is unambiguous, money in the concrete sense—the medium of exchange—has no parallel sharpness. It is impossible to identify money either by reference to use, or by the absence of interest, and the distinction between active money and idle money is only notional and may mislead.

For the purposes of policy we have to think of the pressure of total demand, and for this purpose all claims potentially useful for incurring market commitments are relevant. This includes the gross volume of trade credit, variations in which can dwarf variations in bank credit. Non-bank credit has no regular proportionality to bank credit. If all these problems are re-formulated with the use of the conventional concept of velocity of circulation, the conclusion remains the same, and there remains the question whether any disturbance sets up equilibrating forces.

The question of the relation between an acknowledged kind of money and other assets with some monetary quality has been debated continually since 1800, sometimes (as in the 'Currency School' period) with great vigour; these controversies are reviewed in some detail. It is argued that the equilibrating mechanism depended on the power of bank rate to instil fears of trade depression, that during a long period this mechanism was overlaid by the extraordinary power of bank rate over the foreign exchange situation, and that the power has been undermined by the 'full employment' policy.

In the inter-war period more attention was given to the equilibrating mechanism, and ideas about the function of the rate of interest in this mechanism were developed particularly by Keynes. These developments in monetary thought are briefly reviewed, and it is shown that the formulations then used continued to depend on the notion that the supply of the means of final payment was of critical importance. The dangers of this kind of analysis have since been underlined by the development of financial intermediaries and by the behaviour of trade credit. In a rising boom, the sources of liquidity broaden, and the rising demand for the means of payment comes too late and is too easily satisfied.

These developments have tended to make the banks relatively less influential, and to narrow the basis on which direct authoritative action has traditionally been imposed. This negative conclusion is the most important of the examples given to show how the shape of theoretical analysis bears upon the practical problems of policy.

STATICS AND THE ENGINEER

SIR ALFRED PUGSLEY'S presidential address to Section G (Engineering), which is prefaced by an indication of the notional difficulties that arise in statics when divorced from engineering and is closed by an emphasis on the power and grace of statics, touches on the interests of schoolboys, mathematicians and engineers alike.

An introductory section brings out the way in which mathematics, and particularly statics, entered into constructional engineering, and seeks to show how the relation between theory and practice in engineering has changed from one in which mathematicians were imposed on engineers to one in which, at least in statics, engineers themselves embrace the theory and seek to advance it.

The outcome of this change is then illustrated in some detail by reference to developments in applied statics in a number of fields. The new understanding of solid friction is seen as the result of a replacement of the smooth rigid body notions of classical mechanics by the realistic, rough and deformable-body ideas of the engineering subject of strength of materials. The limitations of nineteenth-century methods of analysing frameworks, based upon classical statics, are seen to fade before the more general energy methods of this century, linked with ideas of elastic strain-energy; and these energy methods are themselves seen to develop—albeit hesitantly—in the hands of engineers. Some attention is also given to the efforts of engineers to achieve economy in the arrangement of their frameworks.

It is an easy transition from the problems of the plane and space frames of great bridges and airships to those of modern suspension bridges. Here there is added to the usual linear problems of strain energy a non-linear gravitational energy problem due to the great weight of the bridge itself compared with the applied loads arising from crossing traffic.

The development of statics for and by engineering works is further illustrated by the problems that arise in the thin tubular structures of ballistic missiles, the reinforced shells of submarines, and the bathyscaphe cabins of Piccard and his successors for deep-sea exploration. The static stability problems of such tubular and shell-like structures are briefly examined and seen to present new challenges for the future.

THE PEASANT AND THE PAST

PROF. ESTYN EVANS, in his address to Section H (Anthropology), spoke of the peasant and the past, and the significance of present-day folk-life studies for the interpretation of archæological evidence and the better understanding of the food-producing societies of Neolithic and later times. An intense interest in the whole past of man on Earth was a feature of the present age, stimulated on one hand by a growing sense of world unity, and on the other by discoveries which had brought the means of giving precision to the chronology of human history in periods before written records were kept. Some peasant values appeared to be so universal and resistant to change that they may help to illuminate the past. The term peasantry, stripped of its sentimental associations and derogatory implications, could be defined as a traditional society for whom farming was a way of life and not a business investment. It was a part-society standing in a two-way relationship with an élite which was normally an urban society. It had to be sufficiently stable and technologically advanced to be worth exploiting in one way or another, and possession of the plough and traction animals, with distinctive regional types of settlements and field-systems, were normal concomitant features. These indices were traceable by archæological methods, and it could be shown that peasantries or near-peasantries were of long standing in many parts of the Old World. Interpretation of the material evidences of archæology could be supplemented by the use of parallels drawn from folk-life studies among surviving peasantries.

Ecological studies of peasant societies were badly needed. Social anthropologists had tended to devote their attention to 'primitives' and they were often so pre-occupied with such matters as kinship that they paid inadequate attention to variations in economy, technology and society in relation to environment. It was dangerously easy to find isolated analogies between societies far removed in space, and it was more profitable to investigate regional examples before trying to establish universals. In an attempt to trace continuities by using evidence drawn from folk-life studies and archæology, Prof. Evans took Ireland as his example, a region where the archæological record was relatively short and complete, where a vast amount of oral tradition was available, and where peasant folk-ways had not entirely succumbed to the accelerated forces of change. It was sometimes objected that such local studies, by seeking continuities, could lead to the false conclusion that civilization was indigenous. They might, at the worst, breed parochialism and a narrow nationalism. "In groping backwards through our own past," said Dr. Evans, "it is important that we should not ignore the warning light brandished, however provocatively, by the diffusionists, and so fall into the trap of regarding civilization as the product of local evolution."

In fact, folk-lore tended to focus its attention on the periods and phenomena of contact and could thus provide a guide to acculturation. At such critical periods folk-lore and folk-ways tended to be revitalized, though they usually changed their forms in the process. Or outmoded ways, driven underground, assumed magic powers, and many curious survivals provided clues to practices that were probably once widespread. The establishment of more folk-museums as instruments of record and research was urgently called for.

Prof. Evans concluded by directing attention to the relevance of such research to the theme of the Cardiff symposium on world food supplies and population. Perhaps two-thirds of the world's population were primary food-producers at, or not far removed from, peasant-levels. Their practices and values were often out of step with the modern world, but in many areas improved standards of living could be obtained with least disruption by respecting the institutional framework of peasant societies. We should know more about them before they are finally transformed and lose their links with the past.

PHYSIOLOGY OF HEARING

In recent years considerable advances have been made in auditory physiology, especially that of the internal ear. At present, also, there is increased interest in noise as an environmental factor, stimulated largely by the introduction of turbo-jet aircraft into commercial operations, and questions are frequently raised on the possible effects of noise on health, working efficiency and hearing. The time was thus opportune for Prof. W. Burns to choose "The Physiology of Hearing" as the subject of his presidential address to Section I (Physiology and Biochemistry).

Considering first the physiology of the peripheral mechanism, the chief interest resides in the mechanism whereby the ear attains its astonishing degree of sensitivity, such a large dynamic range, and how it can act as a peripheral resolving mechanism for different levels of sound intensity and for different frequencies of sound. The original brilliant theorizations of Helmholtz, and the contributions of Rutherford and others, have now been put to the test of rigorous experimental investigation, using refinements of technique and new approaches, especially those made possible by electronic means. The mechanism of the middle ear and the movements of the structures of the cochlea of the internal ear, as a result of sound stimuli, have been established beyond doubt by the series of brilliant investigations, carried out over a period of years, by G. von Békésy. He has shown by direct microscopic inspection by normal and stroboscopic illumination that the movement of the basilar membrane and associated structures, collectively known as the cochlear partition, essentially takes the form of travelling waves of transverse displacement. These originate at the base of the cochlea and travel towards the apex, in response to sound stimuli. These waves of displacement increase in amplitude, reach a maximum, and then rather rapidly die away. The position of maximum amplitude is broadly determined by the frequency of the causal sound, the high frequencies near the base, and lower frequencies near the apex. The lowest frequencies involve the whole cochlea.

These findings, although they do not substantiate any of the earlier theories, do imply a form of resonance, albeit a rather broad and unselective one, which is capable of performing a somewhat low-grade form of frequency analysis at the periphery.

The means whereby this resonance pattern is transformed into nerve impulses has been intensively investigated, especially at the Central Institute for the Deaf at St. Louis by Hallowell Davis and his collaborators. In a long series of investigations, the findings of Békésy on the vibrational patterns of the cochlea have been confirmed by electrical means and much new information of outstanding importance has been obtained. It now appears that the electrical positivity of the scala media with respect to other tissues is maintained by metabolic activity of the groups of cells known as the stria vascularis, and that this potential represents a store of energy which can be released for the purpose of stimulating the auditory nerve endings when the organ of Corti is moved by sound vibrations. The potential changes known as the cochlear microphonic and its associated potentials, called by Davis summating potentials, now appear to be derived from movements in various directions of the hair cells by displacement of the hairs. These displacements are caused by relative movement between the upper surface of the organ of Corti and the overlying tectorial membrane, in which the hairs are embedded. The anatomically distinct group of hair cells, known as the external hair cells, appear to have a separate function and lower thresholds compared with the external group of hair cells. The cochlear microphonic potentials seem to originate solely from the external hair cells; these potentials are an electrical transcript within limits of the sound stimulus, and together with the summating potentials which, in part, originate from the internal hair cells, appear to act as the stimulus for the action potentials of the auditory nerve. It is now becoming clearer how the information on intensity and frequency of sound is coded in the auditory nerve and that further resolution is added by the activity of synaptic mechanisms higher up the afferent pathways to the brain centres.

In considering the effects of noise on hearing, as distinct from its effects of working efficiency or peace of mind, difficulties arise because of the complexity and variety of different noises, and the variability in susceptibility to hearing damage in different people. However, three types of effect of noise on hearing can be distinguished. Noise may produce temporary threshold shift, which is a reduction in sensitivity lasting for months, hours or days, as a result of exposure to sound. The reduction in sensitivity affects frequencies, in general, higher than those which caused the temporary effects, and this is clearly demonstrable in the case of pure tones, although wide-band noise shows the same tendency. Most of the temporary threshold shift is acquired in the earlier hours of a day spent in noise. The second effect may be called 'acoustic trauma'; and it may arise from short exposure to very intense noise, to a sudden explosive sound. Various degrees of permanent hearing loss, accompanied by some temporary loss, result. The third type is occupational hearing loss, in which daily exposure to noise in the course of work may eventually, perhaps after many years, produce permanent losses of hearing of various degrees. In this case temporary threshold shifts will also occur, but when these have passed off, residual permanent losses can be found. Occupational hearing loss tends to occur at the higher frequencies, and may be detected by an audiometric examination long before it is subjectively noticeable, or any social disability has occurred. Neglect of such signs, or continued exposure, however, will result in a progressive involvement of the lower frequencies, including those used for speech recognition, and if this is so the person will become aware, as will his family, of difficulties in understanding normal conversation.

Loss of hearing due to occupation occurs only in certain noise conditions and in certain people. Significant loss is avoidable by the use of certain measures which are not difficult, but may be tedious and time consuming. These measures include the measurement of the noise exposure in terms of intensity, frequency and duration; and the measurement of hearing. The assessment of hearing loss due to noise must take into account various personal factors, including age, to allow for the normal deterioration of hearing with advancing years. The greatest need at present is for more research into the precise relations between the different characteristics of noise exposure and the effect on the ear. In the meantime, tentative relationships are used in deciding whether a given response to noise is, on average, harmful and whether noise reduction, hearing protection, or other means should be used. However, better knowledge in this field will enable more precise and efficient hearing conservation to be practised.

EXPERIMENT IN PSYCHOLOGY—A CENTENARY AND AN OUTLOOK

THE publication, in 1860, of Gustav Theodor Fechner's "Elemente der Psychophysik" is commonly taken to be the starting-point of experimental psychology. Prof. R. C. Oldfield, in his presidential address to Section J (Psychology), traces some features of the subsequent history of the subject and referred especially to inter-relation of theory and experiment.

Fechner, he said, was an outstanding innovator. He introduced the stimulus–response method, made physical measurements throw light on psychological problems and systematized statistical and experimental design. Psychophysics was one of the first branches of biology to make use of quantitative methods. It was Fechner's misfortune to initiate a period of controversy over the problem of measuring sensation. Hermann Ebbinghaus, in his work on memory, shares with Fechner the distinction of first revealing simple quantitative relationships among phenomena at the psychological level. In both cases the outcome of their work is independent of its particular *rationale*, and its interpretation is still a matter of active inquiry. Bartlett's studies of memory, on the other hand, illustrate the usefulness of experimental work not constrained by the more rigid canons of laboratory procedure, and emphasize both the advantages and the dangers of introducing *ad hoc* concepts. These dangers are more evident still in the activities of the *Gestalt* school, though their brilliant record of novel experiment, and the decisive overthrow of gratuitous preconceptions regarding perception which they brought about, gave tremendous fresh impetus in a wide field of research.

More important, probably, in the long run, were the developments which led to the establishment of physiological and comparative psychology on a scientific basis. Watsonian behaviourism itself had at least the merit of provoking controversies which, when they had subsided, allowed a fresh start on a simpler and more direct basis. But the vital step was taken when S. I. Franz, in 1902, combined the quantitative systematic methods for the study of animal behaviour devised by Lloyd Morgan and Thorndike with the cerebral ablation techniques developed by the experimental neurologists of the nineteenth century. Following the extended pioneer work of Lashley, these forms of experiment are now proving remarkably fruitful, not only in the field of cognitive, but also of appetitive and affective, functions. Progress in these directions can be gained without the need for elaborate theoretical constructs. The importance of the psychologist keeping closely in touch with anatomical and physiological factors, Prof. Oldfield suggests, does not primarily lie in the immediate hope of explanations of psychological functions in these terms, but in maintaining theoretical simplicity and in bringing to light fresh phenomena for fruitful study.

Systematic observation of, and simple experiment on, animals behaving in their natural habitat, so extensively developed by the 'ethological' school, has formed the natural and fruitful complement to laboratory studies. The theoretical formulations of this school have proved less rigid than they initially appeared to be, and much may be expected by cross-fertilization between laboratory, and field, observation.

The possibilities of experiment on human beings are, however, not being neglected, and Prof. Oldfield gives one example, from the field of speech and language, where a fresh theoretical approach and new technical resources have led to rapid progress, with extension into other topics such as attention, where a century ago effective quantitative experiment would scarcely have been thought possible.

In concluding, Prof. Oldfield makes a number of observations about the prospects of experimental psychology. The most important factors making for good progress in the immediate future he believes are avoidance of parochialism, full and free collaboration between psychologists and workers in other relevant fields, the attraction of more young people of first-class ability into the subject and the provision of the right atmosphere for them to learn in as undergraduates and as graduate research students. He thinks that the future of the subject will be that of a biological discipline, destined one day, perhaps, to be instrumental in extending the present range of fundamental biological conceptions. The next hundred years promise exciting developments. But, feeling that there is little present evidence of any real wish on the part of human beings to understand themselves, he is unwilling to predict what their impact on people generally may be.

ORIGIN OF ANGIOSPERMS

ATTENTION was directed by Prof. T. M. Harris, in his presidential address to Section K (Botany), to the fact that fossil botanists have had notable success in bringing ancient plants to light, when they happened to have good material to study. They have been much less successful when they have directed their research to answer a specific question. Their longest sustained effort has been to discover the early ancestors of the flowering plants (Angiosperms), and here they have failed almost completely. The main thing that can be claimed on the credit side from much devoted research is that the fossils which they hoped they would be able to establish as ancestral flowering plants have been proved to be so different that no one now so regards them. Instead, they are representatives of extinct and strangely organized plant families. Progress has been made, but not in the way intended.

Unequivocal knowledge of some early flowering plants would not only satisfy the fossil botanists' desires; it would also have a profound effect on the botany of living plants. In two plant groups, the ferns and the conifers, the right sort of information is at hand from fossils; instead of interminable discussion there is simple agreement on the numerous botanical problems where the fossils tell a clear story.

In fact, little more is known now about the fossil history of flowering plants than in 1860, but what was a doubtful boundary of knowledge then is now a clear boundary. It was then known that fossil flowering-plant organs, leaves, wood, fruits, seeds were common throughout the Tertiary period and as far back as the Cretaceous period, but they ceased rather after the Middle Cretaceous. Before that there were plenty of ferns, conifers and other plants, but very few that suggested a flowering plant. Those few which did suggest one were afterwards taken up enthusiastically for study and shown to be nothing of the sort. Each decade has provided one or two new candidates, and most have since been rejected as the result of much hard work.

Fifty or a hundred years ago it was suggested that the flowering plants evolved in remote and geologically unexplored regions, perhaps near the North Pole, or perhaps on an isolated island, like New Zealand. Then, in the Cretaceous, geographical changes allowed them to escape and to spread over the Earth's surface and presently to exterminate most of the previous flora. As more is learnt, this kind of explanation becomes less likely; there is evidence now, for example, that the flowering plants arose at about the same time and in much the same manner in New Zealand as in Britain. There is, indeed, a current idea that they dominated the land a little earlier in the tropics than in high latitudes; but it is not yet agreed where the Cretaceous poles and tropics lay. There is, too, a current theory that they evolved first in dry and upland regions, the fossils of which are seldom preserved. These theories are, in part, excuses for failure and what is needed more than excuses is a hypothesis which is a recipe, if not for success, at least for vigorous work. It seems, too, that the days of these theories may be numbered now that fossil-pollen is being so widely studied. Pollen blows far, and if the flowering plants were anywhere in force before the Cretaceous it should be possible to find their pollen. So far, what is known is that their kind of pollen appears and increases at the same time as the leaves, or only a little earlier. Before the Cretaceous, there are a few claims for flowering-plant pollen grains, but then there are a few debatable leaves and other organs.

A hypothesis that does make for progress is that the ancestors of the flowering plants were present in the regions that have been studied and that they have been collected, but they have been unrecognized because they are not like modern flowering plants and have been wrongly classified. Anyone looking at a fossil flora where everything is neatly classified might think this preposterous; but, in fact, nearly all fossil genera are based on a single kind of organ known in isolation. Its classification is not secure, but merely tenuous reasoning from very scanty evidence. The genera of the text-books are the minute percentage of fully known ones.

These early fossils should be studied, not as early angiosperms, for that is to invite disappointment, but for whatever can be learnt about them. The new facts will provide surprises; that is, sometimes things will be found so new as to be contrary to expectation. Prof. Harris pointed out that nothing is more contrary to his own expectations when he studies a little-known fossil of pre-Cretaceous age that it will prove to be a flowering plant, but since it is almost unknown almost anything may happen: therein lies hope.

THE DANGEROUS CONCEPT OF THE NATURAL FOREST

RELATIVE to agriculture, forestry is still a very young science. The bulk of the world's timber still comes from natural, rather than managed, forests. This being so, it is perhaps not surprising, as Mr. T. R. Peace points out in his presidential address to Section K* (Forestry), that foresters should tend to turn to the natural forest as an ideal toward which they ought to aspire. Many mistakes have been made in the creation of artificial forests, and a tendency has developed to attribute these to departures from natural forest conditions. No one would deny the desirability of more research on forest relationships, but there is no need to evaluate these relationships on the basis of their occurrence in the natural forest. The agriculturist no longer bases his practices primarily on the behaviour of wild plants, and it is certainly necessary to consider whether the forester should do so.

A managed forest, in so far as timber is being removed from it, is inevitably different from a truly natural forest. In fact, there are normally many other differences, especially if the forest is planted. The forester often uses trees which are exotic to the area in which he is working. He usually creates even-aged and often pure forests, whereas natural forests are nearly always uneven-aged and mixed. The forester can improve his forest sites by practices such as ploughing and manuring. He can also improve his crops by selection of species, provenances or individual trees of especially high quality.

Believers in the natural forest tend to decry the use of exotics; but exotics have been planted successfully in many countries, especially in Britain. In any event, the conception of exoticism is based on a misunderstanding of the bases of the natural distributions of plants.

While it is admitted that pure crops inevitably present certain enhanced disease risks, it is clear that they have certain sylvicultural advantages. It should not be assumed that their disadvantages, where these occur, cannot be overcome by appropriate techniques.

From a production point of view, uneven-aged stands have very definite disadvantages. If one does not accept the concept of the inherent desirability of the natural forest, it is hard to find any good reason for their retention.

Admittedly, the use of pure coniferous crops may possibly have undesirable effects on forest soils. It is, however, clearly necessary that this effect should be better understood and evaluated, before admixture of broad-leaved trees is generally advocated. In this connexion, it is considered that the influence of mycorrhiza has often been exaggerated.

The study of the biological relationships of the natural forest will provide valuable data towards our understanding of forest relationships in general. It is, however, highly undesirable that the conditions existing in the natural forest should automatically be regarded as ideal, and any departures from them as retrograde steps.

If we are to make that progress in the acquisition of knowledge, which is necessary for a proper understanding of forest processes, it is dangerous to limit ourselves at this stage by putting forward general principles, even if they appear to have a sound foundation. To burden ourselves with a concept so vague as the general desirability of the natural forest is doubly dangerous.

SIXTY YEARS OF PROGRESS IN ENGLISH EDUCATION

IN his presidential address to Section L (Education), Prof. H. C. Dent points out that in 1900 England was educationally a sadly under-developed country. But the first decade of the twentieth century was one of explosive reform in many directions. Responsibility for all public education was for the first time vested in a single central authority by the establishment of the Board of Education, which took over in 1900. The Education Act, 1902, transferred local responsibility for public education from *ad hoc* school boards and voluntary bodies to the county and county borough councils, and, by granting them powers to provide and aid education 'other than elementary', created a statutory system of secondary education. This system was expanded rapidly, and its social range greatly widened by the introduction of the 'free place' scheme in 1907. Meanwhile, between 1900 and 1909 the number of universities in England was doubled.

Local education authorities were in 1906 empowered to provide school meals for necessitous children, and in 1907 required to set up a School Medical Service—a reform which within a generation effected a revolutionary improvement in child health.

The First World War focused attention on the exploitation of young workers. Though the attempt, made by the Education Act, 1918, to establish post-school day-continuation schools proved abortive, this Act established fourteen as the school-leaving age without exemptions, thus abolishing the 'part-time' system; and by requiring local education authorities to provide advanced and practical courses for older children in public elementary schools, paved the way towards secondary education for all.

A decisive step was taken towards this by the first Hadow Report of the Consultative Committee of the Board of Education, "The Education of the Adolescent", published in 1926, which presented the concept of education as a continuous process conducted in successive stages, of which the first, up to the age of eleven plus, should be regarded as 'primary' education, and the second, available to all, but in different forms to match different abilities, as 'secondary' education. Uneven but unceasing advance towards this ideal was made up to 1939 by 'Hadow reorganization'—the provision of separate schools for primary and post-primary education within the public elementary system. Further reports by the Hadow Committee, published in 1931 and 1933, offered blueprints of curriculum and method for the junior and infant sections respectively of the primary school. These are the bases of contemporary practice.

The Second World War initiated another era of explosive reform. The Education Act, 1944, re-organized the statutory system of public education into progressive stages, and established the principle of secondary education for all. Concurrently, there began an expansion of university and other higher education which bids fair to be without precedent in our history.

We are still in the earlier stages of the present advance. Perhaps more remains to be achieved than has been so far, especially in the sphere of quality. But what has been done since the War should not be under-estimated; it is a very remarkable achievement. The next ten years are likely to prove absolutely crucial, for within them we must match our man-power with our ambitions—we have not yet successfully done so.

PASTORAL SYSTEMS IN RELATION TO WORLD FOOD SUPPLIES

DR. WILLIAM DAVIES, in his presidential address to Section M (Agriculture), directed attention to the fact that world pastoral systems can be classified into five groups: (1) very intensive (supporting 80 cattle units per 100 acres), being typical of the best in Great Britain or New Zealand; (2) intensive (40 cattle units per 100 acres), the average in Great Britain; (3) moderately intensive (20 cattle units per 100 acres), typified by marginal grasslands in Great Britain; (4) extensive (10 cattle units per 100 acres), typified by ranching in the United States; and (5) very extensive (3–5 cattle units per 100 acres), which is typical of the extensive cattle ranching in Africa, Australia and the Americas.

International production data, as published by the Food and Agriculture Organization, are used to estimate the present stock carried in the various pastoral regions of the world. These data are reduced to the basis of a standard cattle unit, the latter being based on data collated and published by the British Grassland Society (1955). In the figure for cattle units all classes of domesticated grass-eating animals are included, for example, cattle, buffalo, horses, camels, mules, asses, sheep and goats.

Two-thirds of the area under 'grassland' in the five continents is occupied by extensive pastoral systems, and these carry about one-third of the total of the world population of grass-eating animals as calculated to a standard basis of cattle units. At the present time grass-eating farm animals total nearly 900 million cattle units for the world as a whole. Half of these are found within the 'tropics' (here defined as 30° N.–30° S.). These produce one-third of world meat supplies, one-fifth of the milk and other dairy produce and a large portion of the hides, skins and animal tallow in world trade.

Each pastoral system is examined, first in the *status quo* and then in terms of potential as suggested by the findings of grass/animal research and experimentation within each zone concerned. Very large and economically important advances have already been made as regards the improvement of grassland and increased output of meat and milk within the intensive pastoral systems of Europe, America and Australasia. Much research activity is in progress which suggests that yet greater advances in output from grassland are easily possible in the not too distant future.

As regards the extensive pastoral systems, few or no detailed grassland researches have been made until recently when Australia and East Africa in particular have caused such work to be initiated, already with notable advances. On the basis of the findings of currently conducted research there is evidence which suggests that large increases in total output of animal products are possible both technically and on the basis of economic profitability. If this proves true, then very large aggregate additions can be made to the world supplies of meat and milk following sound measures of grassland improvement on the ranches of the world.

The need is for agronomic research into the grass/animal/soil complex and particularly in extensive pastoral zones. There exists a serious paucity of both research and advisory agronomists. Farmers as well as governments everywhere must be made cognizant of this position, for if the world is to be fed adequately, there must be an increase in numbers and in gross outputs of farm animals. The answer lies in the steady improvement of grassland, animal and also of soil in every continent. This requires well-planned research and advisory services which are the intimate concern of adequately trained grassland agronomists who can offer sound guidance, but who must have the full support of governments and of the agricultural industry everywhere.

POPULATION GROWTH, FERTILITY AND POPULATION POLICY

IN his presidential address to Section N (Sociology), Prof. D. V. Glass remarks that although we are concerned with the population problems of to-day and of the near future, discussion is so often linked with the name of Malthus that it is desirable to re-examine the context in which Malthus wrote, and to consider whether his recommendations have any relevance now.

Malthus was far from opposed to population increase as such. His concern was with the *rate* of increase, and his recommendations aimed at reducing that rate by delaying marriage. He was opposed to birth control, not only on moral grounds but also because he regarded the 'tendency' of population growth to press upon the means of subsistence as itself a stimulus to individual industry and to social and economic progress. Birth control, he believed, by enabling parents to decide upon the number of their children, would remove that stimulus.

Since Malthus wrote, the main elements in his argument have been largely discarded. Both public and private morality have come to accept birth control. The Catholic Church now accepts responsible parenthood and family planning, though only by abstinence and by the use of the 'safe-period'. Events have also shown that population pressure is not necessary as a stimulus to individual or social action. It was Malthus's successor at the East India College, the Rev. Richard Jones, who saw that it was not primary wants for food, but the secondary wants—capable of indefinite extension—which would constitute the brake on population increase. The intervention of birth control has not reduced the power of this brake; on the contrary, it has been enabled to act with greater effectiveness.

Further, when Malthus wrote, he was concerned especially with Britain, and with the possibility that rapid population growth might lower levels of living. Growth-rates were not, in fact, very rapid in relation to technological development at the time. To-day, in under-developed countries, growth-rates are frequently greater than 1·6 per cent annually. Further, the much more powerful means of reducing mortality may well raise growth-rates above 2 per cent per annum during the next two or three decades. At the same time, levels of living are so low that the first priority must be to raise them rather than to control population growth. Moreover, most economists regard that as possible. Though they view rapid population growth as a hindrance, they do not consider much slower growth an indispensable prerequisite for improving the levels of living in under-developed societies.

Higher levels of living are also necessary if population increase itself is to be re-adjusted. It might appear easier for birth control to spread in under-developed societies to-day than it was in the West during the nineteenth century. There is not the same degree of opposition from organized religion, and some governments have adopted policies for encouraging the use of birth control. But in the present context, the pressures in under-developed societies are not such as to induce many couples seriously to limit the size of their families. Though there is a generally 'favourable' attitude to birth control, positive interest often does not develop until couples have had four children. The fall in the birth-rate in Japan since the Second World War, though it has taken place against a background of official policy and of official and unofficial publicity, is not an example of what can be achieved by persuasion alone in under-developed societies. For in many essential respects, Japan is a highly developed society, with an advanced technology. Moreover, unlike India, Japanese tradition as such involved the control of population growth. Rapid economic and social change is needed if levels of living are to rise substantially in the face of rapid increase of population. Such change is also needed to provide the basis for new aspirations, without which the re-adjustment of population increase itself is unlikely to take place.

SCIENCE BROADCASTING IN SOUND AND TELEVISION

MR. A. B. OLDFIELD DAVIES discusses in his presidential address to Section X (Assembly of Corresponding Societies) the scope and form of science broadcasting in sound and television. Science broadcasting ranges from incidental references to scientific matters in magazine programmes like "At Home and Abroad" and "Matters of Moment" (sound) and "To-night" and "Panorama" (television) to more direct attempts at conveying scientific information by means of regular series of science broadcasts, the oldest established of which is "Science Survey". With a wide appeal because they deal with out-of-doors matters are various programmes on nature study, rural lore and astronomy. In addition to what may be called the staple fare of science programme' in television, of which the series "Eye on Research's is a regular ingredient made notable in 1960 by two special series intended as a prelude to the tercentenary celebrations of the Royal Society, there are the single, quite ambitious, even spectacular, programmes on subjects of current scientific importance once or twice a year.

In science broadcasting, as in all broadcasting, it is necessary to be clear as to the nature of the audience to be reached. Here sound broadcasting with its four domestic programme services has a range and flexibility denied to television which has not the same facilities for catering for minority audiences. The British Broadcasting Corporation's schools programmes, which pay considerable attention to science, are a clear example of catering for a particular audience, which looks and listens under conditions which are known, the pattern and purpose of the broadcast being the result of close consultation with various educational bodies. Here, too, the broadcaster can rely on the teacher to ensure that what is broadcast is likely to be grasped and understood. There is also consultation with outside bodies and individuals in planning adult programmes, but it is more spasmodic. There is no regular channel. Should there be a science advisory committee as there is a music or an agricultural advisory committee? Should there be in the British Broadcasting Corporation a department of science as there is for drama, music and religion? But science is not something which comes to life when it is performed. What is important is that there should be qualified scientists on the staff who are dedicated to the important job of communicating through sound and television broadcasting. Being a scientist is one thing, being professionally keen on communicating especially in terms that the masses understand is another. A person combining these qualities is not easily found. Yet more and more scientists are ready to communicate through broadcasting. In the six months of last winter more than a hundred different scientists took part in science programmes, not counting twenty-five scientists who broadcast in the Welsh language during the same period.

To assess the effectiveness of science broadcasting is not easy. The British Broadcasting Corporation's Audience Research Department helps to obtain the kind of information which a theatre or concert manager gets from his box office returns, or from the immediate reaction of the audiences to what is offered them. There are certain imponderable results which might become apparent over a period: general appreciation of the work of scientists, some notion of what they are after and the spirit that animates them, and a growing respect for knowledge as something good in itself.

THE CARDIFF REGION

The Cardiff Region

A Survey. Chairman of the Editorial Committee: Sir J. Frederick Rees. (Prepared for the meeting of the British Association held in Cardiff, 31 August to 7 September, 1960.) Pp. xv+222+24 plates. (Cardiff: University of Wales Press, 1960.) n.p.

IN the words of Sir Frederick Rees, the chairman of the editorial committee of "The Cardiff Region: a Survey", "During the last forty years great changes have occurred in the region and in our detailed knowledge of it. This survey endeavours to record some of these". The period of forty years is mentioned since the British Association last met in Cardiff in 1920. It also met there in 1891.

Thirty-two contributors, mainly from University College, Cardiff, have produced a volume full of information for the members of the Association. There are sections on landscape and climate; geology; botany; zoology; archæology; history; population; industrial structure; agriculture; the Welsh language; place-names; the literary tradition in Latin, Welsh and English; and educational institutions. It is impossible to mention all the contributors by name, but as all members of the British Association will see, they have done an excellent job.

The population of the city of Cardiff is now 253,000. Two million people live within a radius of thirty miles. Yet in 1801 Cardiff was a provincial market town with a population of only 1,870. As Prof. Brinley Thomas points out in the section on "The Growth of Population", Cardiff is there because of the Industrial Revolution; in particular, because of steam coal. In the early years of the Industrial Revolution the great centre in South Wales was Merthyr Tydfil, which in 1841 had a population of 35,000—three times that of Cardiff. But in 1841 the Taff Vale Railway, between Merthyr Tydfil and Cardiff was opened. There were soon extensions to the Aberdare Valley and the two Rhondda Valleys. Then Cardiff came into its own, for it is the natural outlet for the steam coalfields of South Wales. It soon developed the largest coal-exportation trade in the world.

The peak of the coal trade was just before the First World War. The population in 1911 was nine times the 1861 figure, and coal exports at nearly ten million tons had increased fourteen-fold in the same period. But although the peak came around 1911, the decline set in somewhat earlier, when because of inadequate port facilities in Cardiff, a large proportion of the coal trade was diverted to the nearby port of Barry. Barry's growth was even more sensational than that of Cardiff—from 494 in 1881 to 33,763 thirty years later. In common with other rapidly expanding towns, Cardiff at this time had a large migrant population. In 1911 only half the inhabitants had been born there.

But the growth of Cardiff is inseparable from the growth of the region, and the key to the region is coal. Coal has been worked in Glamorgan for hundreds of years, but until the eighteenth century it was on a small scale, chiefly at outcrops. Some was shipped across the Bristol Channel to Devon and Somerset.

The Industrial Revolution in South Wales started in the region of Merthyr Tydfil. In 1759 a partnership of nine people leased mineral rights in the area and started to build furnaces for smelting iron. One of them was Isaac Wilkinson, who introduced the process of coking coal for smelting iron in place of charcoal. The manager of the enterprise was John Guest, and he and Richard Crawshay, who later obtained control of a neighbouring area, founded the two great families of South Wales ironmasters—the Guests and the Crawshays.

The ironmasters were responsible for the building of the Glamorganshire Canal, from Merthyr Tydfil to Cardiff, and this Canal was the most important factor in the development of Cardiff up to 1840. Before that date not much importance had been attached to the exportation of coal, but in the 1840's, especially after a market was found for it in France, the steam coal from the Aberdare and the Rhondda Valleys began to dominate the region instead of iron. Pithead gears appeared up and down the pastoral valleys, and people moved in. By the beginning of the present century, the population of the Rhondda alone was more than 112,000. The tremendous demand for coal during the second half of the nineteenth century brought prosperity to the region, and led to the growth of the outlet port of Cardiff and later to the new port of Barry.

Coal may have become dominant in the mid-nineteenth century, but there were still plenty of ironworks. However, the development of steel technology in the 'sixties led to the closure of many of the smaller works and the growing dependence on imported ore led to re-siting closer to the sea or tidal estuaries.

The whole economy of the Cardiff region in the first part of the present century turned on coal, iron and steel, which is why the region was so hard hit by the depression in the 'thirties. World markets were contracting, and oil was a growing competition to coal. The result was mass unemployment and the hunger marches. Many left the region for the more prosperous Midlands and London. Between 1921 and 1931 there was a net loss of 230,000 people. The tide began to turn in 1935 when Richard Thomas and Co. bought the old steel works in Ebbw Vale and built there a new strip mill for the production of tin-plate. A trading estate was established, as part of a policy of diversification, and attracted a good many industrialists. By the end of the Second World War it was employing 17,000. By July 1955 unemployment in the region had fallen to 13,400—a peace-time record.

Coal and steel are still major industries in South Wales—the region produces 26 per cent of Britain's steel and has some of the largest and most modern works in Europe; but there are now many other industrial activities as well—aluminium, electrical engineering, synthetic fibres, for example.

The history, as opposed to the prehistory, of South Wales begins with the Roman conquest. The Romans made contact with the local tribe, the Silures, in A.D. 47 and fighting continued for thirty years or so. As usual, the Romans built forts and roads to facilitate the policing of the region. The remains of a typical fort is the Gaer, near Brecon. It comprised at first a rectangle of about eight acres with defensive earthen walls and ditches. Stone walls and gatehouses were added during the second century A.D. Towns grew up around the forts; for example, at Caerwent, where there was a regular street lay-out, public buildings, baths, houses and shops. Part of the defensive wall there still stands, 17 ft. high. At Caerleon, which became an important base about A.D. 75, there are also the remains of an amphitheatre in good condition.

From the departure of the Romans in the late fourth century to the Norman Conquest the history of the region is obscure, but during that time Christianity was introduced and the kingdom of Morgannwg established.

It was Morgannwg that opposed the Normans, under Robert fitz Hamon, Lord of Gloucester, during 1090–93, and he built a moated fort on the site that was later to be Cardiff. Fitz Hamon established feudal manors all over the plain close to the sea, but the mountains were left to the native Welsh.

Throughout the twelfth and thirteenth centuries Glamorgan was the scene of prolonged squabbles and wars, in which the Clare family and Llewellyns were greatly involved. The Clare family gradually gained control of the whole country but they lost it in 1314, and until the Act of Union under Henry VIII it was a pattern of mistake by the various Earls and their officials and rebellion by the Welsh. The new shire of Glamorgan, created by Henry VIII, had Cardiff as its county town.

To-day, Cardiff is the capital of Wales and has one of the finest civic centres in Britain. Adjoining the civic centre is the castle in 400 acres of parkland which was presented to the city in 1947 by the Marquess of Bute. Cardiff is still a major port for South Wales, and the dock area is an important part of the city. The notorious Tiger Bay is no longer what it was, and a recent film with that name was much criticized as not presenting a true picture of the city. Llandaff, a suburb of Cardiff, has been a religious centre for more than 2,000 years, and its fine cathedral dates from the twelfth century. It has been restored many times, and the most recent restoration after bomb damage in the Second World War includes the great choir arch bearing the Epstein "Majestas"—a figure of Christ in aluminium.

The Cardiff region has a remarkable variety of landscape in a small area. To the north is the South Wales Coalfield with its characteristic densely populated valleys—Rhondda, Cynon, Taff, etc.—reaching up into the moorland. Unlike the Midlands and South Lancashire, no one in the South Wales conurbation is far from open country. Farther to the north are the gaunt bare Brecon Beacons, nearly 3,000 ft. high. The steep northern scarp of the Brecon Beacons commands the valley of the Usk, in which the market town of Brecon lies, and to the east are the Black Mountains, less broken up, and more of a natural barrier than the Beacons. The Beacons, Fforest Fawr, the Black Mountains and the Usk Valley form the Brecon Beacons National Park.

To the north-west of Cardiff are the valleys of the Wye and the Monmow—a region rich in medieval buildings. There are Chepstow Castle on its limestone cliff, overlooking the Wye, the great Cistercian abbey of Tintern dating from the thirteenth century, and the bridge over the Monmow at Monmouth—the only one in the country with a two-storey fortified gatehouse. Closer to the sea, the land is flatter and intensively farmed. The lower Usk Valley is one of the best cattle-fattening areas in Wales.

All in all, the Cardiff region, besides fine scenery, provides things of interest to all sections of the British Association. For the physicists there is the Department of Physics at the University and the Post Office Radio Research Laboratory. For the chemists, works of Pilkington Bros., Imperial Chemical Industries, Ltd., and Monsanto. For the geologists, there is the South Wales Coalfield; and for the zoologists, the coast, dunes, caves and mountain lakes. No section is short of interesting excursions.

BRITISH ASSOCIATION PRESIDENT FOR 1961: SIR WILFRID LE GROS CLARK, F.R.S.

SIR WILFRID LE GROS CLARK, Dr. Lee's professor of anatomy in the University of Oxford since 1934, and Fellow of Hertford College, has been elected president of the British Association for the Advancement of Science for 1961. That year, the annual meeting will be held in Norwich.

Sir Wilfrid has achieved world fame as a human anatomist with special reference to palæontology and anthropology. Moreover, recognizing that the scientist should be interested not only in the science of discovery but also in scientific exposition and teaching, he has played a major part in the re-orientation of human anatomy as an academic discipline. This is exemplified by the organization of the new Department of Human Anatomy which was opened in Oxford last year (*Nature*, 183, 1572; 1959).

Sir Wilfrid is also director of the Medical Research Council Unit for Research on Climatic and Working Efficiency and a member of the Royal Naval Personnel Research Committee. His earliest years of professional work were spent in medicine. During 1920–23 he was principal medical officer of Sarawak, and later he was professor of anatomy in St. Bartholomew's Hospital Medical College (1927–29), followed by St. Thomas's Hospital Medical School until 1934, when he transferred to Oxford.

Such is the high esteem in which his work is held that Sir Wilfrid has given numerous special lectures at home and abroad, and he has been the recipient of several medals and honorary degrees.

(*Continued from page* 836)

together with mitochondrial counts revealed a number of important modifications occurring after feeding 3′-methyl-dimethylamino-azobenzene. When 2′-methyl-dimethylamino-azobenzene was substituted for the former dye, the changes were quite different in the early part of the experiment, but approached those observed with 3′-methyl-dimethylamino-azobenzene at later stages. Allard also described a number of electron-microscope observations made on pre-cancerous liver. Particularly interesting were some images suggestive of mitochondrial division and others indicating the appearance of small granules closely associated with ergastoplasmic membranes.

Some problems of mitochondrial regulation were discussed by F. Lynen (Munich) and by J. D. Judah (Philadelphia). Lynen examined in detail the theory, proposed a number of years ago by himself and by M. Johnson, to account for the Pasteur effect in yeast. The mainspring of this theory is that glycolysis and oxidative phosphorylation compete for the limiting amounts of inorganic phosphate and adenosine diphosphate available in the cell. Thus, glycolysis is depressed aerobically and enhanced by anaerobiosis or by inhibition of aerobic phosphorylation. While this interpretation is supported by the results of phosphate analyses, it cannot explain the decreased aerobic utilization of glucose. To account for the latter phenomenon, Lynen has suggested that the adenosine triphosphate, formed aerobically in the mitochondria, may not be as readily available to the phosphokinases of the glycolytic system as the adenosine triphosphate formed in fermentation. Investigations aimed at verifying this possibility have confirmed the existence of an adenosine triphosphate shuttle between the particulate and the non-particulate phases of the cells, but have also revealed that phospho-fructokinase appears to be inhibited preferentially to hexokinase in aerobiosis. At present, there is no satisfactory explanation for this finding. In the discussion which followed this interesting paper, the possible organization of the ground plasm was brought up for consideration by several speakers.

J. D. Judah described a series of recent investigations carried out in relation with the finding that several anti-histamine drugs act as powerful protectors against experimental liver injury. It was observed that these drugs inhibit the swelling of isolated mitochondria, as determined by a variety of conditions, and that they also inhibit the reversal of this phenomenon under the influence of adenosine triphosphate. In addition, anti-histamines were found to have no effect on respiration or on oxidative phosphorylation, but to inhibit the transfer of phosphate from adenosine triphosphate to phosphoprotein. When added to liver slices, previously incubated anaerobically, the drugs prevented the extrusion of water and restoration of the level of phosphoprotein which normally occur when oxygen is allowed to enter into the system. Judah put forward the hypothesis that the reversible changes in the water content of the mitochondria may be determined by changes in their content of phosphoproteins and that anti-histamines may prevent both types of changes by inhibiting a reversible protein phosphokinase.

In the general discussion which concluded the meeting, the necessity for a closer co-operation between electron-microscopists, histochemists and biochemists was stressed. It was also pointed out that further progress in our knowledge of the organization of the cell will be greatly dependent on the development, in all three fields, of new methods of greater accuracy and increased power of resolution.

C. de Duve

THE PHYSICAL SOCIETY

The principal contents of the 1959 Year Book of the Physical Society (pp. vi+124. London: Physical Society, 1959. 12s. 6*d*.), the fifth in the annual series, consists of the presidential address, entitled "Recent Trends in the Theory of the Ionosphere", which was delivered by J. A. Ratcliffe on May 21, 1959, following the annual general meeting of the Society, and the texts of the lectures and addresses given by the recipients of the various medals and prizes of the Society. Details are also given of the discourses delivered at the fifty-third Physical Society exhibition of scientific instruments and apparatus; the proceedings of the meetings of the Society during the period September 1958–June 1959; and the report of the Council of the Society for 1958. In addition, there are obituary notices of ten Fellows, including Sir Alfred Egerton, Prof. E. O. Lawrence, Prof. O. W. Richardson and F. Twyman.

In his presidential address, Mr. Ratcliffe gave a survey of recent ideas concerning the formation of the upper part of the ionosphere, known as the *F* layer. From measurements of the atmospheric density at great heights and computations of the electron distributions, it would appear that the layer is produced by the absorption of a solar ionizing radiation in atomic oxygen, which is distributed through the atmosphere as it would be if mixing were nearly complete up to heights of about 400 km. at least. When the radiation is incident normally, the absorption coefficient of the radiation is such that electrons are produced most rapidly at a height of about 180 km. Small alterations in the amount of mixing can produce marked changes in the electron distribution, and changes of this kind could be the cause of the observed winter anomaly in middle latitudes.

The forty-third Guthrie lecture, which was delivered by Sir Harrie Massey on April 8 at Oxford, was entitled "Collisions", and was confined to a discussion of a selected number of atomic collision phenomena including the elastic and inelastic collisions of electrons and of positrons with atoms, recombination and charge transfer processes in the upper atmosphere, and the dissociation of molecular ions by impact with gas atoms. The subject of the fifteenth Charles Vernon Boys Prize address given by Dr. D. West, of the United Kingdom

Atomic Energy Authority, Harwell, was a description of the method of observing π-mesonic X-rays. The work discussed was carried out on the Liverpool synchrocyclotron during 1952–56 and the main item of measuring equipment was a Hutchinson–Scarrott type kicksorter. It is most interesting, therefore, to find that the thirty-sixth Duddell Medal addresses, which follow Dr. West's article, were delivered by G. G. Scarrott on the application of computer techniques to nuclear physics instruments and by G. W. Hutchinson on 'memories' for nuclear physics.

In 1959 it was the turn of the Physical Society to arrange for the delivery of the Parsons Memorial Lecture, and Dr. C. R. Burch was invited to be the lecturer on October 22, 1959, at the Science Museum, London. He chose to speak about aspheric imaging systems and described the work in this field carried out by the University of Bristol's Optical Group during the past twenty years. Under Dr. Burch's inspiring influence, his devoted band of research workers, all of whom he proudly mentions by name and with affection, have made, many with their own hands, optical instruments of new and advanced design. Advanced testing methods, aspheric reflecting microscope design and manufacture, meniscus-Schmidt camera design and manufacture, cone-cylinder and screw interferometers, and several applications particularly in the biological field of these instruments are all touched on in Dr. Burch's lecture.

The subject of the twentieth Thomas Young Oration, given by Prof. R. W. Ditchburn on November 12, 1959, was also of an optical nature. He dealt with problems of visual discrimination, and described various methods of recording eye-movements and the analysis of involuntary movements. Eye-movements, both voluntary and involuntary, are of importance in contrast discrimination, and from the study of the discrimination of hue, it appears that in some conditions, normal subjects give reports usually associated with defective colour vision. The question as to how far the results obtained on the living eye are related to theories of retinal action is discussed with reference to electro-physiological measurements of impulses in optic nerve fibre of animals.

The lectures and addresses were intended for a very wide audience, and are extremely well and clearly written. They deal with specialist subjects, but their contents do not require specialist knowledge to understand them. The Year Book is a worthy addition to all science libraries.

THE COLONIAL DEVELOPMENT CORPORATION

THE annual report and statement of accounts of the Colonial Development Corporation for the year ended December 31, 1959*, the first to appear over Sir Nutcombe Hume's signature as chairman, follows the general style of Lord Reith's recent reports. Eighty-eight continuing projects are reported, as against seventy-seven the previous year, including fifteen new projects totalling £13,184,000, of which four have been removed from the list, and £4,046,000 further investment in existing projects was approved. Of the continuing projects, representing £90 million, of which £60 million has been spent, 45·2 per cent were concerned with utilities, 43·1 per cent with primary production and processing, and 11·7 per cent with commerce and industry, the corresponding figures for 1958 being 46·9, 40·8 and 12·3 per cent, respectively. No capital has yet been raised from outside sources, nor has any attempt been made to do so. Although the Corporation is now well established and its revenue is increasing, its present capital structure is unsuited to raising outside capital except with the Government's guarantee, but if the recommendations of the Sinclair Committee are adopted it should be much easier to devise a form of capital which would find purchasers among private investors without such a guarantee. The Corporation, however, is nearing the end of the resources it can draw from the Government, and further capital may soon be needed if it is to go forward.

The report emphasizes the importance of the correct adjustment of the relation between the highly industrialized countries and the under-developed countries of the world; and in these territories, for which the United Kingdom Government is responsible, the Corporation is in a unique position to assist in finding a solution to this problem. Even when money and technical aid are available, the capacity to put them to the best use is often lacking, and the Corporation has now built up an organization staffed by experienced people and designed for this very purpose. Their fitness for the task is shown both by the success now being achieved by the Corporation and by the fact that commercial interests, which have been hesitant to participate in risk ventures in territories the political and economic future of which was uncertain, have been reassured when the Corporation has been ready to be associated with their investment.

To assist in securing the maximum use of the Corporation's experienced organization in Great Britain and abroad, the chairman is leading a mission of the general manager and all six regional controllers to Washington to discuss the possibilities of the Corporation working for the International Bank, the International Finance Corporation and the Development Loan Fund. To-day the Corporation is well equipped to make contact with and examine new projects anywhere in the present or former dependent territories, to negotiate or assist in negotiating the terms of investment, to arrange for the management of the project and to watch over its progress. Almost all its capital of £130 million is now committed, and the value of products by direct projects and associated companies in 1959 amounted to about £18 million, much of which contributed to the export trade of the countries concerned. The stimulation of other development caused by the Corporation's example and initiative is more difficult to assess, but the report cites as examples new housing enterprises and ideas due to the Malaya Borneo Building Society and housing schemes in Africa and the Caribbean, and new standards for large-scale agricultural enterprises in Borneo set by Borneo

---

* Colonial Development Corporation. Annual Report and Statement of Accounts for year to 31.12.59. Pp. v+77. (London: H.M. Stationery Office, 1960.) 5s. net.

Abaco, Ltd., in introducing two new crops (cocoa and oil palms). The report also stresses the way in which opportunities are taken for partnership with private industry and association with local interests, and apart from stressing the importance of public relations and encouraging both at home and overseas a correct understanding of the Corporation's purpose and work, the report contains two interesting sections discussing various aspects of management and training schemes which merit separate consideration.

ECHO-SOUNDING EXPERIMENTS IN THE BARENTS SEA

NEARLY all large fishing vessels carry echo-sounders for locating fish. A 'ping' of sound is sent down into the water, and any fish between the ship and the sea bed give echoes which can be detected. In the case of vessels trawling for cod, it is fish within a few fathoms of the sea bed which are of interest, and because of the short separation in time between the echoes from these and the much stronger echo from the sea bed, certain difficulties arise. These have to a large extent been overcome by displaying the echoes on a cathode-ray oscilloscope, arranged to present echoes from near the sea bed on an expanded scale.

A recent booklet contains five papers concerned with the use of such equipment*. They cover the identification and measurement of the echoes, the relationship of the number and size of echoes to the catch of fish, the measurement of the strength of echoes from individual fish, practical and theoretical work on the properties of the equipment, and its use for surveying the distribution of fish on the fishing grounds. Taken together, they form a comprehensive survey of the characteristics and use of the equipment considered primarily from a practical point of view.

One is particularly struck by the high correlation between the count of echo signals, that is, the sum of the strengths of each echo during a trawling run, corrected for depth, and the number of fish caught. The correlation coefficients are in the region of 0·9, in spite of the necessarily rather crude methods of echo measurement.

In the past, much of the information required for systematic design of echo-sounders for fish detection has not been available. Design has been based largely on the properties of previous models known to give reasonably satisfactory results, followed by sea trials and alterations as required. The third paper describes an attempt to obtain some of the necessary basic data. The echo strength given by (dead) cod of different lengths has been measured and compared with the echo given by a standard target, so that the target strength of the cod is known in absolute units. The water-borne noise has been measured as a function of ship-speed and water-depth (though unfortunately only in terms of received voltage without the sensitivity of the receiver being known). The information about the target strength of cod is of universal application, and that about the water-borne noise allows the prediction of the performance of this particular sounder over a wide range of conditions.

The checking of the performance of equipment under working conditions is highly desirable, and helps to give one confidence in both the equipment and one's methods. The first part of the fourth paper describes checks of the beam pattern and of the variation of echo-strength with depth. Such checks have been made on many other acoustic devices, and since in the present case they also agree with theoretical expectations within experimental accuracy, the fifteen pages devoted to this work seem excessive.

In conclusion, these papers describe a great deal of careful work, mostly 'in the field', and form a very valuable contribution to the subject.

M. J. TUCKER

---

* Ministry of Agriculture, Fisheries and Food. Fishery Investigations, Series II, 22, No. 9: Echo Sounding Experiments in the Barents Sea. By I. D. Richardson, D. H. Cushing, F. R. Harden Jones, R. J. H. Beverton, and R. W. Blacker. Pp. vi+57. (London: H.M. Stationery Office, 1959.) 20s. net.

ORIGIN OF TEKTITES

By PROF. H. C. UREY, For.Mem.R.S.

University of California, La Jolla

LAST January, Dr. G. Baker[1] criticized in considerable detail my suggestion[2] that comet heads colliding with the Earth heated the surface to the melting point and spread small fragments of glassy objects to great distances and that these objects are tektites. I believe these objects have compositions which are not greatly different from some of the more acid terrestrial rocks, but that no source of sufficiently high temperatures to melt these materials is known to be present on the Earth's surface or somewhat below the surface. My communication was written to suggest a possible source of high temperatures. I really thought everyone who had worked on this problem would be pleased to consider a mechanism by which terrestrial material could be melted and scattered to great distances even though it did not necessarily answer all questions. This was certainly not true. I have thought over Dr. Baker's very thoughtful criticisms and would like to make a brief reply.

Dr. Baker is quite right about tektites not being spaced some 50 million years apart in age, but Prof. Z. Kopal very soon pointed out to me that cometary collisions with the Earth were probably ten or more times as frequent as I had assumed. I have not troubled to correct this incorrect estimate, for it was very uncertain in any event. We probably have only the most approximate ideas in regard to the numbers of non-luminous comet heads moving in the solar system; and comet heads must certainly collide with the Earth from time to time and should produce some effects which we could look for, and they should produce an effect of sufficient magnitude possibly to melt bits of glassy materials.

Also, Dr. Baker is right about the orientation of tektites during flight through gas. The stable position is motion through the gas with a maximum surface exposed in the direction of flight.

Dr. Baker accepts the conclusion that a swarm of objects of very considerable mass is required if such a swarm is to remain as an entity in the field of the Sun, and he tries to account for a large loss of this mass by abrasion during flight through the air, erosion after arrival at the Earth, and destruction by birds and men. If we postulate very many small masses, say, of millimetre sizes, then it is difficult to answer the first objection. But 100 gm. per cm.^{2} over an area of 5 million km.^{2} is 5×10^{12} tons, and hence we must assume a very large fraction of very fine material in order to account for its destruction in this way. The total energy of this mass of material, using his area of 5×10^6 km.^{2} (2×10^6 square miles) and a thickness of 100 gm./cm.^{2} and a velocity of 20 km. per sec., is 10^{31} ergs. This is equivalent to about 10^{10} ordinary Second World War atom bombs, or 2,000 per km.^{2}. The energy per cm.^{2} is 2×10^{14} ergs. The heat capacity of the atmosphere is about 10^{10} ergs per cm.^{2} and thus very high temperatures would be produced. Possibly such energetic processes occurred over southern Australia some 5,000 years ago, but also some evidence of it might remain. Possibly my scepticism based on inadequate knowledge is not unjustified.

The etching experiments with 4 per cent hydrogen fluoride do not seem to be very appropriate as a test of chemical erosion, since this reagent is used to dissolve rocks of all kinds and is known to be a very effective chemical for such purposes, since it converts silicon dioxide to gaseous silicon fluoride. Carbon dioxide and water is the usual erosion acid in Nature and it is much milder in its effects. But tektites have persisted on the Earth since the Eocene apparently, and during this long period should have been exposed to all the types of erosion that occur in Nature and they still have survived. Also tektites are abundant in the Philippines and other tropical humid regions and are fairly well preserved. The erosion of a layer of tektites of 100 gm./cm.^{2} from the southern Australian continent in 5,000 years does not seem probable to me, especially in view of the fact that, as Dr. Baker emphasizes, some of these objects are beautifully preserved. In fact, most of those that I have seen are so preserved. Could this vast amount of material of a very resistant kind have disappeared so completely in a short period of time? It seems improbable to me that both this great and complete destruction of so much material and the perfect preservation of specific samples under essentially similar conditions could have occurred.

Again, birds and men cannot dispose of such quantities of material, or even a small fraction of it, in so short a time, and it would seem likely that tektites would have become distributed over the whole of Australia instead of being limited to the southern part if such agents moved any important amounts of these materials.

But my mention of the swarm of objects and its elimination was very brief. If we are seriously to assume the existence of such a massive swarm, we must consider whether it would not have accumulated due to its own gravitational forces into a more compact object and hence have arrived at the Earth as such. In this case it approximates to the cometary model, or to a large meteorite model, and then we are back to scattering materials over vast areas. However, with these models it is unnecessary to assume a layer of 100 gm./cm.$^{-2}$, since this estimate depended on the extended cloud model and its stability in the Sun's field; also the energy dissipated, while very great, would be more limited in area and might well initiate volcanic or flooding processes, for example, which would obscure the location of the collision site.

But we are learning more about these objects. It is now found[3] that they do not contain aluminium-26, which was previously reported. There is no evidence that they have been exposed to cosmic rays. If they came from space in a swarm, the time in space was very brief. They may have come as a large compact object or they may have come from the Earth. Also, the potassium-40/argon-40 ages have been determined[4], and it is found that these ages for all tektites of south-east Asia and Australia are the same within the limits of error, namely, 610,000 ± ~ 50,000 years. The ages from geological studies that Dr. Baker mentions might be in agreement with this age for all these objects with the exception of the age of the australites, which he estimates as 5,000 years or "definitely Holocene". The potassium-40/argon-40 ages are calculated assuming that complete degassing took place at some time in the past. The consistency of the ages supports this, though one could wish that the variations, either real or due to observational errors, were less. If the age of 5,000 years given by Dr. Baker and that of 610,000 years given by the potassium-40/argon-40 ratio for the australites are correct, a degassing occurred 610,000 years ago, but delivery to Australia occurred much later. One wonders how and where that heating process occurred and where the objects were kept in the refrigerator free from cosmic rays since that time? I really am most reluctant to assume that the carefully considered age of the australites is wrong, but if they arrived 610,000 years ago it would greatly simplify our attempts to arrive at a satisfactory model. If the differences in geological age estimates and the potassium-40/argon-40 ages for all these groups of tektites are real, then similar questions in regard to the heating and cooling histories can be raised in regard to all of them.

If the agreement in potassium-40/argon-40 ages is significant—and I believe it is—a very great and extensive process must have produced these objects and we must all think again about the entire problem.

Did they come from the Moon? Could a collision of an object with the Moon splash them off in such a closely related pattern that they would all fall in these close patterns[5]? But would all such collisions produce such closely controlled conditions, or would they miss the Earth occasionally or, in fact, usually, and thus on a second, third or the *n*th pass fall all over the Earth? My answer is that they most probably would be very widely, and in fact uniformly, scattered over the Earth[6].

However, it has always been a puzzle to me that terrestrial surface materials containing appreciable water should melt into objects having so little water. Why did they not melt into pumice? But I have only tried to suggest a source of heat for melting this material and scattering it over great distances. It seems more reasonable to try to fashion some hypothetical process to produce them from known terrestrial materials, which they resemble in many ways, than to assume that they come from other places that we know so little about. Must we fashion another planet to produce their chemical composition, and then if we cannot find ways to melt these materials on Earth, why do we think they could be melted elsewhere ? If geologists will find a volcanic process which will produce these objects from appropriate terrestrial materials, such a solution would be the most satisfactory of any that I could imagine. (Mr. Paul Lowman mentioned this possibility to me in conversation.) But a volcanic process distributing material in limited regions over south-east Asia and Australia within a circle of 8,000 km. diameter would be most remarkable.

On the other hand, cometary collisions should occur occasionally, they should be very energetic, and their volatile constituents should supply a mechanism for propelling materials out of the atmosphere and to great distances, and the agreement in the potassium-40/argon-40 ages would be understandable. It could have been a single collision near the centre of this area, instead of multiple but nearly simultaneous ones as suggested previously.

It is nearly three years since my suggestion on the cometary origin of tektites appeared in *Nature*. I wish to thank Dr. Baker for raising the problem for public discussion and am only sorry that he did not do so earlier. Progress in resolving differences of this kind can be made most expeditiously by a public discussion of this kind in which all interested parties, including the one whose work is criticized, may know what doubts are being entertained.

[1] Baker, G., *Nature*, 186, 291 (1960).

[2] Urey, H. C., *Proc. U.S. Nat. Acad. Sci.*, 41, 27 (1955); *Nature*, 179, 556 (1957).

[3] Anders, E., *Geochim. Cosmochim. Acta*, 19, 53 (1960).

[4] Gentner, W., and Zähringer, J., *Zeit. f. Naturforsch.*, 14, A, 676 (1959).

[5] Varsovsky, C. M., *Nature*, 181, 172 (1958). Urey, H. C., *Nature*, 181, 1457 (1958).

ISOTOPIC COMPOSITION AND TEMPERATURE OF FORMATION OF ANTARCTIC SNOWS

By PROF. E. PICCIOTTO
Université de Bruxelles (Expédition Antarctique Belge, 1958)

X. DE MAERE
Service Météorologique de la Force Aérienne de Belgique (Expédition Antarctique Belge, 1958)

AND

I. FRIEDMAN
U.S. Geological Survey, Washington

IN an earlier communication[1], variations in the isotopic composition of the oxygen in falls of snow collected during 1958 at the Belgian Antarctic Base (King Baudouin Base, 70° 26′ S., 24° 19′ E.) were shown.

We intend, here, to present the variations in the isotopic composition of the hydrogen contained in the same samples.

The analysis of the aerological radio soundings carried out at the King Baudouin Base in the course of the International Geophysical Year[2] has enabled us to estimate the temperature range in the cloud corresponding to each snow-fall. This is, to the best of our knowledge, the first attempt carried out with the view of establishing a direct correlation between the isotopic composition of a snow-fall and its temperature of formation. The interesting results obtained in this field up to the present[4,5] originate from average samples representing accumulations over several months, or even years.

Variations of the Deuterium : Hydrogen Ratio

The ratio deuterium : hydrogen has been measured at the U.S. Geological Survey, Washington. The mass-spectrometric methods used have already been described[6].

Fig. 1 shows the variations of the deuterium : hydrogen ratio in the course of 1958. Each point represents an individual sample. The composition of the hydrogen is expressed as percentage variation of the deuterium : hydrogen ratio with respect to a conventional standard (standard mean ocean water). The variations of the deuterium : hydrogen ratio present the same characteristics as those of the oxygen-18 : oxygen-16 ratio previously discussed[1]; but their amplitude is 10 times larger[3]. Thus, summer snows are, in the average, 10 per cent richer in deuterium than winter snows. The maximum relative variation in the deuterium content is 20 per cent.

Fig. 2 shows the variations of ∂ (oxygen-18 : oxygen-16 ‰) with respect to Δ (deuterium : hydrogen per cent). As a first approximation, all the points are grouped about a straight line of equation : $\partial = 0{\cdot}8\,\Delta + 1{\cdot}8$. It appears that some points corresponding to August and September, that is, the end of winter, form a separate group.

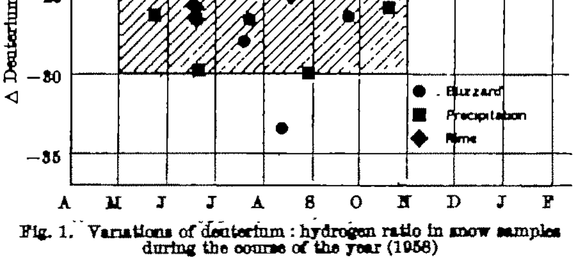


Fig. 1. Variations of deuterium : hydrogen ratio in snow samples during the course of the year (1958)

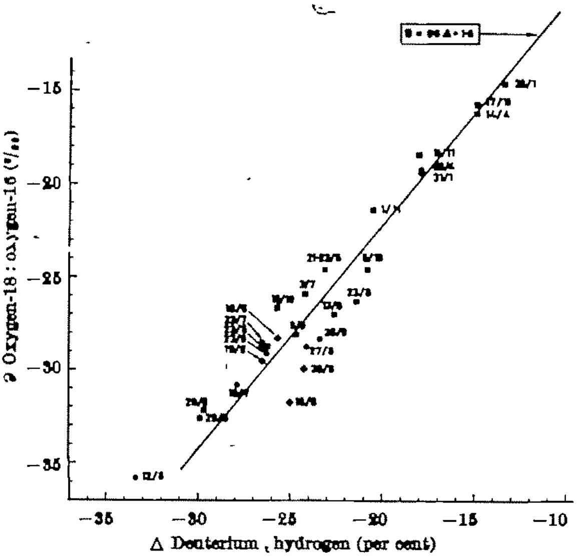


Fig. 2. Deuterium : hydrogen ratio compared with oxygen-18 : oxygen-16 ratio in the same sample. Same symbols as in Fig. 1. The date of collection is given for each sample. Oxygen isotopes data from Gonfiantini *et al.* (ref. 1)

Isotopic Composition and Temperature of Formation

In order to estimate the range of the temperature of formation of every fall of snow, we have noted from the radiosonde data the temperature at the base and at the top of the cloud at the moment of precipitation. This temperature is well defined in the fortunately frequent case of thin stratiform clouds with no higher cloud sheets. In the case of rime deposits, the temperature at a height of 1 metre above ground was taken. Drift-snow samples were excluded.

Table 1 shows the information obtained from the aerological soundings.

Fig. 3 shows the isotopic composition of the oxygen in each fall, with respect to the temperature-range in the corresponding cloud sheet. The straight line corresponding to the mean temperature of the cloud has been traced. There is seen to be a remarkable correlation between ∂ oxygen-18 and the temperature of formation of the precipitation, T.

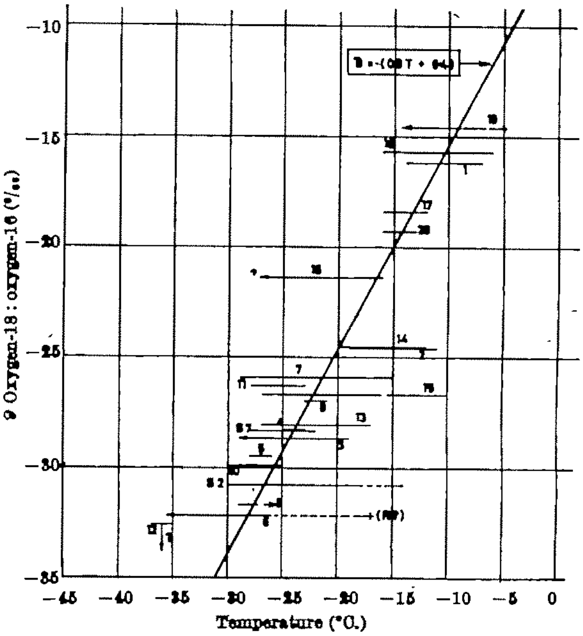


Fig. 3. Isotopic composition of oxygen in snow falls with respect to the temperature in the corresponding cloud sheet. Sample numbers refer to Table 1

The equation connecting ∂ and T is:

$$\partial(\text{oxygen-18}) = -(0{\cdot}9T + 6{\cdot}4)$$

An equally precise correlation has been found to exist between Δ (deuterium) and T, and is represented by the equation:

$$\Delta\,(\text{deuterium}) = -(0{\cdot}8T + 8)$$

The isotopic compositions ∂ and Δ essentially depend on the temperature of formation, and appear, at first sight, to be independent of any other condition such as the cloud height or the type of precipitation.

The very marked seasonal effect, and the very rapid transition from the 'isotopic winter' to the 'isotopic summer' (Fig. 1), may be clearly interpreted by referring to Fig. 4, which presents the mean monthly temperature of the air with respect to its height, in the atmosphere above King Baudouin Base. The known polar climatic characteristics very clearly

Table 1

Sample No.	Date	Ground temperature (°C.)	Temperature in the cloud		∂ Oxygen-18 (‰)*	Δ D/H (per cent)	Type and mean height of cloud
			Min.	Max.			
P 1	14/4	− 7	− 7	−14	−16·2	−14·9	st. 800 m.
P 2	21/5	− 9	−11	−19	−24·6	−23·1	sc. 1,400 m.
P 3	23/5	− 8	−19	?	−28·7	−26·2	as. 3,000 m.
R 4	18/6	−24	−24	−24	−28·3	−25·7	(rime) 0
R 5	19/6	−23	−25	−27	−29·5	−26·5	(rime) 0
P 6	20/6	−17	−22	−29	−32·2	−29·7	sc. 1,750 m.
P 7	3/7	−10	−15	−29	−25·9	−24·2	as. 2,800 m.
S 7	19/7	−18	−19	−30	−30·8	−27·9	ns. 2,300 m.
P 8	17/8	−21	−22	−32	−27·0	−22·6	sc. 1,300 m.
R 9	18/8	−28	−28	−28	−31·7	−25·0	(rime) 0
R 10	20/8	−27	−25	−30	−29·9	−24·2	(rime) 0
P 11	23/8	−24	−23	−28	−26·3	−21·4	sc. 1,100 m.
P 12	29/8	−31	−35	−37	−32·6	−29·9	ac. 2,550 m.
P 13	8/9	−17	−15	−27	−28·1	−24·7	sc. 1,800 m.
P 14	5/10	−12	−12	−20	−24·6	−20·8	st. 1,000 m.
P 15	19/10	− 6	−16	−27	−26·7	−25·7	ac. 3,700 m.
P 16	1/11	− 7	−16	?	−21·4	−20·5	ac. 2,100 m.
P 17	11/11	−10	−13	−16	−18·4	−17·3	st. 1,200 m.
P 18	17/11	− 5	− 6	−16	−15·7	−15·7	sc. 1,200 m.
P 19	28/1	− 3	−11	?	−14·6	−18·4	
R 20	31/1	−18	−13	−16	−19·2	−17·9	(rime) 0

* Oxygen isotopes from Gonfiantini (ref. 1).

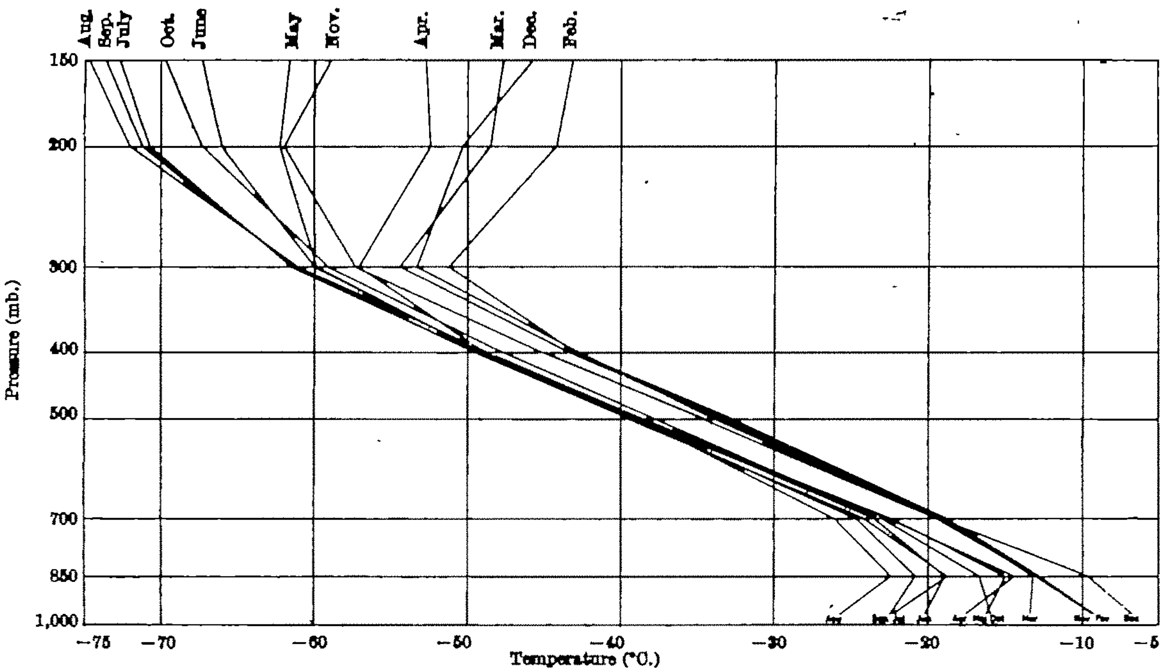


Fig. 4. Monthly mean temperatures from upper-air soundings at King Baudouin Base—1958

discussed in a recent article by Wexler[7] are found here. It is clear that the temperatures of the middle troposphere in which the precipitating clouds form are closely grouped about two mean values, and that these temperatures pass from the mean summer to the mean winter values in two abrupt jumps—between March and April, and between October and November. These two periods correspond very well to the abrupt variations in the isotopic composition of the precipitation (Fig. 1). As this behaviour of the tropospheric temperature is characteristic of the antarctic climate[7], it is to be hoped that the type of isotopic variations observed in 1958 follows a rule which will apply to other years.

On Fig. 4 is to be noted the wide dispersion of the ground temperatures, due mainly to the winter ground-inversion. This shows that ground temperature is not the best parameter to be used in work of this type.

In conclusion, the ratios oxygen-18 : oxygen-16 and deuterium : hydrogen in the snow-falls are seen to vary in a very similar pattern. These two parameters represent a veritable thermometer of the temperature of the middle troposphere, where the clouds causing the precipitation are formed. A variation of 1 deg. C. corresponds to a relative variation of about 1 $^{0}/_{00}$ in the ratio oxygen-18 : oxygen-16, and 0·8 per cent in the ratio deuterium : hydrogen—both values are well above the experimental errors of measurement.

The recent work of Dansgaard *et al.*[5] carried out on Greenland ice of known ages confirms that the isotopic composition of snow is conserved for at least several hundreds of years, even through compaction and transformation into ice. A very important application of these results would be a study of the recent climatic variations of the antarctic continent.

A full account of this work will be published elsewhere.

We wish to thank Dr. H. Wexler (U.S. Weather Bureau), Dr. W. Dansgaard (University of Copenhagen), Drs. E. Roth and G. Nief (C.E.N., Saclay) and Prof. E. Tongiorgi (University of Pisa) for helpful discussions.

[1] Gonfiantini, R., and Picciotto, E., *Nature*, 184, 1557 (1959).
[2] de Maere, X., Exp. Antarct. Belge, 1957–58, Rapports scientifiques, Météo.
[3] Craig, H., and Boato, G., "Ann. Rev. Phys. Chem.", 6, 414 (1955).
[4] Epstein, S., I.G.Y. Bull., No. 21 (1959).
[5] Dansgaard, W., Nief, G., and Roth, E., *Nature*, 186, 232 (1960).
[6] Friedman, I., *Geochim. Cosmochim. Acta*, 4, 89 (1953).
[7] Wexler, H., *Quart. J. Roy. Met. Soc.*, 85, 196 (1959)

VALENCE-BOND STRUCTURES: A NEW PROPOSAL

By Dr. J. W. LINNETT, F.R.S.*

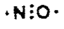
Chemistry Department, University of California, Berkeley

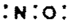
In the simple valence-bond treatment of molecules such as CH_4, two electrons having opposed spins are assigned to each bond. A similar feature applies to such molecules as H_2O in which there are lone-pairs. It is assumed, in all these molecules, that there is a group of electrons of one spin and an *exactly* similar group of electrons of the other spin. For structures such as that of C_6H_6 or CO_2, which cannot be described adequately in such simple terms, the concept of resonance has been introduced, the structure being represented by a combination of two or more structures of the above kind. That is, each

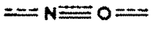
[*] On leave from Inorganic Chemistry Laboratory, University of Oxford.

structure is made up of shared and lone pairs of electrons, and each structure has two identical sets of electrons, one being made up of electrons of spin $+\frac{1}{2}$ and the other of electrons of spin $-\frac{1}{2}$. It is the purpose of this communication to suggest some modifications of this approach, and, in particular, to propose a partial revision of our interpretation of the stability of such molecules as benzene and carbon dioxide, which is usually ascribed to resonance, and measured by resonance energy.

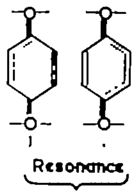
The modification that is proposed here was suggested by a consideration of the structure of the relatively stable 'radicals': nitric oxide, the *p*-benzo-semiquinone negative ion, Wurster's blue ion, diphenyl-picryl-hydrazyl, etc. In nitric oxide, there are five valency-shell electrons of one spin and six of the other. The first form a grouping in the molecule, which is represented by (I) and the second by (II):


I

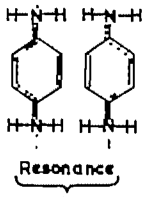

II


III

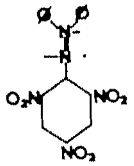
In both (I) and (II), there are four electrons (lone and shared) associated with each atom. So, if (I) and (II) are combined, the structure would be such that each atom possessed a shell of eight electrons made up of four of one spin and four of the other. Moreover, it is possible for each set of four to have a high probability of having a configuration which is nearly tetrahedral, though the two tetrahedra around each atom would not be superimposed. The combination of (I) and (II) may be represented fairly satisfactorily by (III), where —— signifies two electrons with opposed signs, ┘- - - one electron with one spin, and ····· one electron with the other spin[1]. On this basis the *p*-benzo-semiquinone negative ion, Wurster's blue ion and diphenyl-picryl-hydrazyl would be represented by (IV), (V) and (VI), along with other structures which are probably less important.



IV

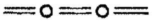


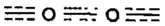
V


VI

In all the above structures every carbon, nitrogen and oxygen atom has a shell of eight electrons, four of each spin. It is postulated that it is because such structures can occur and are important that the above substances show a high stability which may, otherwise, seem surprising. For example, if diphenyl-picryl-hydrazyl were to dimerize, there would be no net gain in the number of bonds, because the formation of the new bond would take place at the expense of the loss of the two half-bonds between the nitrogen atoms. The same is true for the semiquinone, as regards both polymerization and electron-transfer to produce the quinone and hydroquinone double negative ion. In (IV) and (V) above, it has been assumed that the structure is best described by a mixture of the two equivalent structures (resonance). This is required by the symmetry of the molecule.

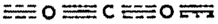
This concept can be applied much more widely, but consideration will be limited here to the molecules O_2, CO_2 and C_6H_6. Oxygen, with twelve valency-shell electrons in all, could be imagined as adopting one or other of the structures (VII) and (VIII).

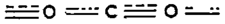

VII

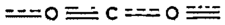

VIII

In both, each atom has a shell of eight electrons, four of one spin and four of the other, and also for both there are four electrons involved in bonding. Which of these is going to be the ground-state? It is not surprising that (VIII) is, because, in this electron configuration, five electrons have the configuration ·O ⁝ O·, whereas the other seven have ⁝ O·O ⁝. As a result, the electrons, forming tetrahedral groupings, tend to be more widely separated on an average in (VIII) than in (VII). According to this approach, which is essentially an extension of the valence-bond method, it is just as easy to understand why the ground-state of O_2 is the triplet state, as it is on the method of molecular orbitals. The $^1\Delta$ and $^1\Sigma$ states of O_2 are 22·6 and 37·6 kcal. above the ground-state[2]. The latter resembles more closely the double bond in a polyatomic molecule (for example, ethylene) because the azimuthal positions of the electrons in the π_g orbital are uncorrelated (by spin correlation) in the $^1\Delta$ state, whereas they tend to be at the same azimuthal angle in the $^1\Sigma$ state. Thus, the adoption of structure (VIII) would appear to lower the energy about 35–40 kcal. relative to (VII), if (VII) represents a double-bonded structure of the type that exists in ethylene.

Now, for CO_2, resonance involving the structures =O=C=O=, ≡O—C≡O— and —O≡C—O≡ is usually supposed to occur. According to the present idea, there would be added:

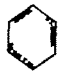

IX


X


XI

Of these, (IX) is likely to be the most important because it reduces the magnitude of inter-electron repulsion energy more than do the others. In (IX) the two bonds are analogous to the bond in (VIII). On this basis, it is not surprising that CO_2 is 36 kcal. (ref. 3) more stable than would be expected for the structure =O=C=O=. Moreover, the stabilization is not ascribed entirely to resonance but to the reduction in the inter-electron repulsion in (IX) as compared with that to be expected in =O=C=O=. Of course, it will still be true that a better description of the structure of CO_2 would be provided by resonance between (IX), (X), (XI) and the three conventional electron-pair structures. However, what is being suggested here is that it seems possible that (IX) is an important structure, and probably the most important one.

In a similar manner, benzene would be written as


XII

and the stabilization energy of 37 kcal. relative to a Kekulé structure (ref. 3) would be interpreted as being due, in large part, to a reduction in the inter-electron repulsion energy in (XII) as compared with that in a Kekulé structure involving the conventional double-bonds. It is of the same order as that found in O_2 and CO_2, and it is therefore not unreasonable to suppose that analogous effects are important in all these molecules. Further, the most simple-minded approach to electron–electron repulsion surely indicates that configurations which have high probability according to (XII) must, in truth, have a considerable probability relative to those indicated by the Kekulé formulæ. Yet, resonance between the two Kekulé forms sets a low probability on such configurations which separate spatially all the six electrons of the 'aromatic sextet' but nevertheless locate all in bond regions.

These ideas can be extended to other aromatic systems, chemical reactions, other free radicals, certain molecular compounds, all other systems which are usually represented in terms of resonance, and complex ions ; and these and other applications will be presented elsewhere. Here the account given has been qualitative, but wave-functions can be devised which correspond to the above structures and hence quantitative and semi-quantitative developments are possible. The method would be an extension of the valence-bond method. However, the wave functions could not be of the Heitler–London type but some modified or new form would have to be developed. This should not be difficult.

The proposal submitted here may be summarized in the following way. G. N. Lewis[4] stressed the importance of the electron octet. In all cases he treated it as made up of four pairs. It is suggested here that it is better to treat it as two groups of four electrons. When the two groups of four are similarly disposed, as they are in many molecules, the descriptions as four-pairs or two-quartets become identical. However, in other molecules and radicals, the employment of the two-quartets concept provides a satisfactory description, whereas the Lewis four-pairs does not. Therefore, it is proposed that the *octet* should not be treated primarily as four pairs but rather as a *double-quartet*.

[1] Linnett, J. W., *J. Chem. Soc.*, 275 (1956). Green, M., and Linnett, J. W., *J. Chem. Soc.* (submitted for publication).

[2] Herzberg, G., "Molecular Spectra and Molecular Structure. I, Diatomic Molecules", 560 (Van Nostrand, New York, 1950).

[3] Pauling, L., "The Nature of the Chemical Bond", third ed., 195 (Cornell Univ. Press, 1960).

[4] Lewis, G. N., *J. Amer. Chem. Soc.*, 38, 762 (1916); "Valence" (Chemical Catalog Co., New York, 1923).

CHROMOSOME PLOIDY AND RADIOSENSITIVITY OF TUMOURS

By LÁSZLÓ REVÉSZ and ULLA NORMAN

Institute for Tumour Biology, Karolinska Institutet Medical School, Stockholm

THE cell populations of animal and human neoplasms frequently show a considerable variation in chromosome number and deoxyribonucleic acid content[1,2]. It is not known whether there is any relationship between the chromosome number and the radiosensitivity of tumour cells. Work on the relationship between ploidy and sensitivity to radiation has been carried out on cells falling into the euploid series and derived from such biological objects as plants, fungi and arthropods[3]. If the effect of radiation on cell multiplication alone is considered, all reported observations indicate that radiosensitivity is greatest in the haploid cell and decreases more or less regularly with increasing ploidy. No direct extrapolations to neoplastic cells are permissible, however, since the predominant stem-line cell type is aneuploid in many tumours. The main stem-line number is frequently doubled, more or less exactly, in a smaller, second stem-line[1]. It cannot be predicted how a given aneuploid stem-line will react to radiation as compared to the doubled stem-line. Rearrangements occurring concurrently with, or after, duplication may, for example, render sensitive sites monosomic and make the cell more sensitive to radiation.

The problem was approached experimentally by determining the radiosensitivity of selected sub-lines of different ploidy derived from the same original tumour. In such material the findings can be interpreted with more confidence than would be the case when comparing independent tumour cell populations of different ploidy which, besides possible differences in radiosensitivity, may differ with regard to many, not necessarily relevant, other characteristics. An Ehrlich ascites tumour, designated *ELD*, also known under the synonym Landschütz sarcoma I or under the designation *LE* was used[4-6]. This tumour and its sub-lines were maintained in adult, heterozygous mice by intraperitoneal transfer of 0·1 ml. ascites diluted tenfold with sterile Ringer solution. During several periods of varying length, the cells were stored at −79° C. Chromosomes were counted on aceto-orcein squash preparations of material treated with colchicin[7]. More than 95 per cent of the *ELD* population is hyperdiploid with a modal chromosome number of 46. Cells with a doubled, hypertetraploid number occur at frequencies between 1 and 5 per cent.

Following Kaziwara's approach of 'immunoselection', that is, taking advantage of the increased

Table 1. PROPERTIES OF THE THREE SUB-LINES OF THE EHRLICH ASCITES TUMOUR

Property	Tumour line *ELD*	*ELT*	*ELTD*
Proportion of hypertetraploid cells	< 5 per cent	> 85 per cent	< 5 per cent
Modal chromosome number	46	92	46
Average cell volume*	1,368 ± 47μ^3	2,238 ± 67μ^3	1,370 ± 51μ^3
Average deoxyribonucleic acid per cell†	11·1 ± 0·5 × 10^{-9} mgm.	20·6 ± 1·1 × 10^{-9} mgm.	

* Determined according to ref. 9.
† Determined according to ref. 10.

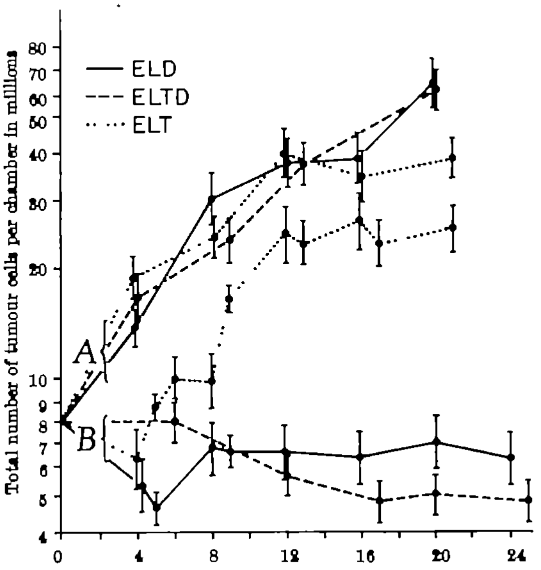


Fig. 1. Growth of hyperdiploid *ELD*, *ELTD*, and hypertetraploid *ELT* in diffusion chambers after inoculation of 8 × 10⁶ untreated cells and after irradiation with 2,000 r. The geometric mean and its standard error are indicated. The means have been calculated from 2–10 separate chambers in 1–8 separate experiments. The standard errors were obtained from calculations based on 17 duplicate and 6 triplicate determinations. *A*, untreated lines; *B*, irradiated lines

resistance of hypertetraploid cells to the homograft reaction as compared to the hyperdiploid cells[4], a predominantly (more than 85 per cent) hypertetraploid sub-line was derived from *ELD*, after homotransplantation of 20 × 10⁶ cells irradiated with 4,000 r. (ref. 4). The new line was designated *ELT* and had a modal chromosome number of 92. The X-ray dose damaged the majority of the cells irreversibly. Such lethally damaged cells may strengthen the homograft reaction considerably[8] and increase its selecting effect on the small viable remainder of the population. The ratios of modal chromosome number, average cell volume, and average amount of deoxyribonucleic acid per cell were approximately 1 : 2 when *ELD* and the first three consecutive transplant generations of *ELT* were compared (see Table 1 and ref. 4). In agreement with the findings of Kaziwara[6], hyperdiploid cells had a proliferative advantage over hypertetraploid cells in the absence of immunoselection[4] and the population of *ELT* shifted back gradually towards the predominance of hyperdiploid cells in the course of serial transfer with large (20 × 10⁶) cell doses. The tumour line derived from *ELT* after fifteen such passages, designated *ELTD*, was cytologically indistinguishable from the main *ELD* line.

In a series of experiments, 8 × 10⁶ untreated or irradiated cells of the three sub-lines were grown intraperitoneally within diffusion chambers of a modified Algire type[11]. The conditions of irradiation *in vitro*, the construction and sterilization of the chambers, and the method of introducing the cells are being published elsewhere[12]. 'Millipore' filters of *HA* type (Millipore Corporation, Bedford, Mass.) with a pore size of 0·5μ were used in order to protect the graft from the influence of cellular host reactions provoked by transplanted, irradiated cells[8,13]. Such reactions (inflammatory reaction, accelerated stroma formation, increased vascularization, homograft reaction, etc.) may have a stimulating or an inhibiting effect on tumour growth, and may therefore interfere with the testing of cellular radiosensitivity. The cell impermeable filter membrane permits the diffusion of soluble material, but prevents the pre-irradiated graft from having direct contact with host cells.

The cell content of the chambers was determined quantitatively at various intervals after inoculation. The technique is being described elsewhere[12]. The growth characteristics of the three sub-lines were closely similar when untreated. They differed clearly with regard to their response to radiation, however. After a dose of 1,000 r., the total number of *ELT* cells was consistently larger than that of *ELD* or *ELTD* at corresponding times during an observation period of 16 days. *ELT* cells, treated with 2,000 r. or 3,000 r., increased in number three- and two-fold, respectively, by the end of the third week after inoculation. No detectable increase of the *ELD* and *ELTD* populations occurred after treatment with the same X-ray doses. Irradiation with 4,000 r. inhibited the growth of all lines completely. The growth behaviour of the untreated cells and the growth curves after treatment with 2,000 r. are illustrated in Fig. 1.

These findings indicate that a difference exists between the radiosensitivity of tumour cell populations of common origin but differing in chromosome ploidy. The change of the radiosensitivity concurrently with the ploidy shift from a hyperdiploid to a hypertetraploid and, afterwards, again to a hyperdiploid dominance, implies that the difference in radiosensitivity can be related directly to the ploidy difference, and is not coincidental to the separate maintenance of the lines.

The question arises whether selection of polyploid cells in the course of radiation treatment may contribute to the development of resistance to radiation in animal or human neoplasms. Recent observations on the change of the deoxyribonucleic acid content associated with the development of resistance to radiation in human uterine tumours may favour this possibility[14].

A detailed report of this work will be published elsewhere.

We thank Prof. G. Klein for his continuous interest in these investigations and his stimulating criticism; and Dr. K. E. Hellstrom for advice regarding the cytological methods. This work was supported by grants from the Swedish Cancer Society and by Grant *C*-4747 (to G. Klein) from the National Cancer Institute, U.S. Public Health Service.

[1] Levan, A., "Genetics and Cancer", 151 (Univ. Texas, Austin, 1959). Makino, S., *Int. Rev. Cyt.*, 6, 25 (1957).
[2] Leuchtenberger, C., Leuchtenberger, R., and Davis, A. M., *Amer. J. Path.*, 30, 65 (1954). Atkin, N. B., and Richards, B. M., *Brit. J. Cancer*, 10, 769 (1956).
[3] Sparrow, A. H., and Schairer, L. A., "Progress in Nuclear Energy", Series VI; *Biol. Sci.*, 2, 351 (1959). Zirkle, R. E., and Tobias, C. A., *Arch. Biochem. Biophys.*, 47, 282 (1953). Clark, A. M., *Amer. Naturalist*, 91, 111 (1957).
[4] Hauschka, T. S., Grinnell, S. T., Révész, L., and Klein, G., *J. Nat. Cancer Inst.*, 19, 13 (1957).
[5] Tjio, H. J., and Levan, A., *Kungl. Fysiogr. Sällsk. Handl.*, NF 65, (No. 15), 1 (1954).
[6] Kaziwara, K., *Cancer Res.*, 14, 795 (1954).
[7] Hellstrom, K. E., *J. Nat. Cancer Inst.*, 23, 1019 (1959).
[8] Révész, L., *Cancer Res.*, 20, 443 (1960).
[9] Klein, G., and Révész, L., *J. Nat. Cancer Inst.*, 14, 229 (1953).
[10] Schneider, W. C., *J. Biol. Chem.*, 161, 293 (1945).
[11] Algire, G. H., Weaver, J. M., and Prehn, R. T., *J. Nat. Cancer Inst.*, 15, 493 (1954).
[12] Seelig, K. J., and Révész, L., *Brit. J. Cancer*, 14, 126 (1960).
[13] Ringertz, N., Klein, E., and Révész, L., *Cancer*, 12, 697 (1959).
[14] Richards, B. M., and Atkin, N. B., *Brit. J. Cancer*, 13, 788 (1959).

LETTERS TO THE EDITORS

PHYSICS

A New Plasma Confinement Geometry

As is well known, the strong synchrotron radiation recently predicted by Trubnikov and Kudryavtsev[1] from a plasma containing a magnetic field at thermonuclear temperatures makes it harder to design a thermonuclear reactor using the deuterium–tritium reaction, and practically impossible to design a deuterium–deuterium reactor. One way to get around this difficulty is to have no magnetic field in the plasma, so that the radiation becomes only a surface phenomenon instead of a bulk one. Of all the magnetic confining geometries at present known, theoretically only one has enough stability to hold a pure (that is, $\beta = 8\pi nkT/B^2 = 1$) plasma. This is the picket fence or cusped geometry[2]. Unfortunately, according to Grad[3], the cusps will be very leaky. Attempts have been made to construct geometries to avoid these leaks by closing the cusps on themselves (compare the most interesting papers by Braginski and Kadomtsev[4]). The same idea was proposed independently by Longmire and me some years ago under the name 'caulked picket fence'[5] (Fig. 1). These geometries involved current-carrying rings, disposed inside a solenoid having a longitudinal magnetic field. Quite apart from the topological impossibility of connecting leads or cooling to these rings without making contact with the plasma, the systems were unstable in their toroidal form because there was no rotational transform[6] in the torus axial field.

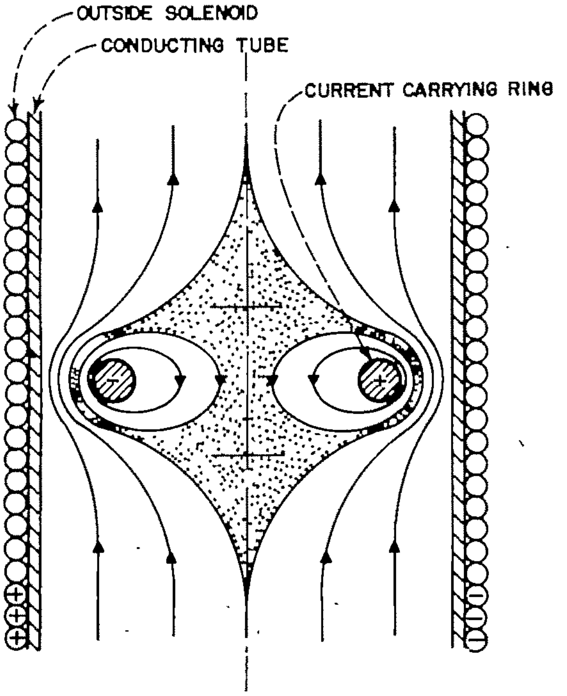


Fig. 1. Caulked picket fence geometry

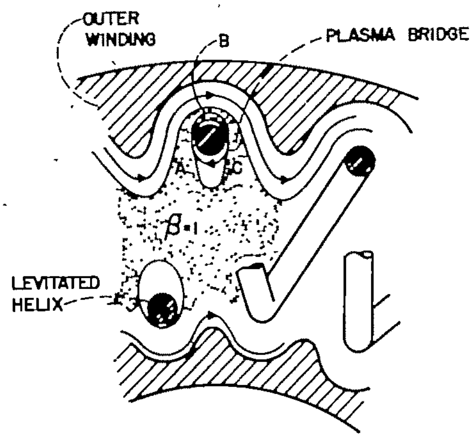


Fig. 2. Toroidal magnetic plasma confinement geometry. The inner spiral is continuous without connexions and floats in the magnetic field. The rotational transform of the field is not shown

During a re-examination of these old ideas, a new geometry (to be known as a helixion) has appeared, based on the helix, which appears to make possible stable $\beta = 1$ confinement with zero cusp losses in a torus. Furthermore, a linear helical system with $\beta = 1$ stable confinement, with cusp losses reducible to an arbitrarily small fraction of the confined plasma in unit time, that can be operated by d.c. and cooled, seems to be possible.

The toroidal helixion is shown in Fig. 2. An external tight helical winding on the torus has linear current density j per unit circumferential length. An internal open helix has mean current density $-j$ (less than this will suffice but involves a sacrifice of the confined volume). The effect of this is to produce a chain of regions along the axis where the field is weakened (there are no neutral points), which are bounded on all sides by magnetic fields of positive curvature. In the limit of infinite plasma conductivity, these places could be occupied by plasma, and be completely stable. However, these regions have cusps—say, A and C which are bridged by a line B encircling the inner conductor. In the region of the bridge, the system has a curvature which is in the sense for hydromagnetic instability. In the old conception (ref. 5 above), it was believed that the regions of the bridge would, since the field there is much larger than that surrounding the main body of the plasma, be largely free from plasma, so that the hydromagnetic instability would convey a negligible amount of plasma to the wall. By reference to the cusp loss theory of Grad[3], the cusp acts at high β like a slit, of width 2δ, where δ is the plasma-field sheath thickness, from which the plasma escapes freely. We now see that line B becomes a connecting bridge (tongue in the words of Kadomtsev) of plasma, having a particle density n no less than that in the main $\beta = 1$ body, although its β can be much less than unity, since the bridge field can be much larger than that at the main $\beta = 1$ plasma surface.

Consequently, it is imperative to retain hydromagnetic stability in the bridge. The problem of the hydromagnetic stability of this region much resembles that of the stellarator, and it is safe to assume that there will be a limiting stable β, call it β_c, in the bridge. Then if B_b is the magnetic field in the bridge, B_1 at the surface of the main $\beta = 1$ region, the critical density for stability everywhere will be $n = \beta_c B_b^2/8\pi nkT$, $\beta_c = B_1^2/B_b^2$.

Note that the inclination of the helical winding imparts a shear to the field in the bridge region, which is beneficial for stability, increasing β_c, and that the axial component of the current in the helix imparts a rotational transform to the axial field which is essential for stability in a torus. The current in the helix must be produced by magnetic induction, so the operation is discontinuous. The quantity (reacting volume/wall area) increases with the scale, as does the decay time constant of the induced current, so it is advantageous to make the device large. The magnetic levitation of a plain ring in a torus has already been demonstrated experimentally in connexion with the toroidal hard-core pinch concept or levitron of Colgate and Furth[7].

So far, in this hypothesis we have $\beta = 1$ stable confinement, with no cusp losses. Only the plasma in the bridges and surface sheaths will give synchrotron radiation. However, it would be idle to pretend that this object is simple from the practical point of view. The discontinuous operation is a disadvantage and it is difficult to cool the helix.

For the extension of this idea to an open-ended helixion, consider the cusped region that could be occupied by a plasma in the vicinity of the neutral point produced by a straight current-carrying wire, in a transverse magnetic field. Such a region has two cusps which are bridged around the wire, and two cusps which connect to the outside world. The plasma region does not touch the wire. Now it turns out that as the inclination of the wire to the magnetic field is reduced, the cusped region shrinks, and ultimately vanishes, without touching the wire. For a uniform magnetic field of magnitude A, and a plasma in pressure equilibrium with a field αA ($\alpha < 1$), the cusped region vanishes when the angle between the axis of the wire and the field is $\cos^{-1}\alpha$. The proof must be reserved for a longer communication.

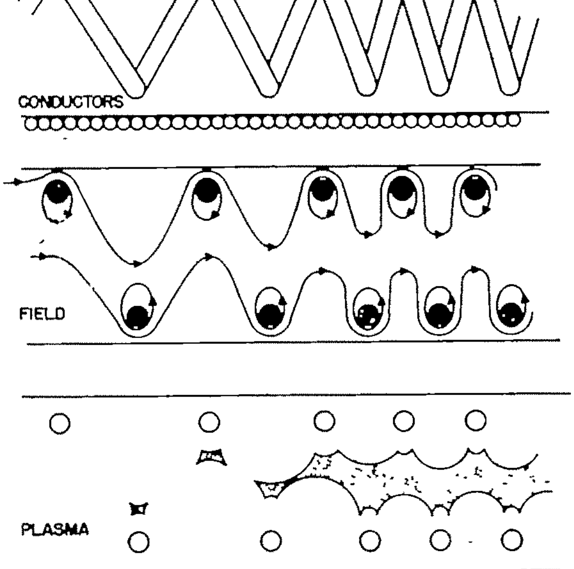


Fig. 3. Linear magnetic plasma confinement geometry with transition to outside connexion on the left. The spiral configuration of the field lines and the plasma bridges are not shown

Now consider a straight long solenoid having in it a helix as in the right-hand side of Fig. 3. The magnetic field is greatly reduced on the axis and is large between the helix and the wall. For connexion of the helix conductor to a source of d.c. current and for cooling, the helix is opened up, increasing the inclination of the turns to the axis, so that it ultimately emerges from the end as an axial conductor. The main bulk of the plasma has bridged cusps, and is connected to the outside world solely at the ends via a ring cusp. Now the losses from the end cusps are independent of the length, and the system can be made very long, since the solenoid can be supported magnetically. As with the torus, the system becomes energetically more profitable as the solenoid radius is increased. Most (possibly all) of the magnetic lines can be made to terminate at the ends of the system. This means that the mean stream of quiescent cross-field diffusion from plasma to wall can, if desired, be intercepted at the ends in the manner of a diverter[6].

Helpful criticism by H. Dreicer and T. H. Stratton is gratefully acknowledged.

This work was carried out under the auspices of the U.S. Atomic Energy Commission.

JAMES L. TUCK

Los Alamos Scientific Laboratory,
University of California,
Los Alamos, New Mexico.
July 20.

---

[1] Trubnikov, B. A., and Kudryavtsev, V. S., Proc. Second U.N. Int. Conf. Peaceful Uses of Atomic Energy, Geneva, 31, 93 (1959).

[2] Grad, H., Washington Report No. 289, 115 (1955). Tuck, J. L., Washington Report No. 289, 7 (1955). Longmire, C. L., Washington Report No. 289, 11 (1955). Berkowitz, J., *et al.*, Proc. Second U.N. Int. Conf. Peaceful Uses of Atomic Energy, Geneva, 31, 171 (1959).

[3] Grad, H., Inst. of Math. Sciences, NYO Report No. 7969 (1957) Berkowitz, J., *et al.*, Proc. Second U.N. Int. Conf. Peaceful Uses of Atomic Energy, Geneva, 31, 171 (1959).

[4] Bragınski and Kadomtsev, "Plasma Physics and the Problem of Controlled Thermonuclear Reaction", U.S.S.R., 3, 300 (1958). Kadomtsev, *ibid.*, 4, 353 (1958).

[5] Various classified conferences. Also Longmire and Tuck registration of invention, Los Alamos, February 1957 (unpublished).

[6] Spitzer, L., *Physics of Fluids*, 1, No. 4, 253 (1958).

[7] Colgate, S. A., and Furth, H., URCL Report No. 5392 (1958).

Thermal Conduction in Mica along the Planes of Cleavage

A NUMBER of measurements on the thermal conductivity of mica perpendicular to the cleavage planes have been carried out in the past[1,2]. However, apart from the work of Jannetaz[3], which suggests that the thermal conductivity is highly anisotropic, no data appear to be available relating to conduction along the planes. We report here the results of some measurements, with heat flow along the planes of cleavage, on phlogopite, a type of mica which is effectively uniaxial and isotropic within the layers.

We employed two different experimental methods. In the first of these, the thermal conductivity was obtained directly using an absolute method[4]. A block of mica, which was built up from a large number of sheets, was cemented with 'Araldite' between two copper plates. The thermal resistance of the mica block was obtained by subtracting the resistance of the layers of adhesive from the measured overall resistance. The thickness of the mica block, perpendicular to the cleavage planes, was found from its weight; it was thought that a direct measurement of the thickness would have been inaccurate owing to the composite nature of the sample.

The thermal conductivity was also determined indirectly from the thermal diffusivity, using the apparatus described by Green and Cowles[5]. Temperatures were measured with 46 s.w.g. chromel-alumel thermocouples inserted in the composite mica sample. In calculating the thermal conductivity, a specific heat of 0·86 joule/gm. ° C. was assumed[6].

The results obtained by the two methods were in good agreement with each other. The indirect method yielded a value of 0·0190 cm.^{2}/sec. for the thermal diffusivity at 27° C., leading to a thermal conductance of 0·0163 ± 0·0009 W./° C. for a rectangular block 1 cm. long, with a mass of 1 gm. Using the direct method, this quantity was found to be 0·0185 ± 0·0018 W./° C.; within the limits of experimental accuracy, it showed no variation over the temperature range −85° to 35° C. Thus, assuming a density of 2·8 gm./c.c. (ref. 6), the values for the thermal conductivity corresponding to the two methods are 0·046 and 0·052 W./cm. ° C. respectively.

It is concluded that the thermal conductivity of phlogopite along the planes of cleavage is about 0·05 W./cm. ° C. This is an order of magnitude greater than the values which are typical for the perpendicular direction[1].

H. J. GOLDSMID
A. E. BOWLEY

Research Laboratories,
The General Electric Co., Ltd.,
Wembley, England.

---

[1] Powell, R. W., and Griffiths, E., *Proc. Roy. Soc.*, 163, 189 (1937).

[2] "International Critical Tables", 2, 315 (1927).

[3] "International Critical Tables", 5, 231 (1929).

[4] Goldsmid, H. J., *Proc. Phys. Soc.*, B, 69, 203 (1956).

[5] Green, A., and Cowles, L. E. J., *J. Sci. Instr.* (in the press).

[6] Warren, H., "Electrical Insulating Materials" (Ernest Benn, 1931).

Measurement of Slip (*Ko*) and Viscous (*Bo*) Flow Coefficients of Permeable Solids

IT is usual to measure the slip (Ko) and viscous (Bo) flow coefficients of permeable solids by plotting $K = \frac{u_1 p_1}{\nabla p}$ as a function of mean specimen pressure $\bar{p}$, and using the slope and intercepts of the curve to find Bo and Ko. It is also possible to find Bo and Ko in one measurement (at a single $\bar{p}$), of K, p_1 (inlet), p_2 (outlet) and the centre-specimen pressure. By knowing that the mass flow:

$$Q_m = -\frac{MA}{RT} K(\bar{p}) \frac{\partial p}{\partial x}, \text{ that } K = a + b.\bar{p}$$

$$\text{where } a = Ko.\frac{4}{3}\sqrt{\frac{8RT}{\pi M}}$$

and $b = Bo/\eta$ (η is gas viscosity), and that the divergence of Q_m is zero (Z — axial flow only, that is, a rod or bar test-piece), a pressure distribution $p(Z)$ can be calculated; by putting $p(Z) = p(\frac{1}{2})$, that is, pressure half-way along the bar-length ($Z = L/2$), a/b can be found as:

$$\frac{\frac{1}{2}(p_1^2 + p_2^2) - p^2(\frac{1}{2})}{2\,p(\frac{1}{2}) - (p_2 + p_1)}$$

by measurements of pressures at three points, independently of flow. Since $K = b.\bar{p}\left[1 + \frac{a}{b} \cdot \frac{1}{\bar{p}}\right]$, by finding K from flow measurements, b can be found, and hence a: that is, Bo and Ko can be found.

$p(\frac{1}{2})$ = R.M.S. value, $\sqrt{\frac{p_1^2 + p_2^2}{2}}$, for the case $Ko = 0$, and $= \bar{p}$ when Bo is zero.

It is hoped to publish this method fully elsewhere.

J. G. BIRAM

English Electric Co., Ltd.,
Marconi House,
Strand,
London, W.C.2.
July 29.

---

[1] Hutcheon, J. M., *et al.*, "Flow of Gases through a Fine-Pore Graphite". S.C.I. Carbon Conference paper (Sept. 1957).

ASTROPHYSICS

Temperatures reached in Electrical Discharges in the Solar Atmosphere

IN a contribution[1a] to the Institution of Electrical Engineers Convention on Thermonuclear Processes, of which a somewhat fuller account was published later in *Nature*[1b], I suggested that the electrical discharge theory of solar flares and the associated magnetic storms and auroræ led to the surprising result that the temperature of these discharges must reach values of the order of 100,000,000° K. somewhere between the Sun and the Earth's orbit. In another account[1c] of this work, I suggested that this need not come as too great a surprise, as temperatures of the order of 1,000,000° K. had been obtained some years earlier in electrical discharges in the laboratory (I. V. Kurchatov, Moscow, 1956), and for long have been known to exist in the solar corona.

Furthermore, a similar increase in temperature is observed when long electrical discharges are propagated down the corresponding, but lesser, density gradients in some stellar atmospheres—those of the combination spectra stars, such as *Z* Andromedæ and *AX* Persei, for example. In these the temperature is initially that leading to the ionization of the metals, hydrogen and helium, that is, probably of the order of 5,000° or 10,000° K. However, by the time the discharge reaches the outer regions of these stellar atmospheres, after periods of the order of 100–200 days, the discharge temperature reaches values of the order of 1,000,000° K. as lines of Fe X and Fe XIV appear in the star's spectra.

Though there was thus some additional theoretical support for the surprising conclusion to which the theory led when applied to these solar phenomena, it is satisfactory to learn that satellite observations made by the U.S. Navy scientists have confirmed[2] that these high temperatures do exist in the disturbances associated with solar flares. As I emphasized many years ago[1d], it is difficult to see how these high temperatures can be built up by any other mechanism than that of an electrical discharge.

Similar temperatures are reached in galactic electric discharges, and can be measured, as I have suggested, by the proposed 'cosmic gas-velocity thermometer'[1e], of which the basic conception is that these high gas velocities observed in stars and galaxies are always the result of electrical discharges, the velocities of these jets being linked closely with their temperatures[1f], in contradistinction to the assumptions often made in other accounts of these solar jets[2]. The only limit to the discharge temperature will be the onset of thermonuclear processes[1f].

On the electrical discharge theory of galactic evolution[1d,g] the main difference between the gas which ultimately forms Population I stars, and that which originally formed Population II stars, is that the former has been subjected to 'thermonuclear temperatures' of the order of 400,000,000° K. for a period of the order of 10–100 million years, during the formation of the spiral arms. It may be, therefore, that it is this difference which has led to the difference in the proportions of the heavier elements observed in these two stellar populations. It is not easy to visualize all the physical characteristics of electrical discharges on such a scale as that envisaged, but at present the value of n, the number of atoms per cm.^{3} of the galactic atmosphere, required to effect the observed chemical change in the time available, appears to be too high. However, it would be interesting to have comments on this suggested explanation of this difference between the two stellar populations.

C. E. R. BRUCE

Electrical Research Association,
Leatherhead,
Surrey.

---

[1] Bruce, C. E. R., (*a*) *J. Inst. Elect. Eng.*, 106, Pt. A, Supp. No. 2, 44 (1959); (*b*) *Nature*, 184, 2004 (1959); (*c*) *Engineer*, 864 (Dec. 25, 1959); (*d*) "A New Approach in Astrophysics and Cosmogony" (London, 1944); (*e*) *C.R. Acad. Sci., Paris*, 250, 61 (1960); (*f*) *Observatory*, 77, 107 (1957); (*g*) E.R.A. Report *S/T* 117 (1958).

[2] *J. Franklin Inst.*, 269, 78 (1960); *Nature*, 186, 750 (1960).

[3] See, for example, Ferraro, V. C. A., Internat. Astro. Union Symp. No. 6, 297 (Cambridge University Press, 1958).

The Sudden Discontinuity in the Orbital Period of *Sputnik* 4 Satellite

THE orbit of the fourth Russian Earth satellite soon after its late launching on May 14, 1960, was similar to the orbits of the previous *Sputniks*, as may be seen from the orbital elements shown in Table 1. A Tass News Agency report of May 17 indicated that there were two objects close together in orbit—the composite satellite itself, consisting of a 'space capsule' attached to an instrumental section, and the last stage of the launching rocket. The instrumental section included a transmitter or transmitters radiating on frequencies of 19·996 and 39·992 Mc./s., as measured at the Radio Research Station, Slough. The first radio directional observations from the United Kingdom were made at the Radio Research Station on transits occurring at about 1054 hr. and 1225 hr. U.T. on May 15. The first reported visual observation from Western Europe of the composite satellite and rocket was made from Meudon at about 0325 hr. U.T. on May 16.

The radio observations of the transmitting component made before May 19.0 indicated that the satellite was behaving normally, the nodal period dropping by about 0·3 sec./day. However, radio observations made after this time indicated that the satellite was reaching northern apex progressively later on each revolution, and by 1200 hr. U.T. on May 19 its transits were some 25 min. later than predicted. Interferometer observations made at the Radio Research Station indicated that the inclination of the orbit had not appreciably altered, and so an increase in orbital period was suspected. A comparison between predicted and observed apex times was made from transits before and after 00 hr. U.T. on May 19, and the differences have been plotted against the observed apex times (Fig. 1). The plot consists of two distinct linear distributions of points and the intersection of lines fitted to each group lies at 2357 hr. U.T. on May 18. The time of this observed discontinuity in the orbital period coincides very closely with the time of 2353 hr. U.T. at which, according to a Tass News Agency report of May 21, an attempt had been made to bring the 'space capsule' out of orbit. It is of interest to note that at the latter time the satellite was almost exactly at perigee position, the geographical co-ordinates of which were long. 60° E., lat. 54° N., and the path of the satellite lay across the whole breadth of the U.S.S.R. The slope of the plot after the discontinuity implies an increase of period of approximately 3 min. from about 91·2 min. to 94·3 min., and the elements of the orbit after this time are shown in Table 1.

Table 1. ORBITAL ELEMENTS OF *Sputnik* 4 SATELLITE

	Before approx. 00 hr. U.T. May 19	After approx. 00 hr. U.T. May 19
Mean nodal period	91·18 min.	94 26 min.
Semi-major axis	6,711 km.	6,861 km.
Eccentricity	0 004	0·026
Argument of perigee	+ 61°	uncertain
Inclination	64 89°	64 89°
R.A. of ascending node	254·3	254 3

At about 0741 hr. U.T. on May 19, the originally composite satellite was observed visually from Canada as two close components which are now slowly separating. The leading component has been identified by directional radio observations made at the Radio Research Station, Slough, as the transmitter section. Later observations indicated the presence of more than two components in approximately the same orbit as the transmitting section: visual observations on a total of five objects in this orbit have reached us.

The information available from the Tass report of May 21 indicates that the 'space capsule' was apper-

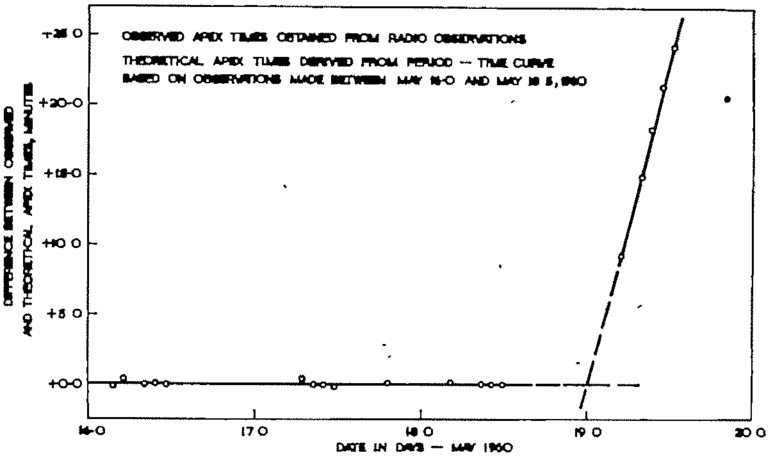


Fig. 1. Discontinuity in nodal period of transmitting component of *Sputnik* 4

ently intended to leave the orbit from near the perigee position by means of a retro-rocket system. The observed discontinuity in the orbital period of the satellite seems to suggest that the satellite was misaligned at the time of firing and, as a consequence, the retro-rocket placed both the capsule and the transmitting section into a higher orbit than that of the rocket.

The work described above was carried out as part of the programme of the Radio Research Board, and is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

B. R. MAY
D. E. SMITH

Radio Research Station
(Department of Scientific and Industrial Research),
Slough, Bucks.
June 21.

OCEANOGRAPHY

Ocean Currents in McMurdo Sound

MEASUREMENTS of ocean currents in McMurdo Sound, Antarctica, were made during May and June 1959, by measuring the potential differences developed between three silver–silver chloride electrodes hung in the sea below the ice.

Initially the electrodes were placed in the sea at the same location to determine the contact potentials and to estimate their variations. The electrodes, labelled *N*, *W* and *S*, were then placed out, *N* 500 m. north and *W* 500 m. west of the third electrode *S* which was 5 km. from Scott Base (77° 51′ S. and 166° 48′ E.) and on a line bearing 200° from it. The electrodes were connected by cable to Scott Base where the potentials between adjacent pairs were recorded by a four-point Honeywell Brown recorder.

On magnetically disturbed days the records were too disturbed to be of use. The records from calm days were selected and the values recorded by each adjacent electrode pair were averaged over a whole day, thus eliminating the tidal effect, which was mainly diurnal, leaving the general ocean drift. Since the instantaneous sum of the *N–S* and *S–W* potential differences equalled the *N–W* difference, the averages found for the respective channels should agree likewise.

For the purposes of calculating the currents it was assumed that there was a uniform flow in a straight channel. After consideration of the formula derived by Longuet-Higgins[1] for flow in a semi-elliptical channel, it was assumed that the shape of the channel and the conductivity of the bedrock were in this instance not important factors. A value of 0·69 oersted was used for the vertical component of the Earth's magnetic field. The results of the analysis of 18 days records are listed in Table 1, giving a mean velocity of 7·5 cm. sec.$^{-1}$ in a direction 44° east of north. Short-term current meter readings were in general agreement with this mean. These results indicate a different direction of drift past Cape Armitage (from McMurdo Sound towards the Ross ice shelf) from that which has been observed during summer months[2].

Lead strip electrodes, placed on the surface of the ice, which was 2 m. thick, were tried also; but the experiment had to be abandoned before conclusive results could be obtained, although the few records obtained indicate that despite a larger contact potential it would be possible to get useful results.

A more detailed account of these measurements, together with associated hydrological and tidal observations, is in preparation.

A. E. GILMOUR
New Zealand Oceanographic Institute,
Department of Scientific and Industrial Research,

W. J. P. MACDONALD
Geophysics Division,
Department of Scientific and Industrial Research,
Wellington.

F. G. VAN DER HOEVEN
Lamont Geological Observatory,
Columbia University,
Palisades, New York.

Table 1. SPEED AND DIRECTION OF OCEAN CURRENTS IN McMURDO SOUND

	May 1959																	
Date	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4
Velocity (cm. sec.$^{-1}$)	11·3	11·4	6·4	5·7	7·0	2·2	6·6	11·1	12·0	2·2	5·4	8·3	10·1	11·2	12·3	10·8	9·0	6·9
Direction, true	22°	16°	10°	34°	79°	36°	357°	80°	76°	54°	23°	24°	30°	44°	71°	60°	59°	0°

---

[1] Longuet-Higgins, M. S., *Mon. Not. Roy. Astro. Soc.*, Geophys. Supp., 5, 285 (1949).

[2] U.S. Hydrographic Office, Washington, Report on Operation Deep Freeze, 1, *TR*-33, 16 (1956).

GEOLOGY

Average Composition of Granites, the Genesis of Tektites, and Petrogenesis

THE recent article by Lovering[1], in which the average chemical composition of tektites was compared and contrasted with the average composition of terrestrial shales, calcalkaline granites and granophyres, involves an important question which is too frequently ignored. Comparison was made with the average bulk chemical composition of shales (78 analyses from Clark's Tables), granites (72 analyses quoted by Nockolds) and acid granophyric differentiates of basic magma (35 analyses available in the literature). As a basis of discussion, it may be assumed that the bulk chemical analyses are accurate representations of each of the 185 samples involved. Probably it is reasonable to assume that each of the 185 specimens was chosen by a competent geologist as a 'typical sample' to represent the rock-mass concerned.

The vast majority of granitic bodies which outcrop at the Earth's surface have received some qualitative but virtually no quantitative study. Thus, there are virtually no granite plutons for which anything like adequate information is available as a basis for determining the quantitative composition of the two-dimensional outcrop (representing the random section through the rock-mass). Even less is known about the three-dimensional composition and variability. At the present time, meagre quantitative data are available for a dozen or so granite plutons. In each case elementary statistical analysis demonstrates that compositional gradients occur in the bulk composition, and one or two 'typical specimens' constitute a totally inadequate sample upon which to base an estimate of the average composition of the target population of specimens comprising the entire pluton. Preliminary results for the 'older granite' of Donegal, Ireland, have been published[2,3] and additional more detailed analyses are in hand. Studies of variability in the Bahalda Road granodiorite (India), the Wollaston and Deloro plutons (Canada), the Beinn an Dubhaich granite (Scotland), and the Mourne Mountain granite $G2$ (Ireland) are the subject of a manuscript in the press.

Critical study of these six and several other granite bodies makes it amply clear that for any one granitic mass the arithmetic mean computed for a few 'typical specimens' yields a meaningless value in terms of the average composition of the entire volume of granite. The geologist who collects the 'typical specimens' almost certainly introduces a strong bias in his selection either involuntarily or voluntarily. Hence adequate sampling of a pluton does not require simply the collection of a large number of 'typical specimens', but involves the implementation of a sampling design adjusted to the individual characteristics of the rock mass (cf. Krumbein[4]). So far as is known, no entirely satisfactory sample has ever been taken for an entire granite pluton, so that the average composition of a body of granite cannot be stated accurately in any single case.

In view of the problem involved in assessing the bulk mineralogical and/or chemical composition of a single granite body, the arithmetic mean of bulk chemical analyses of single specimens drawn from 72 separate rock masses will produce a value having little or no precise relationship to the average composition of the target population for the 72 terrestrial plutons. However, if from a collection of hand-specimens derived from different plutons 72 similar samples are selected by a trained geologist, it is highly probable that the average of the individual chemical analyses will represent the average composition of the 72 specimens, but not of the 72 plutons represented.

Apart from the average composition, reasonably complete sampling in the few masses studied quantitatively shows that a large range in modal and normative composition occurs in each rock-mass. This is contrary to the impression given by the usual published ternary diagrams (both normative and modal) based upon one 'typical specimen' from each of a large number of complexes. In the latter case the points naturally cluster closely together (cf. Tuttle and Bowen[5]), and in the former are scattered widely on the ternary diagrams.

Hence, whether the composition of tektites is related to analyses of the 72 calcalkaline granites or the 35 granophyres may be interesting; even a very strong positive correlation does not indicate whether the tektites are related to the average composition of granite massifs of broadly calcalkaline affinities or to granophyric differentiates. Similar arguments apply with equal force when a few 'typical specimens' are employed to draw comparisons between the bulk quantitative composition of different rock-masses, and also when such samples drawn from different areas are employed as the bases of petrogenetic theories. However, in geological discussion considerable significance is usually attached to such average chemical and mineralogical values. This subject is developed more extensively, and illustrated by quantitative data, in a further manuscript awaiting publication.

E. H. TIMOTHY WHITTEN

Department of Geology,
Northwestern University,
Evanston, Illinois.

---

[1] Lovering, J. F., *Nature*, 186, 1028 (1960).

[2] Whitten, E. H. T., *J. Geophys. Res.*, 64, 835 (1959).

[3] Whitten, E. H. T., Twenty-first Internat. Geol. Congr. (Copenhagen), Proc. Sec., 14 (1960).

[4] Krumbein, W. C., *Liverpool Manchester Geol. J.*, 2, 341 (1960).

[5] Tuttle, O. F., and Bowen, N. L., Geol. Soc. America Memoir 74 (1958).

Nomenclature of the Keuper Series

IN the announcement in *Nature*[1] of the most interesting results of the recent borings penetrating the Trias of the Cheshire Plain, the Director of the Geological Survey made certain suggestions for the nomenclature of the subdivisions of the Keuper Series which, if adopted, may result in considerable confusion. The Keuper Series has, in the past, been subdivided into Keuper Marl and Keuper Sandstone rather than into Upper Keuper and Lower Keuper respectively, although Wills[2] calls the latter usage the "traditional classification". Keuper Marl and Keuper Sandstone were originally what we would now call rock-stratigraphical units which have acquired a time-stratigraphical significance even though this is probably not justified in view of the paucity of fossils in the Trias and the weight that has to be placed on lithological correlation. Difficulties have not arisen to any serious extent, because the subdivisions of both stages of the Keuper have been in rock-stratigraphical units and have been applicable to quite large but distinct areas. It is also of importance that the terms Lower, Middle and Upper Keuper are in use in Germany which, after all, was the type area, and that, at the moment, there is uncertainty concerning correlations suggested by the flora and fauna of the Bromsgrove Keuper Sandstone with the Lettenkohle and the Muschelkalk of Germany and the Grés à Voltzia of Alsace.

The new subdivisions proposed for Cheshire are likely to be confusing because of the use before Keuper of the words 'Lower', 'Middle' and 'Upper', particularly with capital letters, which implies a time significance within the Keuper Series. For example, Lower Keuper Marl is intended to indicate a formation in the lower part of the Keuper Marl, that is, lower Upper Keuper. As pointed out above, Lower Keuper is not, in fact, now normally used by British stratigraphers to indicate the Keuper Sandstone, but to someone not familiar with the stratigraphy of the British Trias the term immediately suggests a marl in the Lower Keuper, that is, in the Keuper Sandstone. The same sort of criticism may be made of the other four subdivisions and of the term Upper Keuper Sandstone.

The provisional names suggested for the Keuper Sandstone raise additional difficulties. In the past[3,4], the Upper Keuper Sandstone has been the name given to what is now normally known as the Arden Sandstone[4], which truly belongs to the upper part of the Keuper Series. It is noteworthy that, to eliminate confusion, the term Arden Sandstone is used virtually exclusively nowadays. Furthermore, Hull[5] used Lower Keuper Sandstone to cover the whole of the Keuper Sandstone, and the use of Upper Keuper

Sandstone to indicate the upper part of the Keuper Sandstone is most undesirable.

Those who have been compiling the "Lexicon of Stratigraphy" have good cause to know the confusion which reigns as a result of the indiscriminate use of 'Lower', 'Middle' and 'Upper', and many similar examples in British stratigraphy could be quoted. It is to be hoped that the Geological Survey, particularly bearing in mind the German usage, will not now add new sources of difficulty at a time when it is widely agreed that there is great need for some simplification and clarification of the nomenclature.

P. A. GARRETT

Department of Geology,
The University,
Birmingham 15.
July 29.

---

[1] Pugh, Sir William J., *Nature*, 187, 278 (1960).

[2] Wills, L. J., "The Palaeogeography of the Midlands", 61 (1948).

[3] Brodie, P. B., *Quart. J. Geol. Soc. Lond.*, 12, 374 (1856).

[4] Matley, C. A., *Quart. J. Geol. Soc. Lond.*, 68, 252 (1912).

[5] Hull, E., "The Triassic and Permian Rocks of the Midland Counties of England", *Mem. Geol. Surv. U.K.*, 66 (1869).

THE Geological Survey of Great Britain produces geological maps distinguishing strata with particular lithological characters and ages; thus Chalk is singled out from other limestones and given a particular colour on small-scale geological maps; on larger-scale maps certain hard bands have been used to divide the formation into Lower, Middle and Upper Chalk; likewise, some argillaceous strata of widespread distribution containing marine fossils are now used to divide the Coal Measures into Lower, Middle and Upper Coal Measures.

In the recent article on Triassic Salt in the Cheshire and Shropshire Basin, it was shown that two horizons of Saliferous Beds would be used to divide the Keuper Marl formation into Lower, Middle and Upper divisions in Cheshire. This will replace the older division into Lower and Upper Keuper Marl, which was used, for example, on the 1958 edition of One-inch Sheet 97 (Runcorn) before the Upper Saliferous Series was known to exist[1].

The use in geology of saliferous horizons as indicators of the past existence of particular climatic conditions over wide areas is not new. Accordingly it is considered that Lower, Middle and Upper Keuper Marl are legitimate terms for the depiction of strata on the geological map, and that to describe such usage as "indiscriminate" is misleading. It is well known that the British nomenclature of subsystemic units is far from ideal; and from time to time the Geological Survey is obliged to accommodate new discoveries by division of time-honoured units, in the present instance the Keuper Marl. In making this particular decision, the names Lower, Middle and Upper Keuper Marl were considered suitable; and no alternative was considered, such as the invention of stratal names based on localities. Such a course may well be taken, however, when investigations are completed on the beds "provisionally called Upper Keuper Sandstone".

C. J. STUBBLEFIELD

Geological Survey of Great Britain and
Museum of Practical Geology,
Exhibition Road,
South Kensington,
London, S.W.7.

---

[1] See also Summary of Progress of the Geological Survey of Great Britain and Museum of Practical Geology for 1954, 38 (1955).

METALLURGY

Non-crystalline Structure in Solidified Gold-Silicon Alloys

EXCEPT for thin films deposited at very low temperatures[1], highly disordered arrangements of the atoms, similar to that of the liquid state, have never been observed in solid metals and alloys. For some metalloids, the bonding of which may actually be more covalent than metallic, such amorphous configurations have been retained in the solid state[2] by cooling from the melt with sufficient celerity so as to prevent formation of the equilibrium crystalline structures.

It is thus conceivable that such non-crystalline structures can be obtained for some, perhaps all, metals and alloys by quenching rapidly enough from the molten state. In the course of experimentation with the apparatus developed by us[3], an amorphous structure has been detected in a 25 atomic per cent silicon–gold alloy which was quenched from ~ 1,300° C. to room temperature.

The quenched alloy was studied by means of X-ray diffraction. A flake (area ~ 0·2 mm.^{2}; thickness ~ 10μ) was mounted in a Debye–Scherrer camera and exposed to copper K radiation. Intensity (on an approximately linear scale), as obtained from the film with a microphotometer, is plotted against sin θ/λ in Fig. 1.

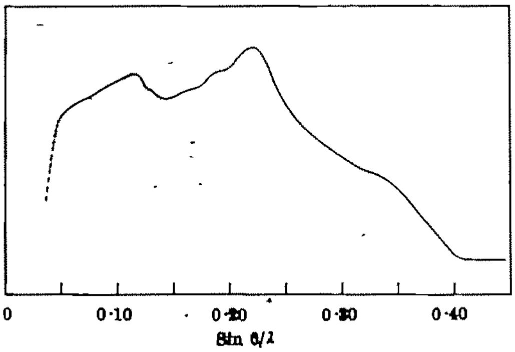


Fig. 1. X-ray diffraction pattern of gold–silicon alloy

It is to be emphasized that the amorphous foil is quite unstable at room temperature (and it is entirely possible that some decomposition could have occurred during the 3-hr. exposure). The decomposition products detected after 24 hr. at room temperature have complex crystal structures, involving d-spacings of the order of 11–12 Å. It is quite probable that many phases may be present under these non-equilibrium conditions. However, at this stage of decomposition, the equilibrium phases are definitely not present.

Since the synthesis and investigation of these amorphous foils are highly uncertain under the present experimental conditions, refinement of the apparatus so as to permit operation at liquid-nitrogen temperatures is now under way. Among the various facets of such non-crystalline metals and alloys which might be of interest, possible superconducting properties should be considered—especially since Buckel[1] has observed that certain metals in thin evaporated layers (amorphous structure) become superconducting at somewhat higher temperatures than with the normal crystal structures.

This work was jointly supported by the Office of Naval Research and the U.S. Atomic Energy Commission.

W. KLEMENT, JUN.
R. H. WILLENS
POL DUWEZ

Division of Engineering,
California Institute of Technology,
Pasadena, California.

---

[1] Buckel, W., *Z. Physik*, 138, 186 (1954).

[2] Krebs, H., and Schultze-Gebhardt, F., *Acta Cryst.*, 8, 412 (1955).

[3] Pol Duwez, Willens, R. H., and Klement, jun., W., *J. App. Phys.* 31, 1136 (1960).

CHEMISTRY

New Compounds for the Control of Water Evaporation

CONSIDERABLE attention has lately been directed towards effective suppression of water evaporation from lakes and reservoirs by spreading insoluble monomolecular films over the water surfaces[1,2]. In order to be effective, the film-forming compound should have several desirable properties[3] such as: (i) low melting point (~50° C.), which will enable it to spread rapidly on the water surface so that its monomolecular film, if damaged, is easily healed; (ii) large equilibrium film pressure at the temperatures of water surfaces (15–40° C.) normally met with in practice; (iii) the film formed should be stable, incompressible and condensed.

Cetyl alcohol exhibits most of the above properties to a fair extent and therefore has been used as such or mixed with stearyl alcohol[4] in field experiments. However, laboratory experiments indicate that at 15–20° C. cetyl alcohol shows a reduction of evaporation of about 60–65 per cent, and at 30–35° C. the resistance is much lower (30–40 per cent) (Fig. 1). In field experiments such films show even lower resistance and are also not durable, since their resistance has been found to decrease rapidly in the course of 24 hr. or so. The influence of ambient temperature on the efficiency of cetyl alcohol film has been considered by Ramdas[5] and by others[1].

The higher homologues of cetyl alcohol should be more efficient but for their higher melting points. Substitution of the —OH group by a less active polar group no doubt gives rise to compounds with lower melting points, but the films formed by them are generally compressible[1,6] and give poor performance.

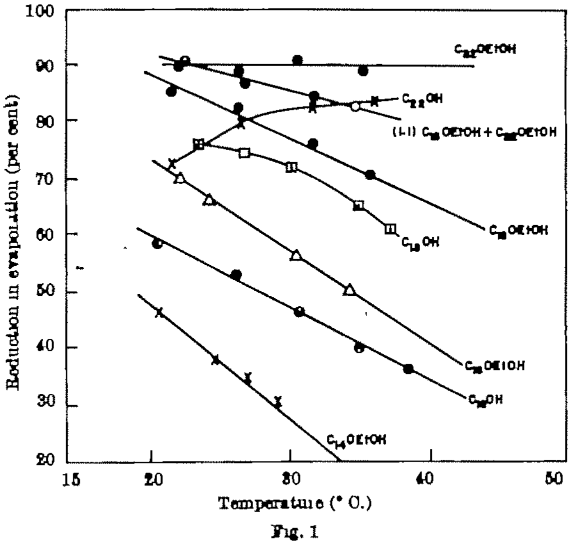


Fig. 1

Further, the films formed by most of these compounds deteriorate rapidly due to decomposition, hydrolysis or reactions with the impurities present in the underlying water.

The unsaturated alcohols have lower melting points, but in these, apart from their higher instability, the *cis*-alcohol (for example, oleyl alcohol, melting point ~5° C.) has a 'bent-chain' structure[6] and thus gives rise to non-compactness. The *trans*-alcohol (for example, elaidyl alcohol, melting point 36–37° C.) also does not yield an efficient film. On the other hand, it was considered that the introduction of an additional oxygen atom at the polar end of the saturated compounds would disturb the periodicity of the chain a little and the melting point would also be lowered slightly. Such a modification in the carbon chain would thus permit the use of longer-chain compounds.

A series of compounds $CH_3(CH_2CH_2)_n$—OCH_2CH_2—OH (referred to as *R*—OEtOH) were, therefore, prepared by reaction of the bromides of pure myristyl, cetyl, stearyl and behenyl alcohols with mono-sodium glycolate and purified by fractional distillation and crystallization. Experiments are also in progress to prepare similar products [*R*—$(OCH_2)_n$—OH] by the direct condensation of *R*—OH with ethylene oxide. A study of these compounds will, *inter alia*, allow us to determine the maximum number of molecules of ethylene oxide to be attached to an alkyl chain in order to obtain the most efficacious film-forming product.

To test the efficacy of retarders of water evaporation in the laboratory, 0·32 ml. of 0·09 per cent solutions of these compounds in 'Analar' (60–80) petroleum ether was spread over a clean water surface in a 9-cm. diameter Petri dish which, with a control dish, was kept on thermostatted metal bases and exposed for an hour to a breeze of 1–1·5 m.p.h. The films of pure cetyl, stearyl and behenyl alcohols were also tested under similar conditions. The reduction of percentage evaporation was calculated from the loss of water in the two dishes, and the results are plotted against the temperature (Fig. 1).

It was found that, for the normal alcohols, the reduction in water evaporation increases with the chain-length in the temperature-range studied, and the efficacy of the C_{14}- to C_{18}-alcohols increases steadily with the decrease in temperature. However, at lower temperatures, for the C_{18}-alcohol the curve tends to flatten whereas that for C_{22}-alcohol shows a decrease in evaporation resistance. This behaviour of the C_{18}- and C_{22}-compounds may be attributed to the difficulty of their spreading at low temperatures.

That the higher homologues of similar compounds with lower melting points show less difficulty in spreading is also borne out by the corresponding curves (Fig. 1) for the *R*—OEtOH products. In these, although the reduction of evaporation changes generally in the same way as that for the alcohols, it is greater and more persistent and there is scarcely any flattening of the curve except for C_{22}-OEtOH, which is surprisingly flat over the range of temperatures studied, indicating that the efficacy remains nearly the same throughout. An equimolar mixture of C_{18}-OEtOH and C_{22}-OEtOH shows reduction of evaporation intermediate between that of the two, as is also observed for similar alcohol mixtures. However, the efficacy of this film tends to be better than that of either component alone at lower temperatures, indicating the relative ease of spreading of, and formation of more compact film by, such a mixture as compared to that of the components.

Similar results were obtained on evaporimeter pans of 4 and 8 ft. diameter kept in an open field during different seasons and varying wind velocities (3–12 m.p.h.). Here also C_{16}-OEtOH and C_{22}-OEtOH consistently gave better reduction of evaporation than cetyl alcohol by at least 30 per cent in summer as well as in winter, and this was corroborated by laboratory experiments at various temperatures. The *R*—OEtOH films were also much more durable than the *R*—OH films, in that the effect of the former lasted for a period of about seven days in contrast to a day or so of the alcohols.

It may therefore be concluded that: (i) the selection of compounds for optimum suppression of water evaporation should be made keeping in view among other conditions the ambient temperature-range; (ii) $R—OCH_2CH_2OH$ or $R—(OCH_2CH_2)_n—OH$ types of compounds are better evaporation retarders than either cetyl or stearyl alcohols; and (iii) the C_{16}-OEtOH in colder season (~ 10–20° C.) and either C_{22}-OEtOH or its mixture with the former, during the summer (~ 25–35° C.), should prove more suitable in practice.

The process for the preparation and use of the new compounds (glycol mono alkyl ethers) for water evaporation control are being patented[7]. The results of fundamental studies on the specific resistance to evaporation, two-dimensional viscosity, rate of spreading, compressibility, phase behaviour, etc., of these and related compounds and their mixtures will be reported elsewhere.

We acknowledge the help given by Dr. L. G. Shah in the synthesis of the various compounds.

A. V. Deo
N. R. Sanjana
S. B. Kulkarni
M. K. Gharpurey
A. B. Biswas

National Chemical Laboratory,
Poona 8.

[1] Mansfield, W. W., *Austral. J. App. Sci.*, 9 (3), 245 (1958); *Nature*, 175, 247 (1955); *ibid.*, 172, 1101 (1953). Sutherland, K. L., *Research*, 10 (5), 198 (1957).

[2] "Evaporation Reduction Investigations" (Report), Lake Hefner, Oklahoma City, Oklahoma (1958).

[3] (*a*) LaMer, V. K., Second Int. Cong. Surface Activity, 1, 259 (1957). (*b*) Cary, A., and Rideal, E. K., *Proc. Roy. Soc.*, A, 109, 301 (1925).

[4] McArthur, I. K. H., Second Int. Cong. Surface Activity, 1, 262 (1957).

[5] Ramdas, L. A., and Narasimhan, S., *J. Sci. Ind. Res.* (India), 16, A. 357 (1957).

[6] Harkins, W. D., "Physical Chemistry of Surface Films" (Reinhold Pub. Co., 1952).

[7] Kulkarni, S. B., *et al.*, New Compounds for Water Evaporation Control, Indian Pat. No. 70670.

Character of the Ligands in Dibenzene Chromium

There has been considerable discussion concerning the molecular symmetry of dibenzene chromium, $(C_6H_6)_2Cr$ (refs. 1 and 2). Theoretical considerations led Ruch[3] to the assumption of a three-fold symmetry of the benzene ligands in the complex, the rings probably being slightly puckered[4]. Fritz and Lüttke[5] stated that the infra-red absorption spectrum of $(C_6H_6)_2Cr$ was incompatible with six-fold symmetry and proposed molecular symmetry D_{3d}. Recently, however, the same investigators[6] changed their interpretation of the spectrum; they proposed symmetry D_{6h} both for the molecule $(C_6H_6)_2Cr$ and for the cation $(C_6H_6)_2Cr^+$; this conclusion was based on a study of the infra-red and Rāman spectra, mainly of $(C_6H_6)_2CrI$. Snyder[7] also proposed an assignment of the infra-red spectrum of solid dibenzene chromium based on molecular symmetry D_{6h}. Six-fold symmetry of the benzene ligands is also assumed by most other investigators in the field of arene metal compounds[8,9].

In view of the importance of dibenzene chromium as the parent compound of the class of arene metal complexes I have undertaken a refinement of the crystal structure of $(C_6H_6)_2Cr$. The outlines of the structure had already been determined by Weiss and Fischer[9]. These authors found the compound to be cubic with cell edge $a = 9 \cdot 67 \pm 0 \cdot 03$ Å. and four molecules per unit cell. The derived space group *Pa*3 immediately led to a centrosymmetric 'sandwich' structure of the molecule, the packing of the molecules being similar to that in solid carbon dioxide. Assuming molecular symmetry D_{6h}, they derived distances C—C of $1 \cdot 38 \pm 0 \cdot 05$ Å. and Cr—C of $2 \cdot 19 \pm 0 \cdot 10$ Å. by trial and error.

My refinement is based on three-dimensional X-ray diffraction data which were obtained by Dr. I. Lindqvist and Mr. R. D. Rosenstein at the Chemical Institute of the University of Uppsala, Sweden. The data comprise the visually estimated intensities of 177 independent reflexions, covering 3,560 points of the reciprocal lattice. Refinement of the structure, mainly by difference syntheses, was straightforward. Extinction difficulties, such as described in the comperable case of the refinement of ferrocene[10], were not encountered to an appreciable extent. At the present stage the disagreement factor *R* amounts to 0·063 and for further refinement the anisotropy of the temperature motion must be taken into account. As this may be rather time-consuming, we feel justified in reporting our preliminary results.

Space group *Pa*3 was confirmed by us, and the cube edge was determined to be 9·667 Å. The molecular symmetry of $(C_6H_6)_2Cr$, however, was found to be distinctly different from D_{6h}. In the C_6H_6 ligands C—C bonds of length 1·353 Å. alternate with bonds of 1·439 Å., molecular symmetry D_{3d} being imposed by the space group. Since the estimated standard deviation in the C—C bond distances is 0·014 Å., the difference between short and long bonds is highly significant; furthermore, it is far too large to be ascribed to intermolecular interaction. The rings are found to be planar within the limits of accuracy; the distances of the carbon atoms to the mean ring plane are 0·008 Å. with an e.s.d. of 0·007 Å. The bond angles C—C—C are 118·9° ± 1° and 121·0° ± 1°, the distances Cr—C 2·135 ± 0·010 Å. and 2·132 ± 0·010 Å. respectively, which is somewhat shorter than has been reported for chromium arene carbonyls[11]. The distance of Cr to the mean ring plane is 1·613 ± 0·007 Å.

In low-angle difference syntheses[12] the hydrogen atoms are clearly visible at the expected distances of the ring atoms. High-angle difference syntheses show the thermal motion to be anisotropic, corresponding to a libration of the rings about the three-fold axis, but certainly not to free or almost free rotation[13]. The root mean square angular amplitude of the libration is approximately 7°, slightly less than in benzene at −3° C. (ref. 14). This libration causes an apparent shortening of the C—C bond distances of the order of 0·010 Å. and of the Cr—C distances of 0·006 Å.; the bond angles and the planarity of the rings remain unchanged. As stated, the anisotropy of the thermal movement has not yet been taken into account in my structure refinement.

The corrected C—C distances in dibenzene chromium of 1·45 and 1·36 Å. are significantly different from the distance 1·397 Å. found in free benzene[15]. They correspond more closely to the distances found for pure single and pure double bonds between carbon atoms with sp^2 hybridization, which have average values of 1·46 and 1·34 Å. respectively[16]. This indicates that little or no delocalization of bonding electrons takes place within the ligands of $(C_6H_6)_2Cr$. The cation $(C_6H_6)_2Cr^+$, on the other hand, possesses one electron less than the neutral molecule; electron spin resonance measurements have shown the unpaired electron to be distributed over the whole ion[17]. This, in its turn, may lead to delocalization of the bonding electrons within the rings and hence to six-fold symmetry of the ion. The chemical implications of the above hypotheses will be described elsewhere.

I wish to thank Dr. I. Lindqvist and Mr. R. D. Rosenstein for giving me their X-ray diagrams and intensity estimations, to Dr. D. W. Smits for adapting his refinement programmes for the electronic computer *Zebra* to the case of cubic symmetry, and to Mr. H. Schurer for performing most of the calculations on the *Zebra*.

F. JELLINEK

Anorganisch-chemisch Laboratorium,
Rijksuniversiteit, Groningen. July 15.

[1] Fischer, E. O., and Fritz, H. P., in "Advances in Inorganic Chemistry and Radiochemistry", 1, 55 (Academic Press, Inc., New York, 1959).

[2] Wilkinson, G., and Cotton, F. A., in "Progress in Inorganic Chemistry", 1, 1 (Interscience Publishers, Inc., New York, 1959).

[3] Rich, H., "Ber. Jahrestagung Chem. Ges. DDR, Leipzig", 125 (1959).

[4] Fischer, E. O., Internat. Conf. Co-ord. Chem., London, April 1959, 73. Special Publication No. 13, The Chemical Society, London (1959).

[5] Fritz, H. P., and Luttke, W., Internat. Conf. Co-ord. Chem., London, April, 123. Special publication No. 13, The Chemical Society, London (1959). See also ref. 1, p. 105.

[6] Fritz, H. P., Luttke, W., Stammreich, H., and Forneris, R., *Chem. Ber.*, 92, 3246 (1959).

[7] Snyder, R. G., *Spectrochim. Acta*, 15, 807 (1959).

[8] Dyatkina, M. E., and Shustorovich, E. M., *Russian J. Inorg. Chem.*, 4, 179 (1959).

[9] Weiss, E., and Fischer, E. O., *Z. allg. anorg. Chem.*, 286, 142 (1956).

[10] Dunitz, J. D., Orgel, L. E., and Rich, A., *Acta Cryst.*, 9, 373 (1956).

[11] Carradini, P., and Allegra, G., *J. Amer. Chem. Soc.*, 81, 2271 (1959); 82, 2075 (1960).

[12] Jellinek, F., *Acta Cryst.*, 11, 677 (1958).

[13] Mulay, L. N., Rochow, E. G., and Fischer, E. O., *J. Inorg. Nucl. Chem.*, 4, 231 (1957).

[14] Cox, E. G., Cruickshank, D. W. J., and Smith, J. A. S., *Nature*, 175, 766 (1955).

[15] Langseth, A., and Stoicheff, B. P., *Canad. J. Phys.*, 34, 350 (1956).

[16] Brown, R. G., *Trans. Farad. Soc.*, 55 694 (1959). Costain, C. C., and Stoicheff, B. P., *J. Chem. Phys.*, 30, 777 (1959). Somayajulu, G. R., *ibid.*, 31, 919 (1959).

[17] For literature, see ref. 2, p. 77.

BIOCHEMISTRY

Amino-acid Sequence about the Reactive Serine of a Proteolytic Enzyme from *Bacillus subtilis*

AN increasing number of hydrolytic enzymes have been reported to be inhibited by di*iso*propylphosphorofluoridate. Where the resulting di*iso*propylphospho-enzyme has been investigated, the phosphate was isolated in the form of phospho-serine peptides and the amino-acid sequence about the reactive serine has been determined in several cases. Trypsin[1] chymotrypsin[2-4], elastase[5,6] and thrombin[7] have the sequence Gly.Asp.Ser.Gly., while horse liver ali esterase[8] and pseudocholinesterase[9] have Gly.Glu.Ser.-Ala.Gly. The proteolytic enzyme subtilisin was isolated from a strain of *B. subtilis* by Güntelberg and Ottesen[10] and they recorded its inhibition by di*iso*propylphosphorofluoridate, while Matsubara[11] obtained a phospho-peptide from strain N^1 but did not report any sequence. The present communication deals with an investigation of the enzyme from Novo Terapeutisk Laboratorium known as 'bacterial trypsin', which is similar to, but distinguishable from, the original subtilisin.

A sample was treated with di*iso*propylphosphorofluoridate labelled with phosphorus-32 at pH 7·4 and a partial acid hydrolysate was subjected to ionophoresis on Whatman No. 52 paper at pH 3·5 in parallel with similarly treated chymotrypsin and liver ali esterase (sample kindly provided by Dr. E. C. Webb). The radioautograph of the ionogram showed that serine phosphate occurred in all three; but the pattern of phospho-peptides from bacterial protease was entirely different from that obtained from either chymotrypsin[6] or liver ali esterase and therefore there must be a different sequence about the labelled site. Repetition of the hydrolysis of samples of di*iso*propylphospho-enzyme, under the same conditions, gave markedly different proportions of the bands within the pattern. The proportions were also affected by subsequent air oxidation and thioglycollic acid reduction, and some individual bands were found to be interconvertible by oxidation or reduction. This suggested that there was, near the labelled serine, an amino-acid which could undergo reversible air oxidation. It seemed probable that this was methionine, which can be readily oxidized to the sulphoxide[12]. The di*iso*propylphospho-enzyme was therefore oxidized with performic acid to convert any methionine into the stable sulphone, and a simplified, reproducible pattern was obtained on hydrolysis. This pattern, which is also obtained if the previous hydrolysates were oxidized with performic acid prior to ionophoresis, is shown in Fig. 1 together with those from di*iso*propylphospho-chymotrypsin and di*iso*propylphospho-liver ali esterase.

The interrelationships of these oxidized bands (numbered in diagram) were determined by study of their behaviour to partial acid hydrolysis and Edman degradation[6] and their chromatographic and electrophoretic mobilities. Additional information about the N-terminal residue was obtained by treating the

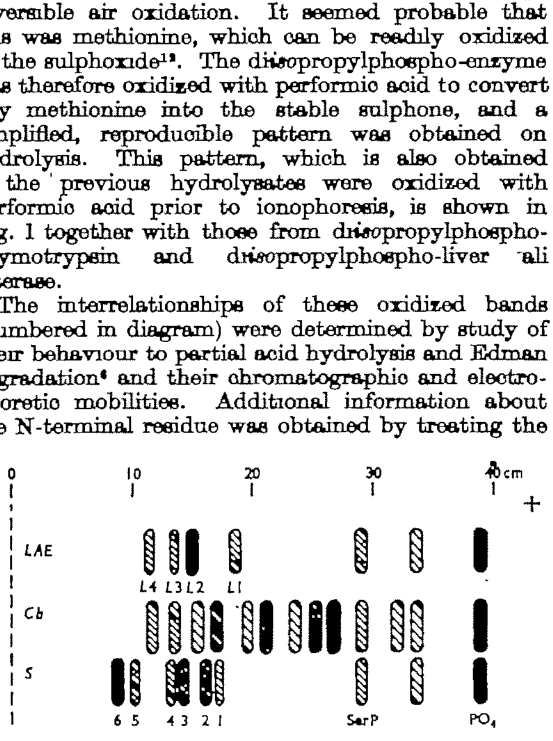


Fig. 1. Diagram of radioautograph of ionogram (pH 3·5, 40 V./cm., 2 hr.) of partial acid hydrolysis of di*iso*propylphospho-enzyme derivatives of liver ali esterase (*LAE*), chymotrypsin (*Ch*) and oxidized bacterial protease (*S*). The *LAE* bands are considered to be *L*1, Glu.SerP.; *L*2, SerP.Ala.; *L*3, Glu.SerP.-Ala; *L*4, Gly.Glu.SerP.Ala. The interpretation of the bands from chymotrypsin is being reported elsewhere (ref. 6)

Table 1

Peptide	Products of partial acid hydrolysis (excluding PO_4 and SerP)	Main radioactive product of Edman degradation	Effect of sodium periodate*
1	1	PO_4	–
2	2	SerP	+
3	1 and 2	1	+
5	1	PO_4	–
6	1, 2, 3 and 5	5	+

* + indicates that the peptide moved faster after treatment; – shows the peptide was not affected.

Peptide 4 is probably a larger peptide the structure of which has not yet been determined.

peptide with sodium periodate solution and observing whether the electrophoretic movement at *p*H 3·5 was affected. N-terminal serine and threonine residues should be oxidized to give a glyoxylic acid residue by loss of ammonia and formaldehyde or acetaldehyde, respectively[13]; so that the radioactive peptide would lose the terminal amino-group and should therefore move faster towards the anode. The results are summarized in Table 1.

A larger sample (50 mgm.) was then treated with di*iso*propylphosphorofluoridate labelled with phosphorus-32, oxidized with performic acid, hydrolysed and the radioactive peptides isolated by paper ionophoresis after removal of the neutral and basic peptides on a column of 'Dowex 50'. The amino-acid composition of each of these, after total hydrolysis, was determined on paper and is presented in Table 2.

Table 2

Peptide	Thr	Ser	Met SO_2	Ala	Asp	Glu	Gly
1	–	×××	××	–	××	*tr*	*tr*
2	×××	×××	–	–	*tr*	*tr*	*tr*
3	×××	×××	×××	–	×	×	×
5	*tr*	×××	××	×××	*tr*	*tr*	*tr*
6	×××	×××	×××	×××	*tr*	–	–

Relative amounts indicated by ×'s and obtained by visual comparison of intensities. *tr* indicates small contamination.

Contamination by non-radioactive, acidic peptides was not great and so from Table 2 and the determined interrelationships of the peptides, represented in Fig. 2, these experiments indicated the sequence Thr.Ser.Met.Ala.

It is interesting that the sequence about the reactive serine in this enzyme is totally different from those determined for other di*iso*propylphosphoenzymes. They had in common an acidic amino-acid, the serine and a small neutral aliphatic residue. Comparing subtilisin with chymotrypsin, trypsin, elastase and thrombin, which are all endo-peptidases with different specificities, it would appear that the sequence immediately about the serine is not responsible for the unusual reactivity towards di*iso*propylphosphorofluoridate which results in the inhibition of the proteolytic activity. Some other grouping, possibly including histidine[14], which is spatially close due to folding of the chain, probably activates the serine.

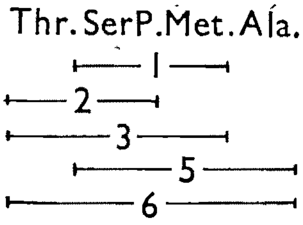


Fig. 2. Interrelationships of peptides. SerP indicates O-phosphoserine

F. SANGER*
D. C. SHAW†

Department of Biochemistry,
University of Cambridge.

* Member of the external staff of the Medical Research Council.

† Hackett Student from the University of Western Australia and on leave from C.S.I.R.O. Wool Research Laboratories, Australia.

[1] Dixon, G. H., Kauffman, D. L., and Neurath, H., *J. Amer. Chem. Soc.*, 80, 1260 (1958).

[2] Turba, F., and Gundlach, G., *Biochem. Z.*, 327, 186 (1955).

[3] Schaffer, N. K., Simet, L., Harshman, S., Engle, R. R., and Drisko, R. W., *J. Biol. Chem.*, 225, 197 (1957).

[4] Oosterbaan, R. A., Kunst, P., Van Rotterdam, J., and Cohen, J. A., *Biochim. Biophys. Acta*, 27, 549 (1958).

[5] Hartley, B. S., Naughton, M. A., and Sanger, F., *Biochim. Biophys. Acta*, 34, 243 (1959).

[6] Naughton, M. A., Sanger, F., Hartley, B. S., and Shaw, D. C., *Biochem. J.*, 77, 149 (1960).

[7] Gladner, J. A., and Laki, K., *J. Amer. Chem. Soc.*, 80, 1264 (1958).

[8] Jansz, H. S., Posthumus, C. H., and Cohen, J. A., *Biochim. Biophys. Acta*, 33, 396 (1959).

[9] Jansz, H. S., Brons, D., and Warringa, M. G. P. J., *Biochim. Biophys. Acta*, 34, 573 (1959).

[10] Güntelberg, A. V., and Ottesen, M., *C.R. Lab. Carlsberg, Sér. Chim.*, 29, 36 (1953).

[11] Matsubara, H., *J. Biochem. (Japan)*, 46, 107 (1959).

[12] Harris, J. I., and Roos, P., *Biochem. J.*, 71, 434 (1959).

[13] Nicolet, B. H., and Shinn, L. A., *J. Amer. Chem. Soc.*, 61, 161 (1939).

[14] Discussed in Symposium on Enzyme Reaction Mechanisms, *J. Cell. and Comp. Physiol.*, 54, Supp. 1 (1959).

PHYSIOLOGY

Effect of Testicular Hyaluronidase on the Permeability of Human Arterial Tissue

THE action of testicular hyaluronidase on acid mucopolysaccharides isolated from human aortic tissue was established in previous work from this laboratory[1]. The present investigation was undertaken with the purpose of studying the effect of testicular hyaluronidase on the permeability of arterial tissue membranes.

For determination of the tissue permeability, measurements were made of the diffusion coefficients of glucose for the membrane. The coefficient determinations were performed on three samples of the human aorta and three samples of the pulmonary artery, before and after the application of a solution of testicular hyaluronidase to the tissue, using the procedure of Johnson and Kirk[2]. After separation of the adventitia, intimamedia membrane samples of appropriate thickness were prepared. 50 ml. of a solution, consisting of 1 vol. 5 per cent glucose and 4 vol. Krebs's phosphate buffer, *p*H 7·1, were placed in the donor compartment of the diffusion apparatus, and 50 ml. of buffer solution in the recipient compartment. Two 1-hr. diffusion periods were first allowed to establish the permeability of the untreated membrane. Following this, the solutions were removed from the diffusion apparatus and the membrane and compartments rinsed with buffer solution. 5 ml. of a solution of testicular hyaluronidase (Alidase, Searle) in 0·05 *N* acetate buffer, *p*H 6·0 (30 viscosity units/ml.), were then introduced in both sides of the apparatus and were left in contact with the membrane for 2 hr. The membrane and the compartments were again rinsed with buffer solution, and glucose-buffer solution and buffer solution placed in the donor and recipient compartments. Diffusion coefficient measurements were then made in two 1-hr. periods. All experiments were carried out at 37° C. 30–45 min. were allowed to elapse

Table 1. Effect of Testicular Hyaluronidase on the Permeability of Human Arterial Tissue

Sample	Thickness of membrane (mm.)	Diffusion coefficient of glucose			
		Before hyaluronidase		After hyaluronidase	
		First period	Second period	First period	Second period
(1) Thoracic aorta	0·63	0·000082	0·000084	0·000103	0·000134
(2) Pulmonary artery	1·15	0·000065	0·000070	0·000091	0·000089
(3) Pulmonary artery	0·96	0·000138	0·000111	0·000297	0·000330
(4) Abdominal aorta	1·33	0·000063	0·000050	0·000074	0·000134
(5) Abdominal aorta	0·92	0·000078	0·000086	0·000086	0·000079
(6) Pulmonary artery	0·89	0·000039	0·000033	0·000041	0·000044
Mean		0·000078	0·000072	0·000115	0·000135

before each set of diffusion periods to permit penetration of glucose through the membrane.

The glucose analyses were performed in duplicate by the colorimetric method of Nelson[3], using the reagents described by Somogyi[4]. A Beckman *DU* spectrophotometer was employed for the colorimetric determinations.

The results of the experiments are presented in Table 1. It will be seen that a definite increase in the permeability of the arterial tissue to glucose was observed in four of the six experiments, whereas in two experiments no significant change was noted.

The diffusion coefficients observed for glucose for human arterial tissue in the present work before treatment with hyaluronidase are of the same order of magnitude as the values reported by Kirk and Laursen[5] for aortic tissue. The higher average values found in the second period following treatment with hyaluronidase may be due to a continued action of hyaluronidase in the tissue membrane.

Jørgen Matzke*

Division of Gerontology,
Washington University,
School of Medicine.
St. Louis, Missouri.

---

* St. Louis Heart Association Research Fellow. Present address: Medical Department *A*, University Hospital, Copenhagen, Denmark.

[1] Kirk, J. E., and Dyrbye, M., *J. Gerontol.*, 12, 23 (1957).

[2] Johnson, S. G., and Kirk, J. E., *Anal. Chem.*, 27, 838 (1955).

[3] Nelson, N., *J. Biol. Chem.*, 153, 375 (1944).

[4] Somogyi, M., *J. Biol. Chem.*, 195, 19 (1952).

[5] Kirk, J. E., and Laursen, T. J. S., *J. Gerontol.*, 10, 288 (1955).

Electro-shock Seizure Threshold of Metacorticoid Hypertensive Rats

It has been shown[1–5] that chronic administration of deoxycorticosterone acetate decreases brain excitability and potentiates anticonvulsant drugs, and that this effect is correlated with increased plasma and decreased brain intracellular sodium concentrations. In contrast, adrenal insufficiency produces the opposite effects[5]. Similarly, deoxycorticosterone acetate is known to be a relatively potent anæsthetic steroid[6].

Deoxycorticosterone acetate also produces, in the presence of dietary sodium, hypertensive cardiovascular disease and disturbances in mineral appetite. After the cessation of chronic administration of deoxycorticosterone acetate to rats, a metacorticoid state ensues in which these alterations persist[7,8]. It is felt that this hypertensive disease is mediated at least in part by increased arteriolar intracellular sodium[8,9]. It was of interest to determine whether the decreased brain excitability also persisted in metacorticoid rats.

Systolic blood pressures[10] and electro-shock seizure thresholds[11] were determined in 15 male Sprague–Dawley rats and in 30 similar rats that had previously received a subcutaneous implant of 20 mgm. deoxycorticosterone acetate and 1 per cent saline as drinking fluid for 3 months[8]. Both groups were being maintained on tap water, however, when blood pressure and electro-shock seizure thresholds were determined. The electro-shock seizure threshold refers to the convulsive threshold to a 60 counts per sec. current, delivered by corneal electrodes for 0·2 sec., that does not vary more than 1 m.amp. in 3 consecutive trials at least 48 hr. apart. The metacorticoid rats were found to have a mean electro-shock seizure threshold (35 m.amp.) that was not significantly different from that of the control rats (33 m.amp.), although their mean blood pressure (169 mm. mercury) was significantly elevated from control levels (129 mm.).

If the mechanism of electro-shock seizure threshold elevation by deoxycorticosterone acetate involves decreased brain intracellular sodium, and the mechanism of blood-pressure elevation by deoxycorticosterone acetate involve increased arteriolar intracellular sodium, then perhaps the former is reversible while the latter is not.

F. M. Sturtevant*

Smith Kline and French Laboratories,
Philadelphia, 1, Pa.

---

*Present address: Research Laboratories, Mead Johnson and Company, Evansville 21, Indiana.

[1] Davenport, V., *Amer. J. Physiol.*, 156, 322 (1949).

[2] Woodbury, D., and Davenport, V., *Amer. J. Physiol.*, 157, 234 (1949).

[3] Aird, R., and Gordon, G., *J. Amer. Med. Assoc.*, 145, 715 (1951).

[4] Woodbury, D., *J. Pharmacol. Exp. Therap.*, 106, 29, 46 (1952).

[5] Timiras, P., Woodbury, D., and Goodman, L., *J. Pharmacol. Exp. Therap.*, 112, 80 (1954).

[6] Selye, H., *Proc. Soc. Exp. Biol. Med.*, 46, 116 (1941).

[7] Green, D., Saunders, F., Van Arman, C., Calvin, L., and Sturtevant, F., *Amer. J. Physiol.*, 170, 486 (1952).

[8] Sturtevant, F., *Ann. Int. Med.*, 49, 1281 (1958).

[9] Raab, W., *J. Mt. Sinai Hosp.*, 19, 233 (1952).

[10] Kersten, H., Brosene, W., Ablondi, F., and Subbarow, Y., *J. Lab. Clin. Med.*, 32, 1090 (1947).

[11] Swinyard, E., *J. Amer. Pharmaceut. Assoc.*, Sci. ed., 38, 201 1949).

RADIOBIOLOGY

Delayed 'Primary' Effects in *Chara vulgaris* L. subjected to X-Rays

'Primary' or 'non-localized' effects in the form of clumping of metaphase chromosomes or the sticking together of sister chromatids in cells that complete mitosis shortly after irradiation during the period when mitotic frequency is decreasing have already been described by numerous investigators.

Study of the restoration process in the freshwater alga *Chara vulgaris* L. ($n = 14$) on X-radiation has shown that the effects referred to as primary could still occur long after irradiation, although re-establishment of the normal structure had already been achieved.

Irradiation was performed with unfiltered X-rays delivered by a Machlett *A.E.G.* 50 beryllium-window X-ray tube operated at 40 kV. peak and 25 m.amp. The dose-rate at the target distance employed (12 cm.) was 14,000 r./min., measured in air. The algae were irradiated under 5 mm. of tap water. The irradiation time ranged from 85 sec. (20,000 r.) to 28 min. (80,000 r.). After irradiation, the algae were put back in their normal culture conditions: filtered water from their place of origin, photo-period 16 hr., illumination 1,000 lux, temperature 20 ± 2° C.

In these conditions we observed for the most part that plants the telomes of which were treated with 20,000 r., 40,000 r. and 80,000 r., kept growing and formed whorls of phyloids having atypical morphology. Among these, however, a sudden restoration of the normal structure may occur after a series of 3–4 abnormal whorls. This process occurred about 5 weeks after irradiation. (A detailed study of the modalities of this process and survival and growth of irradiated algae will be published elsewhere.)

The mitosis of somatic cells in recovered whorls and of spermatogenous threads in antheridia borne by the former were investigated after fixing in modified Carnoy's fluid and staining with the Schiff reagent (Feulgen's method). This has shown a difference in the behaviour of nuclear divisions in these two cellular categories.

Whereas in the somatic cells the mitotic cycle is normal, without any appearance of chromosomic aberrations, on the contrary diverse mitotic disturbances were observed in the cells of the antheridial filaments. These differences are summarized in Table 1.

Table 1. MITOTIC ABERRATION FREQUENCIES IN SPERMATOGENOUS THREADS OF *Chara*

Mitotic aberration types per 100 cells	Dosage (kr)			
	0	20	40	80
Clumping (metaphase) (Fig. 1)	0	53·6	63·9	85·4
Stickiness (anaphase)	0	21·8	5·3	57·1
Anaphasic bridges	0	1·6	5·3	100
Micronuclei	0	5·8	0	4·8
Pycnosis	0	0	0	8·4

They are for the most part aberrations referred to as the usual 'primary', 'physiological' or 'non-localized' effects. The sister chromatid fusion results in bridge formation at anaphase.

The nuclei of the sperm mother cells resulting from these divisions also show different structural changes. With reference to Delay's work[1] on normal spermatogenesis in *Chara vulgaris*, the principal following abnormalities have occurred, especially in irradiated plants at 80,000 r.: (1) Central chromocentre ring, dumb-bell, filament shaped; (2) nuclear swelling or uneven contour of the nuclear membrane; (3) variation in nuclear volume; (4) nuclear fragmentation and pycnotic micronuclei.

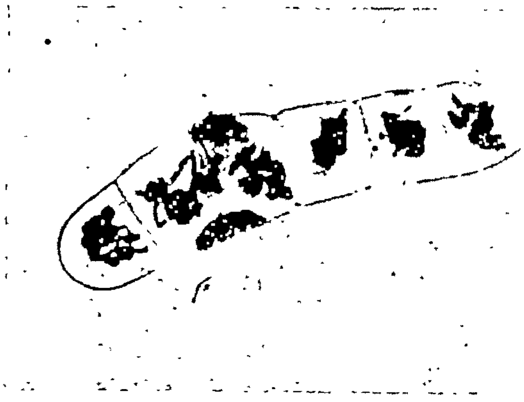


Fig. 1. Clumping in metaphase and stickiness in early anaphase. Spermatogenous thread of *Chara vulgaris* L. (× c. 1,500)

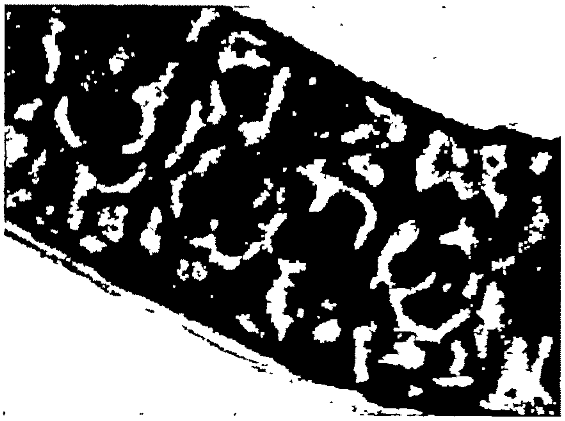


Fig. 2. Central vacuolization along the main axis (arrow) and degenerative pycnosis in the spermatozoids. Spermatogenous thread of *Chara vulgaris* L. (× 3,350)

Several degenerative processes occur in the spermatozoids: central vacuolization along the main axis and pycnosis (Fig. 2).

It is of interest to observe that aberrations referred to as primary effects can still appear at least 5 weeks following irradiation, after a minimum number of 12 mitoses between the irradiated apical cell and the antheridium initium, without the least mitotic damage being observed during the last nine divisions.

Thus it seems that these aberrations are bound with the metabolism of the nucleic acids in the course of spermatogenesis, whether this involves a depolymerization of deoxyribonucleic acid, as Darlington[2] and Taylor *et al.*[2] suggest, or partial dissociation of the nucleoproteins and damage to their organization pattern, as proposed by Kaufman[2].

These injuries due to X-rays are latent. The factor by means of which these injuries can be revealed is probably the very important heterochromatinization of the euchromocentric nuclei in the antheridial threads during spermiogenesis.

Moutschen and Dahmen[3] have stated that heterochromatin depolymerization and coalescence were emphasized by direct irradiation of the antheridia of *Chara vulgaris*. Moreover, some of the abnormal figures achieved by these authors immediately after direct irradiation are the same as those described here.

Effects referred to as primary are not limited to cells which complete mitosis immediately after irradiation; they can also occur in an organism long after X-ray treatment when the morphogenesis of the latter has again become normal. They can probably be transmitted by normal mitotic divisions and be revealed suddenly by a normal modification of nucleic acid metabolism in the nuclei heterochromatinization process during spermiogenesis in *Chara vulgaris*.

C. M. GILLET

Institute of Plant Morphology
and Systematic Botany,
University of Liège.

[1] Delay, C., *Rev. Cyt. Biol. végét.*, 11, 3–4, 315 (1949).

[2] See discussion in Carlson, J. G., and Harrington, N. G., *Rad. Res.*, 84 (1955).

[3] Moutschen, J., and Dahmen, M., *Rev. Cyt. Biol. végét.*, 17, 3–4, 433 (1956).

Fertility of Mice treated with Phosphorus-32

SINCE radioisotopes became available, many papers have been published concerning their clinical use as well as their potential harmful effects. One of these agents, phosphorus-32, is now occasionally being used in non-malignant conditions; consequently an effect which may be irrelevant in a cancer patient may become important in a young person who is likely to survive for some years; for example, the effect on the gonads. Previous knowledge on the subject is somewhat confusing[1-4], and no functional test has apparently been carried out so far.

The experiments reported here were carried out in *BALB* mice of both sexes, 1½–5 months old at the time of injection. Doses of phosphorus-32 ranging from 16 to 205 μc. were given intraperitoneally and the animals were mated with normal ones, previously checked for fertility, at periods of 1–8½ months after the administration of the agent. 3–12 months after treatment all the animals were killed and their ovaries and testes studied.

Tables 1 and 2 show the results obtained. 40 μc. seemed to be the threshold dose inducing sterility in all the females, since 6 of them so treated and mated with normal males revealed no pregnancy during 3–5 months of observation. With larger doses no pregnancies were encountered either, although the animals were kept under observation during periods up to 12 months. Males, however, were fertile even after receiving the largest dose administered, namely, 205 μc., which killed 5 out of 8 animals of this group. Since they were observed during periods ranging from 3 to 12 months, it seems safe to conclude that no dose short of the lethal one is capable of inducing sterility in males, whereas females become sterile with doses much below the lethal ones (approximately one-third *LD*50) and probably similar to those used in therapeutics.

Table 1. *BALB* FEMALE MICE TREATED WITH PHOSPHORUS-32

Dose (μc.)	No. of females treated	No. of females pregnant
16	2	2
28	8	3
34	5	4
40	6	—
60	2	—
90	6	—
120	8	—
200	3	—

Table 2. *BALB* MALE MICE TREATED WITH PHOSPHORUS-32

Dose (μc.)	No. of males treated	No. of males fertile
40·7	1	1
90	2	2
106	1	1
137	1	1
205	3	3

Ovaries and testes showed patterns generally in agreement with the observations of Bloom[1] and Odeblad[3]. However, no reappearance of the pearl formation in the ovaries, as described by Warren *et al.*[2], has been seen even 150 days after treatment. The results reported here seem to indicate that there is a real absence of oogenesis with doses of 40 μc. and not a decreased frequency as observed histologically by Warren *et al.* using much larger doses (250 and 2,000 μc.).

We are indebted to Fundaleu (Fundacion para combatir la leucemia), which partly supports the Seccion Leucemia Experimental, the Comision Nacional de Energia Atomica, for supplying us the radioactive phosphorus used, and E. R. Squibb and Sons, Argentina S.A., which partly supported this investigation.

E. A. D. HOLMBERG
A. PAVLOVSKY
C. D. DE PASQUALINI
Seccion Leucemia Experimental,
Instituto de Investigaciones Hematologicas,
Academia Nacional de Medicina,
Melo 3081,
Buenos Aires.
S. L. RABASA
Instituto de Investigaciones Medicas,
Rosario, Argentina.

---

[1] Bloom, W., *NNES*, Div. IV, 22, 1 (1948).

[2] Warren, S., MacMillan, J. C., and Dixon, F. J., *Radiology*, 55, 557 (1950).

[3] Odeblad, E., *Acta Radiologica*, 38, 33 (1952).

[4] Odeblad, E., *Acta Radiologica*, Supp. 93 (1952).

[5] Kawin, B., Hanford Atomic Products Operation, Richland, Washington (Nov. 21, 1958).

ANATOMY

Pattern of Hæmopoiesis in the Fœtal Liver

WHILE the importance of the hæmopoietic role of the fœtal liver is universally recognized, remarkably little precise information is available about the changing cytology of this organ during the course of development. The recent interest in techniques for the transfusion of suspensions of human fœtal liver, as a source of hæmopoietic stem-cells, has, however, made it desirable to study more fully the processes of fœtal blood formation.

We are investigating the development of the blood and blood-forming tissues in the human embryo and fœtus, using quantitative methods wherever possible. In 35 fœtuses, obtained by hysterotomy between the second and seventh months of pregnancy, the livers have been examined both in sections and in smears.

The composition of the hæmopoietic cell population of the liver differs in a striking fashion from that of the bone-marrow (Fig. 1), and it would appear that the pattern of hæmopoiesis in the two situations is fundamentally different. Whereas the cytology of the bone-marrow suggests active erythropoiesis and granulopoiesis from the inception of the hæmopoietic process, that of the liver indicates an overwhelmingly erythropoietic pattern of hæmopoiesis and we can find no evidence of granulopoiesis. The occasional granulocytes which are observed in liver preparations are in all probability derived mainly from the blood. Bridges *et al.*[1] administered a suspension of fœtal liver to a patient suffering from pancytopenia, and afterwards observed a pronounced granulocytosis. It is possible, therefore, that the liver does in fact contain myeloblasts, which *in situ* fail to differentiate into granulocytes because of local metabolic conditions but which do so on reaching an appropriate environment. The liver certainly contains a few cells which we would confidently label myeloblasts if we saw them in the bone-marrow.

The liver and bone-marrow also differ in their lymphocyte content. Although no evidence of lymphocytopoiesis can be found in even the earliest bone-marrow, about one quarter of its nucleated cells are

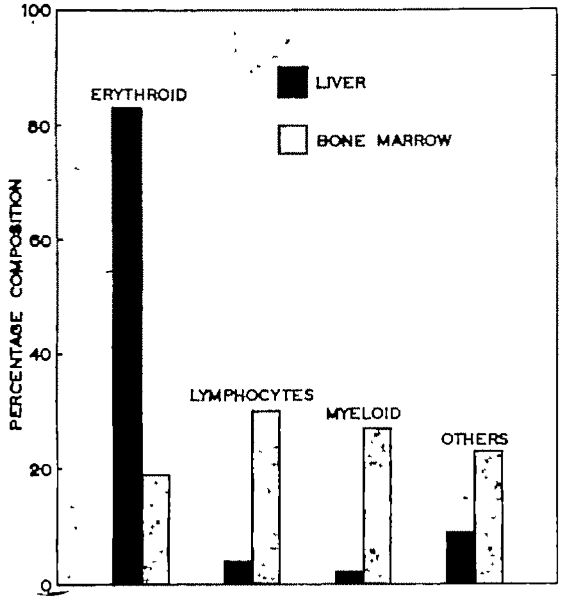


Fig. 1. Hæmopoietic cells of fœtal liver and bone marrow. Human fœtus, 203 mm. crown-rump length

lymphocytes; 15 per cent of these are transitional in appearance between typical small lymphocytes and hæmocytoblasts, resembling closely the cells previously described in the bone-marrow of the guinea pig by Yoffey[2]. In the liver, on the other hand, very few lymphocytes are seen and these, like the granulocytes in this situation, are probably derived from the blood.

The sparsity of lymphocytes in the fœtal liver, in which cell proliferation is extremely active, is difficult to reconcile with the view of Andreasen[3] and others, that lymphocytes are somehow mitotic adjuvants.

Furthermore, it seems unlikely that the lymphocytes of the bone marrow are concerned in antibody production, of which there is little evidence in early fœtal life. It would appear, therefore, that the lymphocyte population which is such a conspicuous feature of bone marrow—and presumably an indispensable cellular constituent from the earliest stages of development—must subserve a non-immunological function. The abundance of 'transitional' cells in fœtal marrow accords with the conclusion of Yoffey[4], that at least some of the small lymphocytes serve as hæmopoietic stem-cells in the marrow. Hæmopoiesis in the fœtal liver is quite unlike that in the bone marrow, for not only is it mainly erythropoietic, as has been noted already, but also the hæmopoietic stem-cell in this situation appears to be radically different from that in the marrow.

According to the widely accepted view of Maximow[5], it is represented by the undifferentiated mesenchymal cells which are trapped among the hepatic trabeculæ as they grow into the septum transversum. Our observations have failed to yield any evidence in support of this view. On the contrary, when mesenchyme occurs independently of hepatic trabeculæ, it contains very few differentiating hæmopoietic cells in comparison with the latter. Although occasional hæmocytoblasts and a variety of other immature hæmopoietic cells are seen intravascularly, in which situation they may undergo mitosis, the overwhelming majority of hæmocytoblasts and differentiating erythroid cells is extravascular, being found in the substance of the hepatic trabeculæ in intimate relationship with the liver cells. Here cells intermediate in appearance between hæmocytoblasts and early liver cells are observed in profusion and a complete morphological spectrum, linking the two, can be readily synthesized. We are, therefore, inclining more and more to the conclusion reached by Toldt and Zuckerkandl[6], that the hepatic hæmocytoblasts are derived not from the mesenchyme but from entoderm, namely, the as yet undifferentiated liver cells. In this connexion it is interesting to note that Gladstone and Hamilton[7] have ascribed an entodermal origin to the hæmocytoblasts of the human yolk-sac.

This work will be reported in detail elsewhere.

D. Brynmor Thomas
P. M. Russell
J. M. Yoffey

Department of Anatomy,
The University,
Bristol.

---

[1] Bridges, J. B., Bridges, J. M., Edelstyn, G. J. A., Lyons, A. R., and Nelson, M. G., *Lancet*, i, 629 (1960).

[2] Yoffey, J. M., Brookhaven Symposia in Biology, 10, 1 (1957).

[3] Andreasen, E., in "The Kinetics of Cellular Proliferation", edit. by Stohlman, F. (Grune and Stratton, New York and London, 1959).

[4] Yoffey, J. M., "Quantitative Cellular Haematology" (Chas. C. Thomas Co., Springfield, Ill., 1960).

[5] Maximow, A., *Arch. mikr. Anat.*, 73, 444 (1909).

[6] Toldt, C., and Zuckerkandl, E., *Sitzungsber. d. K. Akad. d. Wiss. Wien*, 72, Abt. 3, 241 (1875).

[7] Gladstone, R. J., and Hamilton, W. J., *J. Anat.* (Lond.), 76, 9 (1941).

BIOLOGY

Recapture in the River Tweed of a Sea-trout marked in Devonshire

During the winter of 1959–60 a number of sea-trout (*Salmo trutta* L.) kelts were tagged at the experimental fish trap installed by the Ministry of Agriculture, Fisheries and Food in the River Axe at Colyford, south Devon.

One of these fish, tagged on October 29, 1959, was recaptured on July 21 (266 days after liberation) in the estuary of the River Tweed, Northumberland, at the Yardford fishery situated about four miles from the mouth of the river.

The minimum distance travelled from the point of tagging to the point of recapture, via the Straits of Dover, is approximately 580 miles and via the Irish Sea is approximately 1,130 miles.

In addition to this recapture, a number of other sea-trout kelts similarly tagged at the trap last winter have been recaptured in the Rivers Otter (1), Exe (1), Teign (4), Erme (1) and Taw (1). In the last case, the minimum distance travelled was 244 miles in 174 days. Two of the fish caught in the Teign were taken in fresh water several miles above the tideway but the others were taken in the estuaries of the various rivers. The extent of the migrations of sea-trout in the sea are almost entirely unknown and these observations suggest that they are more extensive than has hitherto been supposed.

A. Swain
I. R. H. Allan
M. J. Bulleid

Salmon and Freshwater Fisheries Laboratory,
Ministry of Agriculture, Fisheries and Food,
London, S.W.1.

Interspecific Hybrids of *Tilapia*: *T. nigra* × *T. zillii*

THE increasing recognition of fish (and in the tropics of *Tilapia* in particular) as farm animals has stimulated interest in the breeding of new and useful strains. In Malacca, Hickling[1] hybridized two geographical stocks of *Tilapia mossambica* Peters to produce both a faster growing strain as well as a skewed sex ratio in favour of males, the latter greatly simplifying the monosex culture technique of Brown and van Someren[2]. Hybrids have now been reported between *T. nilotica* (Linné) and *T. galilaea* (Artédi)[3], but their value for fish culture has not yet been assessed. Field observations led Lowe to suspect hybridization of the former with *T. nigra* (Günther) and *T. esculenta* Graham in Uganda[4].

The species involved in these crosses are female mouth-brooders. Although all show a basic similarity in breeding pattern, quite distinct from that of male mouth-brooders or substratum-spawners (as defined by Lowe[5]), interspecific differences, especially in courtship and male breeding coloration, have been considered important barriers to natural hybridization. It is therefore of great interest to record hybrids between the mouth-brooder *T. nigra* and the substratum-spawner *T. zillii* Gervais. It is difficult to imagine two more dissimilar species of *Tilapia*. They show striking differences, not only in breeding patterns but also in anatomy, behaviour and feeding habits.

Hybrids were found in a flooded rice paddy on the Tebere rice irrigation scheme in Kenya which had been stocked with *T. nigra*, but into which two male *T. zillii* had gained entry. Similar hybrids were also found in Lake Naivasha, Kenya, which had been stocked with both species. The hybrids were recognized in the field principally by coloration: dark body-shape the hybrids conformed to *T. nigra*; and the iridescent blue sheen of *T. zillii*; light, pearly green spots on the body and on dorsal, anal and caudal fins; no trace of the crimson flush on the chest found in breeding *T. zillii*, and no dorsal '*Tilapia*-mark'; and six or seven dark vertical bars on the body (absent in large *T. nigra*). In general body-shape the hybrids conformed to *T. nigra*; however, in all but one case the mouths were noticeably smaller. The Tebere hybrids also exhibited a 'gasping' behaviour (protrusion of the mouth) and tended to erect dorsal and anal fins when handled, a behaviour found in *T. zillii* but rare in *T. nigra*.

In most anatomical characters the hybrids resembled *T. nigra*, but (except in one case) larger specimens lacked the enlarged snout (elongation of the horizontal ramus of the premaxilla) associated with that species. Premaxilla, maxilla, dentary and articular were slightly shorter than in *T. nigra*, but less robust than those of *T. zillii*. Otherwise neurocranial, branchiocranial and pectoral elements, very different in the two species, were in the hybrids within the range of proportions found in *T. nigra*. Jaw and pharyngeal dentition resembled that of *T. nigra*, although simplification of the outer jaw teeth appeared to have been retarded slightly. Some hybrids had the three anal spines of *T. zillii*, while others had four anal spines (found in 10–20 per cent of natural populations of *T. nigra*). Five anal spines, the normal in *T. nigra*, occurred in 11 per cent of the Tebere hybrids.

Since female hybrids were not recognized in the field, but afterwards when post-mortem colour changes had eradicated the hybrid coloration, and since the few females found had either four or five anal spines, it is possible that female *T. nigra* were included in the samples. In most cases testes were well developed, and breeding occurred in ponds stocked with three- and four-spined males and five-spined females. No three-spined progeny were produced and the fry resembled *T. nigra* in all respects, including coloration. The cross male *T. zillii* × female *T. nigra* has been repeated at the Inland Fishery Research Station at Sagana in Kenya, and a brooding female was found after six weeks. The results of the reverse cross are not known.

Although the hybrids appear to be fertile, a skewed sex ratio may occur. Alternatively, spine-counts may facilitate the determination of the sex of small fishes. The production of a sterile or predominantly male weed-eating hybrid seems at present unlikely, only four hybrids having apparently fed on higher plants as does *T. zillii*.

These results will be reported more fully elsewhere.

P. J. WHITEHEAD

Ministry of Forest Development,
Game and Fisheries,
Kenya.

---

[1] Hickling, C. F., *Nature*, 183, 28 (1959).

[2] Brown, J. M., and van Someren, V. D., *Nature*, 172, 330 (1953).

[3] Yashouv, A., and Chervinsky, J., *Nature*, 184, 1739 (1959).

[4] Lowe, R. H., *Rev. Zool. Bot. Afr.*, 57 (Fasc. 1–2), 129 (1958).

[5] Lowe, R. H., *Proc. Zool. Soc. Lond.*, 132, Pt. 1, 1 (1959).

Occurrence of *Pyrosoma* on the Continental Slope

Hurley and McKnight[1] have reported that the pelagic tunicate *Pyrosoma atlanticum atlanticum* rests on or swims just above the sea-floor at a depth of 160–170 metres. Indirect observations made on this species in the course of a line-fishing survey of the fishes of the south-eastern Australian continental slope[2] corroborate the concentration of this species near the sea-floor and extend the habitat to the floor of the continental slope.

While fishing off the east coast of Tasmania during June 1954–July 1955, 1,141 specimens of *Hyperoglyphe porosa* (Richardson) (deep-sea trevally)—previously considered to be quite rare—were taken by dropline in depths ranging from 330 to 640 m. These fish were found to feed almost exclusively upon *Pyrosoma*, their stomachs often being crammed full with the tests of this organism. Of 363 stomachs containing food 86 per cent contained the tests of large colonies of *Pyrosoma*. Fish having *Pyrosoma* in their stomachs were taken on hooks set 2–48 m. from the floor of the continental slope. Since fish were never taken until the fishing gear was touching bottom it is assumed that *Pyrosoma* were available at these depths. This would seem to be confirmed by the observations of Hurley and McKnight[1]. With one exception, all fishing operations were carried out during the hours of daylight, the incidence of *Pyrosoma* in the stomachs showing no significant variation throughout the day. Only 5 fish were taken at night and these had empty stomachs.

Thompson[3] recorded occurrences of *Pyrosoma* from Tasmanian waters at all seasons of the year and at all depths examined (0–500 m.) and was unable to discern any particular season of maximum occurrence.

From an examination of the stomach contents of *Hyperoglyphe* off the east coast of Tasmania in June, July, September and October 1954, and in January, March, May and July 1955, it was apparent that the incidence of *Pyrosoma* in the stomachs was at its maximum during the months of January and March. No other food organism became dominant at any time, so the incidence of *Pyrosoma* in the stomachs may reflect the seasonal abundance of the tunicate, though it could possibly reflect seasonal variation in the feeding intensity of the fish.

The specimens of *Pyrosoma* were identified by Mrs. M. Mather of the Zoology Department, University of Queensland.

T. R. COWPER

Division of Fisheries and Oceanography,
Commonwealth Scientific and Industrial
Research Organization,
Marine Laboratory,
Cronulla, Sydney.

---

[1] Hurley, D. E., and McKnight, D. G., *Nature*, 183, 4660 (1959).

[2] Cowper, T. R., and Downie, R. J., C.S.I.R.O., Aust. Div. Fish. Oceanogr. Rep. No. 6 (1957).

[3] Thompson, Harold, "Pelagic Tunicates of Australia" (Commonwealth Council for Scientific and Industrial Research, Australia, Melbourne, 1948).

MISCELLANY

'Dex' or 'Order of Magnitude' ?

THE phrase 'order of magnitude' is in constant use. It has at least two different meanings. In astronomy the magnitude of star *A* exceeds that of star *B* by unity if the amount of radiation (measured visually, photographically or bolometrically) reaching an observer or instrument on the Earth in a given time from *A* is $10^{-0 \cdot 4}$ or 0·3981 times that from *B*. In other sciences *A* is said to exceed *B* by an order of magnitude if it is ten times as large. To take an example, Lowy[1] wrote, "Thus, in the tonic anterior byssus retractor of *Mytilus*, the decay of tension can be two orders of magnitude slower than that of the active state". I take it that this means that the time needed for the tension to fall to a given fraction of its initial value after tonic contraction can be 100 times greater than the corresponding time after active contraction.

There is a shorter and more precise word to express such a comparison. This is the word 'dex', for 'decimal exponent', due to Allen[2,3]. He defines it as follows. "Dex converts the number before it into its 10-based antilogarithm. The term can be used for a typographically convenient method of expressing large numbers, as in the example 10^{39} = 39 dex. It can also be used to introduce verbal simplicity into statements on probable errors, ranges, and variations." He gives, among others, the example "The frequency range of useful radio-astronomy observations is 3·2 dex".

I suggest that outside astronomy 'dex' can always be substituted for 'order of magnitude' with advantage. I give a few examples from biology. "The range of weights of vertebrates is 10 dex, that of weights of birds only 4 dex." "A man consists of about 14 dex of cells." "The ratio of length to breadth in a nerve fibre can exceed 6 dex." "There are about 11 dex of birds." "The coefficient of variation of linear dimensions of unworn mammalian teeth rarely exceeds 0·05 dex." "The human ear has a frequency range of about 3·5 dex (1 octave = 0·301 dex) but the range of tones used in music is only 2·1 dex."

It can also be used with advantage in the social sciences, for example, "There are 8·6 dex of human beings in India, and about 8 dex of adult males. The range of incomes certainly exceeds 3 dex and may exceed 4".

Biologists will have to learn to think rapidly in terms of large numbers, as physicists, chemists, astronomers, and geologists do already; and even in the case of small numbers, the use of the word 'dex' may be an aid to precision of thought. I venture to hope that it may also be taken over from the terminology of astrophysics into other non-biological sciences. I am trying to use it systematically in lectures in this Institute.

J. B. S. HALDANE

Indian Statistical Institute,
Calcutta, 35.

---

[1] Lowy, J., *Nature*, 184, 1445 (1959).

[2] Allen, C. W., *Observatory*, 71, 157 (1951).

[3] Allen, C. W., "Astrophysical Quantities" (London, 1955).

PSYCHOLOGY

Effects of Medial Temporal Lesions on Taste Preference in the Monkey

MONKEYS with lesions in the medial portions of the anterior temporal lobes (the amygdala and pyriform cortex) tend to show marked changes in their responses to events that, pre-operatively, served as rewards or punishments. For example, it has been claimed that animals tend to be unafraid of snakes and strange people, to mount inanimate objects, to ingest a host of objects that were unacceptable pre-operatively. According to one descriptive generalization[1] monkeys are still motivated by reward and punishment, but the classes of events that are rewarding or punishing alter. In order to examine this view more specifically and also to rule out the possibility that the changes in reward–punishment classification occur simply because of changes in sensory capacity, the following experiments were undertaken.

Prior to operation saccharine preference curves for ten monkeys were determined. Each animal was given daily tests with one drinking dish containing distilled water and the other one containing saccharine sodium in one of four concentrations (1·0, 0·25, 0·05, 0·017 per cent). The actual concentration given on any day and the positions of the two dishes were randomized. Once a week both dishes contained distilled water.

This procedure lasted five weeks, so that a reasonably stable preference curve for each animal could be determined. Typically monkeys showed an aversion for the 1 per cent concentration and a moderate preference for the 0·017 per cent concentration, with a clear and strong preference for the middle two concentrations. Throughout the entire experiment, monkeys were provided with unlimited quantities of their standard diet of diet 41 lab chow, with vitamin C added.

In addition, with six of the monkeys, absolute thresholds for saccharine were determined using a method that does not depend upon the animal's preference for saccharine. The animal was trained to lick up 5 drops of a solution placed upon a piece of aluminium foil clamped to the top of a small iron cylinder. Until the animal made the licking response, the cylinder was held firmly in place by means of an activated electromagnet placed directly beneath it. If the solution was distilled water, the animal could then lift the cylinder within 10 sec. following the licking response and obtain a small piece of apple placed within it. If the solution was a saccharine solution, the animal was rewarded directly by the experimenter (who was situated behind a one-way vision screen) if he did not lift the cup for at least 10 sec. following the licking response. By systematically varying the concentration of saccharine, the point at which a weak concentration could no longer be discriminated from water was determined. The aluminium foil was renewed on each trial and an interval of 1 min. was inserted between all trials to allow for adaptation. An opaque screen was lowered between trials so that the animal could not see the solution being placed on the foil. The fact that thresholds were obtained indicates that the animals were not using extraneous cues in making their responses.

After these tests had been carried out, six of the monkeys were given bilateral medial temporal lesions, three were given partial striate cortex lesions, and one was given an anterior frontal lesion. All threshold and preference tests were then repeated, beginning one week post-operatively.

The results indicated that the absolute threshold for saccharine was not detectably altered in the six medial temporal monkeys. The average threshold was of the order of 0·008 per cent pre-operatively and post-operatively. Preference for saccharine, however, underwent a clear change in the medial temporal group as indicated in Figs. 1 and 2. The stronger concentrations became much more preferred than they had been pre-operatively. The weak concentrations did not change. In the striate control group, if there was any trend, it was in the opposite direction. (The data for frontal monkeys are not included in these graphs. As has been found in earlier studies, for example, ref. 2, they fell between the medial temporal and control group results.) Of the six medial temporal animals, all showed an increase in preference for the strongest solution; all three striate monkeys showed a slight decrease. Associated with the increase in preference for strong saccharine was, in some cases, a large increase in fluid intake for those solutions. One monkey, for example, consumed an average of 3,550 c.c. a day of the 0·25 per cent solution, which was almost equal to his own body-weight. On the weak concentrations, however, and on water versus water, there was no change in the total fluid intake, indicating that a simple diabetes insipidus will not account for the results.

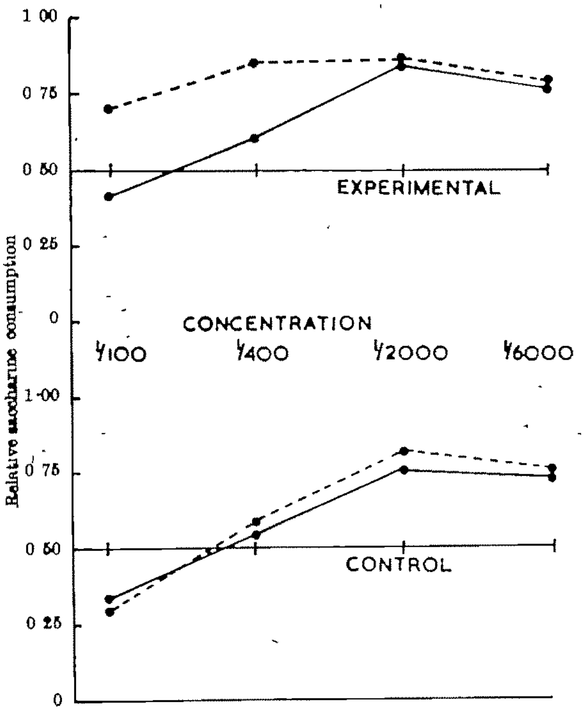


Fig. 1. Mean preference curves. The ordinate represents consumption of saccharine divided by saccharine plus distilled water. Each point is the average of all animals in each group, at least six determinations per animal with each concentration. ——, pre-operative; – – –, post-operative

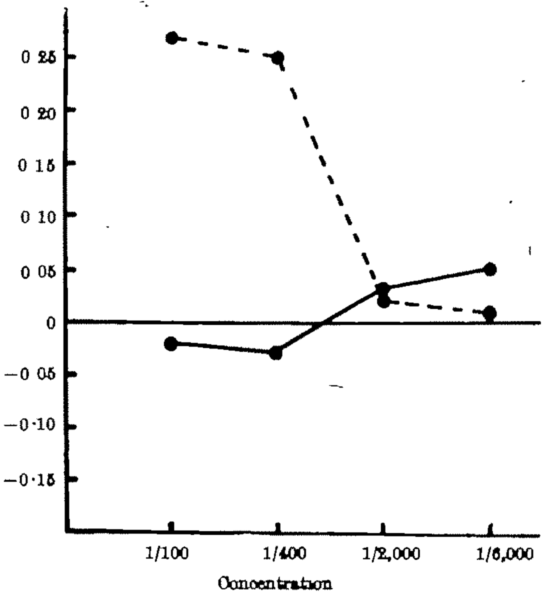


Fig. 2. Mean preference change. The ordinate represents the difference between post-operative and pre-operative preferences with each concentration, determined for each animal and then averaged. ——, Controls, – – –, experimentals

The results confirm, threfore, the view that medial temporal lesions change preferences—and thereby the relative strength of rewards—without changing the sensory capacity to discriminate the rewards. The experiments also incidentally point out the inadequacy of measuring changes in taste threshold in animals by means of preference, as is frequently done.

The preference results are unexpected in their direction. It was predicted, from gross observations, that the monkeys would become more indiscriminate, that is, tend to show no clear preference between saccharine and water. Instead, they became virtually saccharine 'addicts', especially for strong concentrations. Further work is therefore necessary to determine whether medial temporal monkeys prefer any strong testing substance or whether the change is specific to the dimension of sweetness. There is some evidence that the former alternative is likely.

L. Weiskrantz

Psychological Laboratory,
University of Cambridge.

[1] Weiskrantz, L., *J. Comp. Physiol. Psychol.*, **49**, 381 (1956).

[2] Weiskrantz, L., and Wilson, jun., Wm. A., *J. Comp. Physiol. Psychol.*, **51**, 167 (1958).

FORTHCOMING EVENTS

Sunday, September 4—Wednesday, September 7

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at Cardiff)—Continuation of 122nd Annual Meeting.

Sunday, September 4

At 11 a.m.—Service at Llandaff Cathedral. Preacher: The Bishop of Llandaff.

Monday, September 5

At 10 a.m.—Symposium on "World Food and Population". Chairmen: Sir George Thomson, F.R.S., and Sir James Gray, F.R.S. Principal Speakers: Dr. N. C. Wright, Prof. D. V. Glass, Prof. W. A. Lewis, Dr. L. Dudley Stamp, Sir Alexander Fleck, F.R.S., Dr. H. D. Kay, F.R.S., Prof. P. M. S. Blackett, F.R.S.

At 8 p.m.—Dr. E. B. Chain, F.R.S.: "Microbiological Methods in the Development of Drugs" (Evening Discourse).

Tuesday, September 6

At 10 a.m.—Mr. G. F. Mitchell: "Pleistocene History of the Irish Sea" (Presidential Address, Section C).

At 10 a.m.—Prof. D. V. Glass: "Population Growth, Fertility and Problems of Policy" (Presidential Address, Section N).

Wednesday, September 7

At 10 a.m.—Mr. Martin J. Wells: "What the Octopus Makes of it: Our World from Another Point of View" (Darwin Lecture).

Wednesday, September 7

INSTITUTE OF PETROLEUM (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. D. Downs, Mr. S. T. Griffiths and Mr. R. W. Wheeler: "The Part Played by the Preparational Stage in Determining Lead Anti-Knock Effectiveness".

POLAROGRAPHIC SOCIETY (at "The Feathers", Tudor Street, London, E.C.4), at 7 p.m.—Informal Discussion Meeting on "The Use of Ion Exchange Water in Polarography".

Thursday, September 8

PHYSICAL SOCIETY, ACOUSTICS GROUP (in the new Physics Building Imperial College, South Kensington, London, S.W.7), at 9.30 a.m.—Symposium on "Sound Propagation in the Atmosphere".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT IN VETERINARY PHARMACOLOGY in the University of Glasgow Veterinary Hospital—The Secretary of University Court, The University, Glasgow (September 9).

ASSISTANT INSPECTORS OF FISHERIES (2) (male, not over 40, with a degree, or equivalent in zoology, plus adequate knowledge of botany) IN THE DEPARTMENT OF LANDS, Dublin—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (September 9).

ASSISTANT EXPERIMENTAL OFFICER (with a degree in science or horticulture) IN THE ENTOMOLOGY SECTION—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (September 10).

BIOCHEMIST (Top grade) (well qualified chemist, preferably with a medical qualification) TO BE HEAD OF THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, United Birmingham Hospitals, Queen Elizabeth Hospital, Birmingham 15 (September 10).

SENIOR LECTURERS (2) (preferably with a good honours degree and teaching or other suitable experience), one to teach electrical engineering and the other to teach electronics to equivalent degree level for Sandwich Diploma Courses—The Principal, Royal Radar Establishment College of Aeronautics, Malvern (September 10).

TECHNICIAN (preferably with experience in photography) IN THE DEPARTMENT OF ZOOLOGY—The Registrar, University College of Wales, Aberystwyth (September 10).

TUTORIAL STUDENT (graduate, or about to graduate) IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, King's College (University of London), Strand, London, W.C.2 (September 10).

SENIOR LECTURER (with qualifications in either pure or applied mathematics) IN MATHEMATICS at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, September 16).

LECTURER (graduate with experience in the dairy industry or of dairy teaching) IN DAIRYING—The Registrar (Room 22, O.R.B.), The University, Reading (September 17).

RESEARCH FELLOWS (2) (preferably with a Ph.D. degree in engineering or physics, or equivalent research experience) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING (under Prof. A. L. Cullen), for work in the field of millimetre waves techniques—The Registrar, The University, Sheffield (September 17).

BRITISH OIL AND CAKE MILLS RESEARCH FELLOW (graduate, preferably with honours, in agriculture, economics or pure science) IN THE DEPARTMENT OF AGRICULTURE—The Professor of Agriculture, The University, Leeds 2 (September 21).

LECTURER/ASSISTANT LECTURER (with a good honours degree with suitable research and teaching experience, together with a good knowledge of both plant and animal biochemistry) TO TEACH AGRICULTURAL BIOCHEMISTRY at the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Kuala Lumpur and London. September 30).

LECTURER IN CHEMICAL ENGINEERING at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, September 30).

PHYSICIST or SOIL PHYSICIST (Ref. SD.1) (with a first- or second-class honours degree in physics with at least two years postgraduate experience in research or in natural science with at least two years experience or training in soil science), for research on the mechanical and physical properties of agricultural soils and their relationship to the performance of tillage implements; and an ENGINEER (Ref. SD.2) (with a first- or second-class honours degree in mechanical or agricultural engineering or equivalent and with postgraduate experience in agriculture), for research on the design and performance of ploughs and cultivation machinery and on improved methods of cultivation—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire, quoting appropriate Ref. No. (September 30).

SENIOR LECTURER IN FARM MANAGEMENT in the INSTITUTE OF AGRICULTURE, the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 30).

SENIOR LECTURER IN PREHISTORY IN THE DEPARTMENT OF ANTHROPOLOGY, University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, September 30).

SENIOR LECTURER and a LECTURER (with a degree in science or in agriculture, followed by postgraduate training in biochemistry, and previous experience in teaching or research) IN BIOCHEMISTRY at Canterbury Agricultural College, University of New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, October 15).

SENIOR LECTURER IN CYTOLOGY AND GENETICS at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, October 15).

SENIOR LECTURER or LECTURER IN PHYSICS at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, October 31).

UNIVERSITY LECTURER (with at least an honours degree in psychology and some knowledge of statistical methods) IN PSYCHOLOGY—The Secretary, Cambridge University Department of Education, 17 Brookside, Cambridge (November 3).

ASSISTANT PROFESSOR (Ph.D. or M.B.) IN PHARMACOLOGY—Prof. M. F. Murnaghan, University of Ottawa, Ottawa, Ontario, Canada.

ASSISTANT PROFESSOR OF PHARMACOLOGY—Prof. J. G. Aldous, Department of Pharmacology, Dalhousie University, Halifax, N.S., Canada.

ASSOCIATE PROFESSOR (preferably Ph.D.) OF HORTICULTURE at the University of Saskatchewan, Saskatoon, Saskatchewan, Canada—The Agent-General for Saskatchewan, 19 Chester Mews, London, S.W.1.

COMPUTER (preferably woman graduate) for the MATHEMATICS DEPARTMENT—The Assistant Secretary, University College, Gower Street, London, W.C.1.

COUNTY LABORATORY RESEARCH FELLOW, to work in the field of hair growth in collaboration with Dr. F. J. Ebling—Dr. F. J. Ebling, Department of Zoology, The University, Sheffield.

GEOLOGIST (man or woman, aged 23–45, with a degree in geology, general experience in geology and geophysics, and a knowledge of the occurrence of ground water) with the Government of Kenya, for the location of sites for water boring, geological mapping with special reference to the occurrence of ground water and general investigations connected with engineering problems—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.112/7/044/T.

HEAD (well qualified chemical engineer with responsible industrial experience, including that of original design, and preferably previous experience and/or research experience relevant to the development of undergraduate and postgraduate work in collaboration with industry) OF THE DEPARTMENT OF CHEMICAL ENGINEERING—The Registrar, Bradford Institute of Technology, Bradford 7.

LECTURER (with a good honours degree and teaching experience) IN THE SCIENCE DEPARTMENT, to teach pure and applied mathematics and statistics to G.C.E. Advanced Level and B.Sc. General degree students—The Clerk to the Governors, South-West Essex Technical College and School of Art, Forest Road, Walthamstow, London, E.17.

LECTURER or SENIOR LECTURER (with a university degree in medicine and preferably with interest in applied pharmacology and therapeutics) IN PHARMACOLOGY—The Secretary, Charing Cross Hospital Medical School, 62–65 Chandos Place, London, W.C.2.

PHYSIOLOGIST, Assistant Professor or Associate Professor (with an M.D. or a Ph.D. degree and capable of independent research)—Prof. M. Beznak, Department of Physiology, University of Ottawa, Ottawa, Canada.

POSTDOCTORAL FELLOWS IN THE DEPARTMENT OF CHEMISTRY, for research work in the fields of electron spin resonance spectroscopy of free radicals at liquid helium temperature, and mass spectrometry, including photo-ionization studies—Prof. C. A. McDowell, Department of Chemistry, University of British Columbia, Vancouver 8, B.C., Canada.

RESEARCH ASSISTANT for wind tunnel investigation in the field of industrial aerodynamics—Head of the Aeronautics Department, Imperial College of Science and Technology, South Kensington, London, S.W.7.

RESEARCH ASSISTANT (PHYSICIST) (preferably with a knowledge of electronics and a degree in physics), for work with the X-ray scanning microanalyser (electron probe) in the field of ore microscopy—Dr. A. P. Millman, Mining Geology Department, Royal School of Mines, Prince Consort Road, London, S.W.7.

RESEARCH ASSOCIATE IN CHEMISTRY, to work on the physical chemical properties and synthesis of heteropoly compounds—Prof. Egon Matijevic, Department of Chemistry, Clarkson College of Technology, Potsdam, New York, U.S.A.

TECHNICAL OFFICER (aged 22–25, with a degree in mathematics or an honours degree in geography with a mathematical background) IN THE SURVEY DEPARTMENT, Government of Kenya, for survey computations and checking of survey plans—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.103/7/09/Cl.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Ministry of Agriculture, Fisheries and Food. Bulletin No. 34: Mushroom Growing. Seventh edition. Pp. v+66+16 plates. (London: H.M. Stationery Office, 1960.) 6s. net. [226

Department of Scientific and Industrial Research. Torry Research 1959 on the Handling and Preservation of Fish and Fish Products: Report of the Torry Research Station Steering Committee, and Report of the Director of the Torry Research Station. Pp. iv+31. (London: H.M. Stationery Office, 1960.) 2s. 6d. net. [226

British Empire Cancer Campaign. Thirty-seventh Annual Report covering the year 1959. Part 1: The Chairman's Statement and the Accounts. Part 2: The Scientific Report of the Researches undertaken by the Central Organization and Its Autonomous Councils in the United Kingdom, and by some of Its Affiliated Organisations Overseas. Pp. liv+666. (London: British Empire Cancer Campaign, 1960.) [226

Association of British Manufacturers of Agricultural Chemicals. Pharmacy and Poisons Act 1933 and Poisons Rules 1960 relating to the sales of Insecticides, Fungicides, Weedkillers, Rodenticides. Pp. 15. (London: Association of British Manufacturers of Agricultural Chemicals, 1960.) 3s. [226

An Outline of Luvale Social and Political Organization. By C. M. N. White. (The Rhodes-Livingstone Papers, No. 30.) Pp. xiii+52. (Manchester: The University Press, 1960. Published on behalf of the Rhodes-Livingstone Institute.) 8s. 6d. net. [226

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 699, Vol. 243 (16 June 1960): The Structure and Function of the Respiratory Horns of the Eggs of some Flies. By H. E. Hinton. Pp. 45–73. (London: Royal Society, 1960.) 11s. [226

Institution of Gas Engineers. Publication No. 565: 97th Annual Report and Accounts of the Council of the Institution of Gas Engineers. Pp. 46. Publication No. 566: Presidential Address given at the 97th Annual General Meeting, Edinburgh, 31st May to 3rd June, 1960. By Duncan D. Melvin. Pp. 16. Publication No. 567: The Westfield High-Pressure Coal-Gasification Plant. By T. S. Ricketts. Pp. 66. Publication No. 568: Gasification at the Isle of Grain. By C. Stott. Pp. 55. Publication No. 569: The Architect and the Gas Engineer: Their Purpose, Responsibilities and Inter-Relationship. By R. Baden Hellard. Pp. 36. Publication No. 570: The Development of the Industrial Gas Load in Scotland. By A. Higgs and R. W. Deans. Pp. 53. Publication No. 571: Coke in a Changing Market. By Dr. F. A. Burden and D. G. Rose. Pp. 31. Publication No. 572: White Lund—Some Aspects of a New Works. By F. C. Buckley. Pp. 40 (7 plates). Publication No. 573: Live Gas. By Stirling Everard. Pp. 21. Publication No. 574: Official Programme, 97th Annual General Meeting, Edinburgh, 31st May to 3rd June, 1930. Pp. 12. (London: Institution of Gas Engineers, 1960.) [226

Royal Physical Society of Edinburgh. Proceedings of Meetings devoted mainly to Experimental Biology and Natural History. Vol. 28, Parts 1 and 2: The Cell Surface. (Second Symposium of the Society held in Edinburgh on 22nd and 23rd May, 1959.) Pp. viii+1–122+plates 1–8. Price of *Proceedings* per volume (three parts) to Non-Fellows—25s. (Edinburgh: Oliver and Boyd, Ltd. Obtainable from the Secretary and Executive Editor, Dr. H. Kacser, Department of Animal Genetics, University of Edinburgh, King's Bldgs., Edinburgh, 9.) [226

De Havilland Propellers Limited. The De Havilland Anatrol Low Cost On-line Computor: Analogue Computer for the Process Industries. Pp. 6. (Hatfield: De Havilland Propellers, Ltd., 1960.) [226

Scottish Society for Research in Plant Breeding. Report of the Scottish Plant Breeding Station, 1960. Pp. 106. (Pentlandfield, Roslin: Scottish Plant Breeding Station, 1960.) [226

Department of Scientific and Industrial Research: Road Research Laboratory. Road Research Technical Paper No. 49: Road Accidents—Christmas 1959: an Investigation of the Fatal Road Accidents in England and Wales, December 24th–27th, 1959. Pp. iv+20. (London: H.M. Stationery Office, 1960.) 1s. 9d. net. [226

Ministry of Education: Scottish Education Department. Grants to Students: Report of the Committee appointed by the Minister of Education and the Secretary of State for Scotland in June, 1958. Pp. xii+135. (Cmnd. 1051). (London: H.M. Stationery Office, 1960.) 6s. 6d. net. [226

Commonwealth Relations Office—Colonial Office. Commonwealth Educational Co-operation. Pp. 7. (Cmnd. 1032). (London: H.M. Stationery Office, 1960.) 6d. net. [226

Universities Council for Adult Education. Report on the year 1958–1959. Pp. 34. (Bristol: W. E. Salt, Hon. Secretary and Treasurer, The University, 1960.) [226

Air Ministry: Meteorological Office. Scientific Paper No. 1: Airborne Measurements of the Latitudinal Variation of Frost-Point, Temperature and Wind. By N. C. Helliwell. Pp. ii+30. (M.O. 664). (London: H.M. Stationery Office, 1960.) 3s. 6d. net. [226

Regent Advertising Club. If You Want to get into Advertising here's how you can help Yourself. Pp. 14. (London: Regent Advertising Club, 1960.) [226

Research Defence Society. Conquest Pamphlet No. 11: Vaccination Against Whooping-Cough, Diphtheria and Tetanus: Outstanding questions posed and answered by the Research Defence Society. Pp. 16. (London: Research Defence Society, 1960.) 6d. [226

Bulletins of Marine Ecology (formerly *Hull Bulletins of Marine Ecology*). No. 41, Vol. V (May 1960): Continuous Plankton Records: Methods of Analysis, 1950–1959. By J. M. Colebrook. Pp. 51–64. (Edinburgh: Scottish Marine Biological Association, 1960.) 6s. 6d. [226

Tobacco Manufacturers' Standing Committee. Research Papers, No. 3: The Constituents of Tobacco Smoke—First Supplement. Edited by H. R. Bentley and E. G. N. Berry. Pp. i+25. (London: Tobacco Manufacturers' Standing Committee, 1960.) [226

Empire Cotton Growing Corporation. Annual Report for the year ending 31st March 1960. Pp. ii+21. (London: Empire Cotton Growing Corporation, 1960.) [226

Department of Scientific and Industrial Research. Water Pollution Research 1959: The Report of the Water Pollution Research Board with the Report of the Director of the Water Pollution Research Laboratory. Pp. vi+116+4 plates. (London: H.M. Stationery Office, 1960.) 7s. net. [226

Other Countries

Annals of the New York Academy of Sciences. Vol. 79, Article 10: Biology of the Pleuropneumonia-like Organisms. By D. G. ff. Edward and 79 other authors. Pp. 305–758. 5 dollars. Vol. 86, Article 2: Modern Concepts of Thyroid Physiology. By Rulon W. Rawson and 49 other authors. Pp. 311–676. 3.50 dollars. (New York: New York Academy of Sciences, 1960.) [86

University of California Publications in Geological Sciences. Vol. 34, No. 5: Origin of Rock Creek and Owens River Gorges, Mono County, California. By William C. Putnam. Pp. 221–280+plates 31–40. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1960.) 2 dollars. [86

Forest Research in India, 1953–54. Part 1: The Forest Research Institute. Pp. ii+105. Rs. 2.75 nP.; 4s. 6d. Forest Research in India, 1957–58. Part 1: The Forest Research Institute. Pp. iv+107. Rs. 2.75 nP.; 4s. 6d. (Delhi: Manager of Publications, 1960.) [136

Tata Memorial Hospital, 1959. Pp. iii+34+11 plates. (Bombay: Tata Memorial Hospital, 1960.) [136

Indian Forest Records. New Series. Silviculture, 1957. Vol. 10, No. 4: General Volume Tables for *Abies pindrow* Spach. By S. K. Seth, S. N. Dabral and M. M. Singh. Pp. ii+103–114. Rs. 1.75 nP.; 2s. 6d. Timber Engineering, 1958. Vol. 1, No. 1: Wind Pressure on Buildings (Rationalised) (from Foreign Experimental Approach). By N. J. Masani and A. N. Bajaj. Pp. 33. Rs. 2.25 nP.; 3s. 9d. (Delhi: Manager of Publications, 1959.) [136

International Council of Scientific Unions. The Year Book of the International Council of Scientific Unions, 1960. Pp. 109. Financial Statement for the year ended 31 December, 1959. Pp. 12. (The Hague: International Council of Scientific Unions, 1960.) [136

World Health Organization. Technical Report Series. No. 193: Teacher Preparation for Health Education—Report of a Joint WHO/UNESCO Expert Committee. Pp. 19. (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) 1 Swiss franc; 1s. 9d.; 0.30 dollars. [136

State of California: Department of Fish and Game. Fish Bulletin No. 108: The Marine Fish Catch of California for the years 1957 and 1958. By the Biostatistical Section, Marine Resources Operations. Pp. 74. A Field Guide to Some Common Ocean Sport Fishes of California, Part 1. By Daniel J. Miller. Pp. 40. Offshore Fishes of California. By John E. Fitch. Pp. 80. (Sacramento, California: Department of Fish and Game, 1958, 1959 and 1960.) [136

Rubber Research Institute of Malaya. Annual Report, 1958. Pp. ii+122. (Kuala Lumpur: Rubber Research Institute of Malaya, 1960.) 3 dollars. [136

Carnegie Institution of Washington. Contributions to American Anthropology and History, No. 60: Prehistoric Ceramics and Settlement Patterns in Quintana Roo, Mexico. By William T. Sanders. Pp. 155–264+19 figures. (Preprinted from Carnegie Institution of Washington Publication No. 606.) (Washington, D.C.: Carnegie Institution of Washington, 1960.) [136

Osservatorio Astrofisico di Arcetri. Relazione sull'attività dell'osservatorio per il 1959. Pp. 19. Centro di Studio per l'Astrofisica del Consiglio Nazionale delle Ricerche. Astronomical Data for the Solar Eclipse, February 15, 1961. Computed by A. Kranjc. Climatological Data for Italy. By L. Santomauro. Pp. 27+2 plates. (Firenze: Osservatorio Astrofisico di Arcetri, 1960.) [136

Province of Quebec: Department of Mines. Laboratories Branch. P.R. No. 402: Sample Preparation Techniques for X-ray Fluorescence Analysis. By F. Claisse. Pp. 1+9. (Quebec: Department of Mines, Laboratories Branch, 1960.) [136

Det Kongelige Departement for Industri og Handverk. Norsk Polarinstitutt. Skrifter Nr. 117: The Downtonian and Devonian Vertebrates of Spitsbergen X: Two New Species of the Genus *Pteraspis* from the Wood Bay Series in Spitsbergen. By Natascha Heintz. Pp. 13+2 plates. (Oslo: Norsk Polarinstitutt, 1960. Distributed by the Oslo University Press, 1960.) 3 kr. [136

Companhia de Diamantes de Angola (DIAMANG). Servicos Culturais. Dundo-Lunda-Angola. Servicos de Saúde. Subsidios para o Estudo da Anthropologia na Lunda. Publicacoes Culturais No. 49: A Drepanocitemia e a Antropologia (Uma revisao e um estudo na Lunda e Songo). Por J. H. Santos David. Pp. 102. (Lisboa: Companhia de Diamantes de Angola, 1960.) [136

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

Pure Chemistry Library,
SCIENCE COLLEGE.
92, Upper Circular Road,
CALCUTTA.

CHEMICAL LABORATORY
Date. 25..10..60
SCIENCE COLLEGE

THE NEED FOR EDUCATIONAL RESEARCH

WHEN the first part of the Crowther Report was published in December 1959 it was recommended that more information about education should be obtained and made available : "... attention will have to be paid to the inadequacy of the tools that lie to the hand of the educational planner . . . There are the most extraordinary gaps in our knowledge of what goes on in the schools and technical colleges we have to-day . . . ". This is sharply brought out in Vol. 2 of the Crowther Committee's Report, which has now been issued*.

Before preparing its Report, the Committee was required to consider the work of technical colleges, the teenager in employment or industrial training, in the youth service and at leisure. The members always had to remember that two sexes were involved, each presenting its own educational and social problems ; and although little was known about the way educational and industrial and social pressures influenced boys, even less was known about their effects on girls.

What the Committee had not expected was that the factual evidence on which it could consider its terms of reference could be so meagre . . . "the information was sometimes lacking both to gauge the task or estimate the harvest. For instance, though an appreciable expansion in the output of students through the technical college courses was accepted as a major aim in public policy on which economic health on the long term depended, little was known nationally in 1956 about the circumstances in which students succeeded or, more often, failed, and how many years of study success or failure had cost them".

To help the Committee in its deliberations, special surveys were arranged with respect to the relation between home background and length of school life, of the progress of students through technical courses, the use of leisure, and the reserves of latent ability.

It is unfortunate that these three surveys could not have been published at the same time as the Report. They show both how slender was the evidence on which the Committee's sweeping recommendations were based and, more important, how much so-called educational progress is based upon popular—and sometimes passing—public opinion of a particular age.

In these surveys, for example, there is little or no evidence to support the Committee's major proposal to raise the school-leaving age for all children to sixteen. Accepting that "the attitude of the school-leavers themselves is obviously of importance in any examination of factors which may influence the length of school life", the investigators reported that "it was impossible to deal more than superficially with attitudes to the school-leaving age and reasons for leaving school". If any conclusion can be drawn from the survey report it is the rashness of the Crowther Committee in suggesting that *all* children should be kept in school until they are sixteen years of age. Thus, of the secondary modern boys and girls who had fairly recently left school and who were asked if they would have liked to stay longer, only 16 per cent of the boys and 23 per cent of the girls had regretted leaving school when they did.

A similar question was put to a group of National Servicemen, and despite their greater maturity and time for reflexion, only about one man in six who had left school at fifteen had afterwards wished that he had not left so early. Of those who had wished that they had remained in school longer, the investigators report that four-fifths of them realize that now, with better education, their chances of getting better jobs would be considerably improved. The investigators did not determine whether these young men of eighteen were seeking to remedy the defects in their education or whether they had the capacity to profit by it. Their wistful desire for more education may have been more bound up with the fruits of better jobs than with the effort required to attain them.

The Government's decision to make no firm forecasts about the date on which the school-leaving age is to be raised was largely based on financial and economic arguments. Before a great step of this nature is taken, it could well spend a little money to dig deep for information which has only been scratched in these surveys. Many well-informed people believe that it is educationally and morally wrong to compel all young adolescents to continue a formal education which many of them find irksome and restrictive, and which might well contribute less to their social and educational development than would a planned period of vocational training in industry supported by continued education of both a vocational and recreational nature.

If educational reformers are genuine in their desire to bring the greatest educational good to the greatest number, they should first accept that more than their own wishes and experience is needed before advocating a 'reform' which could well bring misery and frustration to many young people. Evidence has been accumulating that young people (and especially girls) of fifteen to-day are as mature as young people of sixteen and seventeen of 25 years ago. In terms of biological and psychological age, may not the 1944 goal of raising the school-leaving age to sixteen have already been reached ? More information about the wishes and feelings of young people is required.

For a number of years much has been made about the ill-effects of too much money on young wage-earners. Little real investigation has been carried out to determine the truth of this charge. The majority of young delinquents come from boys and girls still at school. Why ? Which types of schools—grammar, or modern, or comprehensive ? Also, from which classes in the school? *A* stream or *D* stream? Is there direct correlation between the delinquents and the types of homes from which they come? Doctors, youth leaders and industrial training officers could well join parents and teachers in providing much useful information about the needs of young adolescents. So, too, will the investigation being carried out by the University of Sheffield into transition between school and work. Before the precedent is set of compelling all young people to remain at school until they are sixteen—at present those who stay on at grammar, technical or modern school do so because they wish—much educational research is needed into the biological and psychological and social requirements of young people and how they can best be met.

---

* Report of the Central Advisory Council for Education—England. 2 (Surveys). (H.M. Stationery Office.) 8s. 6d.

The case for more research to support educational thinking is also brought out in the third survey conducted on behalf of the Crowther Committee. This was undertaken to establish the broad facts about the efficiency of education continued by part-time day release classes. For some years investigators whose contacts with industry have been superficial have raised considerable dust about the wastefulness of City and Guilds and National Certificate courses. Their standards were set almost entirely by the number of students who began courses and the numbers who obtained Final City and Guilds and Higher National Certificates. (See also the article by Dr. J. Heywood in *Nature* of July 16, p. 189.)

The survey now shows that since National Certificate courses were begun in 1923 some 18,028 Ordinary National Certificates have been awarded, about a third of these going to students who left school at the minimum statutory age. "Neither should the wastefulness of the process be exaggerated. The shedding has taken place pretty steadily along the route, and it is not a fact that all those who have not reached the end of the road have wasted many hundreds of hours of their own and their teacher's time in fruitless endeavour." Those who have regarded the process as utterly wasteful have insisted that more attention be paid to selection, and that teachers in technical institutions should join industrial management in making the selection of industrial apprentices and others. This report makes it clear that much more than stringent selection at the outset is required. "The course itself is a kind of selective process, and all that may be hoped of a more stringent and deliberate process is that it would be somewhat, but not a great deal more efficient."

This report will remind many educationists of the Education Act of 1944. Against the advice of almost every educational psychologist, a tripartite system of secondary education was set up with rigid selection at the age of eleven. Although administratively convenient, the folly of the tripartite system has become only too evident in the last fifteen years. It is to be hoped that future reforms will be based much more on facts patiently gathered by careful investigation rather than by well-meaning intentions to do good. It is time the social reformer was replaced by the social engineer, who uses facts as a basis for change.

DESIGNING FOR SPACE TRAVEL

Soviet Space Science

By Ari Shternfeld. Translated by the United States Air Force (Technical Documents Liaison Office). Pp. xxii+361. (London: Hutchinson and Co. (Publishers), Ltd., 1959.) 30*s*. net.

Space Technology

Edited by Prof. Howard S. Seifert. Pp. xvi+1160. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 180*s*. net.

PERHAPS the most dramatic engineering development of the past few years has been the demonstration of the practicability of flights in the solar system at least by unmanned vehicles. The development of this technique has received a substantial impetus from motives as diverse as a recognition of a new, powerful tool for astronomical observations and the desire for pre-eminence in human space-travel for political reasons. Space technology is in consequence rapidly building up a literature to which the two volumes forming the subject of this review represent substantial additions. Since ultimately they emanate one from each of the two nations most concerned with these developments it might be supposed that they would provide an interesting comparison, but a comparison is vitiated by the fact that they aim at quite different readers. Moreover, "Soviet Space Science" draws information from sources on a wide international basis showing, if anything, a bias towards American work in the field.

The title is, in fact, altogether a misnomer, for this book is really concerned with space flight. The first and largest section, comprising five chapters, deals with the launching and subsequent motion of an artificial Earth satellite. The explanation is clear, detailed and non-mathematical, and at times unduly repetitive. It is evidently aimed at a non-technical reader since extensive use is made of tables and diagrams rather than graphs. Subsequent chapters are concerned with the hazards and physiological problems of manned space flight, the scientific uses of satellites and space probes, the problems of telemetry and communication, and landing. In these sections the author is content to skim over the surface of his subject; it is noticeable that no effort is made here, unlike the opening chapters, to expound the basic principles. Moreover, few references are made to the direction of future technological advances, even where their direction can be clearly discovered.

Particular exception can be taken to the account of experimental space science, which is very shallow, and where the language employed is often imprecise. (For example, the expression "the voltage of the current" is used.) There is not a large number of misprints in the book, and it is unfortunate that they should largely occur among the numerics in this section, where they are particularly liable to mislead.

There are two appendixes, dealing respectively with astronautical societies and the international law of space, an epilogue by Willy Ley, which brings the account of vehicles launched up to *Lunik* I and a good index.

"Space Technology", which deals primarily with the engineering of guided rockets for orbital missions, is based on a series of lectures delivered during 1958 at the University of California by a total of 38 different lecturers. The editor, Prof. Howard S. Seifert, has handled with considerable success the problem of reducing to a reasonably uniform style and level contributions from such a large number of authors.

The book opens with a brief introduction of a historical and astronomical character, which is followed by an extensive account of the motion of powered and unpowered vehicles in gravitational fields. Approximate methods of calculation, such as perturbation techniques, are described for the many-body problems which are encountered, leading to the solution of design optimization problems. The topics covered in this way include ballistic missile trajectories, Earth satellite orbits and lunar and interplanetary flights (in which propulsion is used only near the beginning and end of the flight). These are followed by an account of the use of low-thrust motors, such as those employing positive-ion jet or nuclear fuels, to expand Earth satellite orbits for interplanetary travel. After a chapter on relativistic time dilatation effects, this section concludes with a description of methods of soft landing. It will be seen that this part of the book is both detailed and comprehensive. The explanation of some of the most complex orbital problems, such as the motion of a satellite in the Earth–Moon system, is excellent and brings out very clearly the principles involved. Similarly the limitations of various propulsion systems for different missions are thoroughly covered.

The subsequent sections are somewhat less detailed and deal with propulsion (using both chemical and nuclear fuels), rocket system design procedures, communications, guidance, and the physiological aspects of manned flight. The last section is rather briefly concerned with the upper atmosphere and the scientific uses of satellites. Finally, there is, even for the enthusiastic reader, an examination paper of 102 questions!

In conclusion, it can be said that "Space Technology" gives an excellent account of the methods employed to select optimum orbits. The description of motors and guidance systems provides a good background to this subject and an introduction to its technological aspects. A certain amount of information on the environment which will be encountered, in planetary atmospheres, for example, and on the performance which can be expected from human beings in a space ship, is also presented. Most of this is rather general in character, and these sections suffer from a rather low density of hard facts.

In perspective, both the books which are the subject of this review can be seen as descriptions, at quite different levels, of the dynamics of space vehicles together with an account which is given in breadth rather than depth of the associated technology and planetary physics. Each in its way can be recommended.

A SOURCE-BOOK OF SEMICONDUCTOR PHYSICS

Semiconductors

By Dr. R. A. Smith. Pp. xvii+494. (Cambridge: At the University Press, 1959.) 65*s*. net.

SEMICONDUCTOR physics has become a vast field of research and development over the past decade. Any text on the subject must of necessity be selective, but in the present volume the author has presented those topics which are of fundamental interest and moreover has provided critical discussion at all stages. This is particularly important for those who may use the book as an introduction to the theoretical aspects of phenomena with which they are concerned experimentally. It is perhaps not often realized that a semiconductor cannot always be distinguished by a negative temperature coefficient of resistance, as is pointed out in the first chapter. Here can be found a reference to other problems of early work in the field which were only resolved by the production of single crystal specimens of high purity, by the careful distinction between volume and surface effect on physical properties, and by recognition of the decisive part played by crystal defects and impurities. In introducing the essential wave-mechanical basis of semiconductor physics, Dr. Smith is careful to carry the reader forward to more complex configurations than simple spherical energy-surfaces in wave vector-space, and to indicate the important experimental approach obtained in cyclotron resonance. In treating crystal binding some brevity has obviously been necessary, but one cannot help wishing that the problem of mixed binding and experimental methods of assessment had been afforded more discussion. In reading the section on excitons the reader must not forget that in the case of some high-band-gap materials, such as cadmium sulphide, the existence of excitons is not satisfactorily proved.

Many of the phenomena associated with semiconductors occur under conditions of thermal equilibrium or with very small departures from it. It is not therefore surprising that a significant fraction of the text is devoted to energy distributions of electron and positive holes, to transport phenomena and to the very important matter of scattering mechanisms for carriers. This part of the book is very up to date; for example, a discussion of recent work on 'hot' electrons, that is to say, carrier behaviour in high electric fields, is included. There is also a very adequate treatment of thermomagnetic effects not always found in texts on solid-state physics.

Much information on semiconductors results from a study of optical properties such as the position and structure of the lattice absorption edge. The author gives a review of recent experiments and their significance in distinguishing between direct and indirect, phonon-assisted, electron transitions. Here he draws on powerful data obtained by his own research team, among others. Within the electro-optical phenomena discussed none is perhaps more important than the release of carriers by photon absorption, which manifests itself in photoconductivity, the photovoltaic effect and the photo-electromagnetic effect. These are described briefly at first, but elaborated later in the book when a treatment of carrier diffusion has been given which provides a more complete and essential background for discussion. In the latter section we find the *p*-*n* junction, the problems of contact and surface conditions and the mechanisms of carrier injection and recombination.

For many experimentalists it will be a pleasure to find that after many pages of theoretical treatment Dr. Smith anchors it all by a critical review of the experimental methods available for the determination of the many parameters which have previously emerged in the theory. His chapter on such methods effectively introduces the survey of practical semiconductors of various types, particularly germanium, silicon, intermetallic compounds and, from his particular interests in the past, the sulphide, selenide and telluride of lead. The latter is a useful inclusion, although a more complete account has been given previously by the author and some of his co-workers. High-band-gap semiconductors may appear to have been neglected, but data for them are so incomplete and still inconclusive compared with those for such solids as germanium and silicon.

This book makes an important and critical contribution to the subject which is based on the author's personal experience as leader of one of the most important research teams of to-day in semiconductor physics. It will be an excellent 'source-book' for many workers in this and closely related fields, and will certainly satisfy an important need in postgraduate university courses of solid state physics.

G. F. J. GARLICK

SOLID STATE PHYSICS

Solid State Physics

Advances in Research and Applications.
Vol. 7. Pp. xiv+525; 1958. 12 dollars.
Vol. 8. Pp. xiv+519; 1959. 13.50 dollars.
Vol. 9. Pp. xv+548; 1959. 14.50 dollars.
Vol. 10. Pp. xv+516; 1960. 14.50 dollars. Series edited by Frederick Seitz and David Turnbull. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd.)

Paramagnetic Resonance in Solids

By William Low. (Solid State Physics: Advances in Research and Applications, Supplement 2.) Pp. viii+212. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 7.50 dollars.

THE contributions to the volumes of "Solid State Physics" under review maintain the high standards of scholarship and readability set by previous writers in the series. Research workers in the field have come to rely so much on "Solid State Physics", both as an invaluable source for their own work and as a kind of lifebuoy to keep them afloat in the flood waters of the literature, that one wonders how the subject maintained any kind of unity before the series was started. Perhaps it did not; and perhaps even now individuals read only articles bearing directly on their tenth (or hundredth) of the field. If this is so, the best service a reviewer can do is indicate the nature of the topics discussed.

There are three major articles on electrons in metals. J. Callaway, in "Electron Energy Bands in Solids" (Volume 7), describes first the general properties of bands (with special reference to symmetry and the use of critical points) and then gives a complete survey of existing experimental and theoretical results. It is all very carefully done and it is apparent that the calculations are now sufficiently sound for experiments to constitute a genuine test of theoretical assumptions about core potentials. The oscillatory dependence of magnetic susceptibility and electrical conductivity on the magnetic field is considered by A. H. Kahn and H. P. R. Frederikse in Volume 9. These phenomena are now very effective tools for investigating electron bands—especially the shape of the Fermi surface. There is a fine, 200-page article by the late M. R. Schafroth on superconductivity in Volume 10. Half the article is phenomenological and half is microscopic; it constitutes the best available account of the exciting progress in this field since 1950. The author's exposition of Bogoliubov's version of the theory is specially lucid and convincing. In spite of the present inability to explain the vanishing resistance (which gives the phenomenon its name) and the still controversial explanation of the Meissner effect, the other phenomena are now so well explained that one must surely accept Schafroth's conclusion: we are very close to a final theory of superconductivity.

The next group of articles is concerned with lattice properties of solids. A. F. Wells, with characteristic clarity and excellent illustrations, describes and classifies inorganic crystal structures in Volume 7. This is done not from the formal basis of symmetry, but rather from a more friendly and intuitive 'topological' point of view which asks how crystals can be built up from given elementary units of bonds and nets. Also in Volume 7 is a long and useful review by H. B. Huntington giving theory, experimental methods and results concerning the elastic constants of crystals. Among many other topics, the author discusses Laval's question: "Should local rotations and torques be considered in forming the elastic tensor?" The verdict is 'not proven'. D. Lazarus in Volume 10 gives a full and satisfying account of diffusion in metals. In Volume 7, P. G. Klemens contributes an article on the difficult subject of lattice thermal conductivity. An attractive feature of the paper is the way in which the author describes how the measurement of thermal conductivity can be used, at least as a supporting technique, in the study of crystal defects: dislocations, stacking faults and grain boundaries.

Defects and inhomogeneities in crystals are discussed in three further papers. There is a long article on the structure and properties of grain boundaries by S. Amelinckx and W. Dekeyser in Volume 8. This succeeds well in tying together the modern theoretical work which treats grain boundaries as arrays of dislocations and the extensive experimental findings, structural and kinetic. Certain aspects of the continuum theory of stationary dislocations are developed further by R. de Wit in Volume 10 than they were taken by Eshelby in an earlier volume of "Solid State Physics". In curious contrast to the state of affairs 100 years ago, it seems that one now discusses elasticity with the help of electromagnetism. A. Guinier writes in Volume 9 on "Heterogeneities in Solid Solution". The article naturally deals with the Guinier–Preston precipitation-zones in aluminium–copper alloys, but includes much more, such as a section on short-range order in solid solutions in equilibrium.

The editorial policy of providing detailed surveys of important groups of semiconductors is continued here with three contributions. W. W. Scanlon writes in Volume 9 on a little-known group of polar semiconductors: lead sulphide, lead selenide and lead telluride. The important feature of these materials is that whereas they enjoy NaCl-type binding and structure, their energy gap is sufficiently small to allow the electrical properties to be investigated easily. They thus form more useful test materials for the theorist than alkali halides. A detailed account of electronic processes in zinc oxide is provided by G. Heiland, E. Mollwo and F. Stöckmann in Volume 8, and in the same volume R. Newman and W. W. Tyler review photoconductivity in germanium. The latter authors emphasize the usefulness of germanium—the intrinsic properties and impurity levels of which are well understood—as a model for theories of photoconductivity. Consequently their article is much more than a collection of results.

In Volume 10, B. S. Gourary and F. J. Adrian present an elaborate account of the work on wave functions for electron-excess colour centres in alkali halides. This is one of four articles on the optical spectroscopy of solids. Two of them are on the relatively new field of molecular spectroscopy in molecular crystals (for example, benzene, anthracene) and cover virtually the same ground. I found the article by H. C. Wolf in Volume 9 more coherent and enlightening and indeed more up to date than the article on the same topic by D. S. McLure (Volume 8). However, the latter author has provided us with an excellent account of the spectra of ions in crystals (Volume 9), where, of course, the symmetry properties of crystalline fields are of vital importance.

The articles mentioned above contribute to well-established branches of solid state physics. Rather more exciting to the novelty seeker are a group of three reviews describing applications of the techniques of nuclear physics to problems of the solid state. Perhaps the best known of these topics is the use of thermal neutrons to investigate vibrational spectra, discussed in workman-like manner by L. S. Kothari and K. S. Singwi (Volume 8). More esoteric is the use of angular correlation measurements on oriented nuclei to get extra-nuclear data, examined by E. Heer and T. B. Novey in Volume 9. The idea is that in the time between successive nuclear emissions, local nuclear motion may perturb the intermediate nucleus. The information obtained is similar to that found by studying spin-lattice interactions by nuclear magnetic resonance. Although the technique is clearly far less flexible and general than that of nuclear magnetic resonance, it may be useful in some cases because, first, no radio-frequency field is needed and, secondly, it can be made to work with about 10^{8} nuclei cm.$^{-3}$ as compared with the nuclear magnetic resonance requirement of 10^{18} nuclei cm.$^{-3}$. Perhaps the main lesson to be learnt from D. R. Wallace's account of position annihilation in solids and liquids (Volume 10) is that this phenomenon is less a tool than a challenging problem in its own right—one that is far from exhausted.

New results on surfaces are expounded by J. A. Becker in Volume 7. They have been obtained by the ingenious use of ion gauges and field emission microscopy. It is remarkable that Müller's recent extension of the latter technique, in which ions are used instead of electrons to form the image, permits surface pictures which, at least in some respects, show the surface on an atomic scale.

I was specially attracted by a delightful article by D. J. Montgomery (Volume 9) on one of the oldest, yet least understood, topics in physics: the static electrification of solids. While concealing none of the essential complexity of the problem the author has been bold enough to describe a simple rational scheme based on electron transfer from the bulk of the solid (thereby ignoring specific surface effects) which seems to give a 'zero order' account of the main phenomena. Teachers who dabble in the catkin and amber branch of witchcraft will read this article with pleasure and profit.

In addition to the main volumes described above, there is a second 'supplement' consisting of a monograph on paramagnetic resonance in solids by W. Low. Although most of the material can be found in three well-known reviews published elsewhere, this is the first connected account of the whole subject since the early 1950's. It is admirably done, and will clearly become a theoretical handbook for workers in the field.

R. O. DAVIES

CHEMICAL ENGINEERING PRACTICE

Chemical Engineering Practice

Edited by Herbert W. Cremer and Sidney B. Watkins. Vol. 11: Works Design, etc. Pp. vi+390+xviii. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1959.) 95s.; 13·30 dollars.

CHEMICAL works are frequently large in area, and in their general design and administration present problems which are to be found in all large enterprises. In this volume we are taken away from the specialized field of chemical plant design and are concerned with the more general topic of works construction and organization; we are concerned with the factory and its problems rather than with the details of any particular unit.

This is a guide to the structure of a large chemical works. We are brought face to face with the problems of management of people, of the arrangement of contracts, and with planning and production and its impact on sales. The peculiarities of the chemical industry, with its frequent demand for continuous working and the resulting problems for personnel, its hazards arising from the toxic and inflammable nature of many of its materials and processes—all these difficulties are clearly indicated as part of the life of a chemical works. In the very long section on works administration Mr. Hiscock of the Consolidated Zinc Corporation, Ltd., gives some suggestions for their solution. Those entering these industries are usually crammed with academic facts, but here they can see that they will be brought problems which will demand an entirely new approach. It is not simply a question of learning the techniques of a given industry, it is a question of harmonizing the demands of a very wide range of people to form a happy community. There must be an understanding of what constitutes incentive. "Work study does not replace management, nor does it necessarily ease the burden of management". "Method study presents facts; it does not make the decision. Whether to proceed is the responsibility of management". The importance and problems of work study in the chemical industry are in general agreed; but it is very useful to have the facts set out, and their limitations, as in this text.

The chemical industry in Britain, like other enterprises, is governed by Factory Acts and other legislation. Many in all positions in the chemical industry will be indebted to Sir George Barnett for his most welcome chapter on "Factory Acts and Legislation". This chapter, together with that by Dr. Carter on "The Alkali Acts and Works Regulations", should be read by all who contemplate entering this industry. We can see from this text the kind of organization that must be developed if the problems of the chemical industry are to be tackled and inducements given for profitable working in the company. This is above all a record of experience, of personal observation and analysis. We can learn from here something of the secret of 'what makes a factory tick'. We can learn from a body of men who have all taken an active part in developing industries of this kind. This is an excellent volume for which we should be grateful to Mr. Cremer and Mr. Watkins.

J. M. COULSON

SCIENCE AND MEAT

The Science of Meat and Meat Products

By Members of the Research Staff of the American Meat Institute Foundation. (Series of Books in Agricultural Science.) Pp. x+438. (San Francisco and London: W. H. Freeman and Company, 1960.) 68s.

THE growth of education in the subject which has come to be known as food science has been handicapped by a lack of suitable texts. For this reason the publication of "The Science of Meat and Meat Products" is an event of some importance. Yet the book is more than a text. As its preface claims, it is no less than an attempt "to present the current scientific knowledge on meat and meat products, and to show how various scientific disciplines are applied in meat research."

In common with other foodstuffs, meat has attracted the attention of chemists, biochemists, nutritionists, microbiologists and others for more than half a century. The quickening tempo of research in recent years has both stimulated and been stimulated by the increasing industrial demand for fundamental information. The problem starts with the geneticist in breeding from the gene pools at his disposal the types of animal best suited for the varied purposes of use. It ends perhaps at the level of human nutrition; but between the beginning and the end diverse scientific disciplines have many parts to play.

With this field to survey within the compass of a modest 438 pages, the American Meat Institute Foundation has undertaken a substantial task. It is inevitable that an individual reader will find some topics treated less fully than he would have liked. Moreover, the various chapters were written by a panel of twenty-six authors, and some unevenness of treatment would seem inescapable. That the reader is not unduly conscious of multiple authorship in the circumstances is a tribute to the editorial board. Formal references have been wisely avoided, but at the end of each chapter a carefully selected list of source material is given to ease the path of those who would study further. The compression of factual information does not always make for easy reading, but the style throughout is lucid, and comprehension is aided by excellent illustrations.

The necessity for keeping the book in proportion has cramped the writers of certain sections, and it is to be regretted that space has been devoted to topics such as Michaelis-Menten kinetics and the methods of protein chemistry which will be familiar to most of its readers. The space saved by omitting such material might have been devoted to the anatomy of meat animals and to a fuller treatment of the relations between carcase conformation and meat quality. The average butcher is a better anatomist than some scientists engaged in the study of meat.

The indexing of such a book presents peculiar problems, and the index, although good, is not comprehensive and fails to list some of the important items considered in the text. Few misprints were noticed, apart from a very obvious one in the table of contents, but a curious mistake in connexion with federal regulations governing the use of ascorbic acid was noted on p. 359.

Notwithstanding these criticisms, this book is an important work which may become a standard text. It is an essential purchase for food science libraries, and a laboratory copy in British meat-packing plants might well contribute to improvements in practice in our own industry.

J. HAWTHORN

BIOGRAPHY OF *AUSTRALOPITHECUS*

Adventures with the Missing Link

By Prof. Raymond A. Dart, with Dennis Craig. Pp. xv+251+20 plates. (London: Hamish Hamilton, Ltd., 1959.) 25s. net.

PROF. Dart has brought together many of his controversial theories in this book, which is partly autobiographical, but mainly a biography of *Australopithecus*. The story begins with the discovery of the Taungs infant in 1924 and ends with a footnote on *Zinjanthropus* added while the book was in the press.

Nearly half the pages concern the 'osteodontokeratic culture', which has been Dart's main interest for 14 years. Only by proving that the Australopithecines were tool-makers could he resolve the interminable arguments as to their hominid or pongid status. Sceptics discredited the 'culture' as the work of bone-collecting hyenas, a myth which Dart took great trouble to disprove. His detailed analysis of bone fragments from Makapansgat revealed that the great majority were antelope mandibles and the distal ends of humeri. By comparing these finds with a similar bone 'industry' from a Middle Stone Age site at Kalkbank, he became convinced that the Makapansgat specimens were artefacts.

Whether one agrees with Dart's conclusions or not, he cannot be accused of drawing on too little evidence. The task of sorting thousands of tons of breccia, chiselling out the bone fragments and identifying them must have been formidable. Nor did he neglect practical experiments, such as reproducing the famous cannon bone 'apple-corers' which necessitated striking over a hundred blows with a bone fabricator. But to suggest that the Australopithecines went to such lengths to make scoops to convey pulped food to the mouths of toothless infants is surely to overestimate their technological skill—and our own credulity.

Dart's genius and persistence might be interpreted by some as impetuosity and obduracy. He makes no attempt to conceal his faults, of which the most serious is touchiness. He refused to study the Mapungubwe skeletons because "any report I might make on the remains would be regarded as prejudiced" (p. 68); and would not interpret the endocranial casts from Sterkfontein because of Hooton's remark that "a dispassionate interpretation of new fossil evidence is usually obtainable only . . . by persons not emotionally identified with the specimen" (p. 86).

Some of the causes which Dart took up with such enthusiasm found few supporters: the Eastern origin of Rhodesian mining and stone building; Mongoloid contacts with the Bushmen; the fire-making abilities of *Australopithecus prometheus*. But on several occasions he has been proved triumphantly right, notably over the tool-making capabilities of the Australopithecines—in stone. His unorthodox views and his imagination, no less than his discoveries, have had a most stimulating effect on anthropology. They are very apparent in this most absorbing and readable book, which is marred only by the poor quality of the drawings.

Sonia Cole

A NEW TREATISE ON PLANT PHYSIOLOGY

Plant Physiology
A Treatise. Edited by F. C. Steward. Vol. 2: Plants in Relation to Water and Solutes. Pp. xvii+758. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 22 dollars.

PLANT physiologists cannot complain of a shortage of literature designed to provide up-to-date information of the state of knowledge of the various branches of the subject. As well as a number of monographs on different parts of the subject there has appeared each year for the past ten years the "Annual Review of Plant Physiology" which has given summaries of recent advances in selected aspects of plant physiology, while about four years ago the publication of the "Encyclopedia of Plant Physiology" began, about a third of its projected 18 volumes having still to appear. Now we have the first volume of what is described as a treatise which is designed to cover the field of plant physiology in seven volumes. Although very much smaller in size than the "Encyclopedia", this new venture will yet be a considerable work when completed. How then is it to be appraised? According to the preface of this first volume to appear, it is intended not only to be a work of reference but also to give "a reasoned analysis of the status and development" of each subject discussed, and the readers for whom this analysis is intended are listed as "advanced and postgraduate students, teachers, research workers and investigators in other fields of knowledge, who need information about the present state of physiology".

This first volume to appear consists of seven articles, varying very much in length, by writers who have worked in the respective branches of the subject with which they deal. As is pointed out in the preface, each of these articles is affected by its author's own opinions. This should be borne in mind by the reader, for other workers in these same fields might have other opinions. For example the reviewer, who has had more than a casual interest in the salt relations of plant cells and tissues for nearly half a century, and who was concerned in some degree with earlier investigations on these relations, also has his own opinions, and it is clear that these do not always coincide with those expressed in the article on this subject in the volume under consideration.

Works of this kind, well produced and well bound, extending to several volumes and composed of a greater or less number of articles written by different contributors, have become the fashion. Of their value to the student there can be no doubt, but whatever their merits they have one character in common: they cost what seems to the reviewer quite a lot of money. This is no doubt unavoidable, but it probably means that in Great Britain at any rate they find their way mainly into the libraries of universities and other institutions and that comparatively few are purchased by students and teachers, who are not among the most opulent members of the community. If this should be so with the present volume it is to be regretted, as probably many plant physiologists would like to have it on their own shelves

Walter Stiles

VITAMIN B_{12}

Vitamin B_{12}
By Dr. E. Lester Smith. (Methuen's Monographs on Biochemical Subjects.) Pp. xii+196. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1960.) 15*s*. net.

VITAMIN B_{12} is unique in many ways. It took more than twenty years from the time of the discovery in 1926 that liver cured pernicious anæmia until the isolation in 1948 of the active principle, which we now know as vitamin B_{12}. The vitamin is active in fantastically small quantities; the body needs something of the order of one millionth of a gram daily. This is about one thousandth of the requirements of some of the other vitamins in the B groups. Vitamin B_{12} is the only vitamin which contains a metal in its very complicated molecule. It seems to be synthesized only by micro-organisms, yet in our diets it exists virtually exclusively in foods of animal origin. Its final isolation in 1948, almost simultaneously in the United States and in England, would no doubt have been even longer delayed but for the resources of the two large pharmaceutical companies which could work up one ton of liver to produce about 20 mgm. of red crystals.

Dr. Lester Smith, the Glaxo chemist who was responsible for the isolation in England, has produced the first book devoted entirely to vitamin B_{12}. It is a short book, and this is probably the reason for the only serious criticism one can make of an otherwise excellent survey. Some of it is so condensed as to make it difficult to understand at first reading; it becomes more of a reference book than a simple account of the subject. Of particular usefulness for reference is the description of the chemistry of vitamin B_{12} and its many relations; this is splendidly done by the author, who himself has contributed a good deal to its elucidation. On the other hand, a few errors and ambiguities—none of them at all serious—have crept into the description of the biological aspects of the vitamin. For example, the author cites the work of Morgan and Yudkin on the vitamin B sparing action of sorbitol, but this work in fact makes no reference to vitamin B_{12}. Again, how many readers know of the enzyme rhodanese? I have only one criticism of production: it is certainly difficult to print chemical formulæ so as to give the effect of three dimensions, but something better can be done than those given on pp. 36–37.

This is a book that every nutritionist will have to possess and use; and we shall look forward to new editions produced by Dr. Lester Smith to keep us up to date in the rapidly advancing knowledge in this field. I hope he will then be kind enough to indulge the prejudices of at least one reader, who believes that 'human' is an adjective and not a noun, and who also believes that there is a difference between the symptoms and the signs of an illness.

John Yudkin

Advances in Clinical Chemistry

Vol. 2. Edited by Harry Sobotka and C. P. Stewart. Pp. xiii+387. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 12 dollars.

TWO of the articles in this volume are primarily concerned with methods ("Paper Electrophoresis" by H. Peeters and "Automation" by W. H. Marsh). The four others survey certain selected biochemical fields. Dr. Peeters deals first with electrophoresis on strips and then with the less-familiar paper curtain electrophoresis. Factors underlying separations are examined in great detail and illustrated with many diagrams and tables. Much of the information is the author's original work which has been presented at the annual colloquia on proteins at Bruges. Dr. Marsh's article is timely in view of the increasing difficulties of obtaining personnel to cope with growing demands in clinical chemical laboratories. Simple as well as complex apparatus and processes are described and the article will be of special interest to those in charge of clinical chemical work. S. P. Bessman surveys the history, metabolism, measurement and pathological alteration of blood ammonia, and his article should stimulate interest in a subject the significance of which is not as widely appreciated as it ought to be. "Idiopathic Hypercalcaemia of Infancy" is a well-written review by J. O. Forfar and S. L. Thompsett, in which the clinical picture, biochemistry, aetiology and treatment of the disease, is covered. However, this article would possibly be more appropriate in a medical book rather than in this volume. E. J. Bigwood and associates provide a most valuable survey of amino-acid excretion in health and disease. Much of the data is quantitative and obtained by means of ion-exchange chromatography. Finally, "Bile Pigments in Jaundice" by Barbara H. Billing is an excellent account, including identification, chromatographic behaviour, methods of measurement and metabolism of these substances. Altogether, this well-produced second volume is full of interest for clinical chemists.

R. Consden

Traité Général de la Fabrication des Colles des Glutinants et Matières d'Apprêts

Par Dr. Maurice de Keghel Nouvelle édition, augmentée et remise à jour. Pp. ii+764. (Paris: Gauthier-Villars, 1959.) 7,000 francs.

THIS new edition does not appear to be any appreciable improvement on the original version. The ground to be covered by a single author—animal glue, vegetable adhesives, casein, synthetic resins, silicate adhesives, rubber, etc., in some sections including both manufacture and use—is so wide that full references to the sources of information are essential. No references are given throughout the book, the only indication of origin being a manufacturer's name for plant, and, very rarely, an author's name, without detailed reference, for some experimental method. What basic scientific information is included is, in the main, unrelated to modern work. As an example, the conversion of collagen to gelatin is given as:

$$C_{102}H_{149}O_{38}N_{31} + H_2O = C_{102}H_{151}O_{39}N_{31}$$

This type of approach was already being superseded forty years ago when the equation was given in the text-books of that time. To-day it is not merely wrong, but also neglects the whole development of the concepts of the chemistry of macromolecules of the past thirty years.

The descriptions of plant and of industrial processes also neglect many recent developments which have changed the position of whole sections of the adhesives industry. The very large number of recipes for adhesives of various kinds are presented uncritically, with no attempts to explain the significance or function of the components used.

Certain methods of test are included. These appear to be selected at random, no reference being made to the versions accepted by the national standardizing bodies.

Neither for the manufacturer nor for the user of adhesives can this volume be said to serve a useful purpose, and less-informed readers would be misled by its many omissions and out-of-date information.

A. G. Ward

The Hollow Universe

By Prof. Charles de Koninck. (The Whidden Lectures, Series IV.) Pp. xii+127. (London: Oxford University Press, 1960.) 12s. 6d. net.

THE author of these lectures, now so attractively issued in book form, was not hampered by any rigid terms of reference, but could discuss what he liked and how he liked. Such opportunities are rare, and reflect credit upon the founder and the establishment of his trust. The theme is not altogether new; it displays the anxieties which are common enough at the ways things are going in the intellectual world. In brief, if we are nothing more than "a mere collection of occurrences", there will be (at the best) little left to wonder at in the whole domain of natural philosophy and human thought. Maybe this is so, but it makes something like nonsense of life as we known it. Prof. de Koninck is a very sensible person, and, moreover, fully alive to the claims of the positivists. His point is that in mathematical physics and everything related thereto one can, and must, be utterly impersonal, and regard Nature as purposeless.

But this does not necessarily apply to the biological sciences in which it is argued (very forcibly, in the reviewer's opinion) that an organism—that is, something provided with 'tools'—is meaningless if devoid of any teleological characteristics whatever. Incidentally, it is maintained that concentration on the lowest forms of life is not the best way to build up an understanding of Nature, any more than it is epistemologically rewarding to seek for goals and ends in plants, however fascinating, one may add, are the problems of morphology.

Thus, we are left with the tremendous question of the fundamentals of biophysics, and the advance of computers. Nobody is likely to ascribe wholly axiological judgments to mechanical systems for some time to come. That these judgments remain seem to make it probable that the universe is not entirely hollow.

F. I. G. Rawlins

Theories of Figures of Celestial Bodies

By Wenceslas S. Jardetzky. Pp. xi+186. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd. 1958.) 45s.

ONE of the deepest mysteries of the universe is that everything in it rotates. This remark, by the late Sir Arthur Eddington, probably explains why the theory of figures of celestial bodies has exercised the minds of many famous mathematicians during the past century. The reader of the book under review may be surprised to find names such as Dirichlet, Liouville, Riemann, Poincaré, Volterra, and more recently, Kahler, Liapounov, Lichtenstein and Wavre associated with the subject, but this list alone indicates that the problems involved are fundamental and of the highest status. Liouville published three papers on the theory during the years 1845–1855 and Dirichlet and Riemann each published a paper in 1861. Since about this time a great deal of research has been carried out in this field and the book by Prof. Jardetzky gives a careful and faithful account of the developments that have occurred.

There are two parts, one dealing with figures of equilibrium of a rotating fluid mass, and one with other figures. The former is classical and describes the most exact methods available for determining the figures. It includes chapters on the methods of Poincaré, Liapounov, Lichtenstein and Wavre. The second part covers zonal rotation, varying figures, systems composed of fluid and rigid parts, fluid mass and centres of attraction, and figures of compressible masses. This part takes into account more physical features than the first and is to that extent more realistic, but its results are not so rigorously developed and many of the problems still await solution.

One really valuable feature of the book is that it covers material which, for the most part, was formerly tucked away in obscure or old journals not generally available. The author was the last pupil of Liapounov and thus is well qualified to bring into the light the work of his teacher in this field. He has himself contributed greatly to the subject, and there are references to his work throughout the book. Anyone working in this field will want to consult the bibliography, which is unusually comprehensive.

L. S. GODDARD

The Jaws and Teeth of Primates

Photographs and Commentaries. By W. Warwick James. Pp. xii+328. (London: Pitman Medical Publishing Co., Ltd., 1960.) 105*s*. net.

THIS book is essentially an atlas of more than two hundred photographic illustrations of the skulls and teeth of representative genera of the modern Primates from tree-shrews to man, each series of illustrations being accompanied by a brief summary of the main features of the dentition. As such, it will provide a convenient work of reference for those who have not ready access to original material in museum collections. The photographs are excellent and have been most skilfully reproduced. The author's notes on the general characters, habits and habitat of each genus are derivative, but unfortunately too often based on early statements in the literature which have been superseded in more recent studies. A number of his observations, also, are surprising and even misleading—for example (in reference to the teeth of 'civilized man'), "Their beauty is regarded as their chief attribute"; in the Prosimii "the cerebral hemispheres are only slightly convoluted"; "Very few fossil Primates have been found in North or South America"; gibbons "live in large colonies which may contain fifty to a hundred members"; "Man in his present state, both mentally and physically, is very different from his ancestor a few thousand years ago"; and so forth. The appendixes on tooth development and the articular eminence raise some interesting points, but are too brief to permit any conclusions of value. Although the text contains statements open to criticism, I would repeat my main assessment, that, considered simply as a photographic atlas, the book certainly deserves commendation as a useful work of reference.

W. LE GROS CLARK

Africa's Place in the Emergence of Civilisation

By Prof. Raymond A. Dart. (The Van Riebeeck Lectures.) Pp. 96. (Johannesburg: South African Broadcasting Corporation.) 2*s*. 6*d*.

THE name of Prof. R. A. Dart, who until recently was professor of anatomy at the Witwatersrand University, will always be associated with the discovery of the Taungs skull. At first some of his ideas were scouted as being fantastic, but of recent years new discoveries have brought to light other ape-men of a very early age and many of his notions have been vindicated. A short while ago he was asked to inaugurate the Van Riebeeck Lectures of the South African Broadcasting Corporation, and "Africa's Place in the Emergence of Civilisation" is the result. Prof. Dart is tremendously impressed with the "Miraculous Community-building effects of fishing upon humanity", and it is fair to say that this theme is central to the book. But naturally the first lecture deals with earlier times and the cultural differences between an ape and a first real man. Here perhaps a saying of Schweitzer to me may be of interest; Schweitzer has kept young gorillas and other anthropoid apes in West Africa and he stated that the difference between a gorilla and a man is minimal compared with the difference between a gorilla and any other anthropoid ape. Chapter 2 is concerned with the appearance of true civilization in the Near East; and then we come to fishing, which, of course, involved boats and boat building. But while this helped forward the march of progress, true civilization is based, surely, on community life and law. May I interpolate here the suggestion that civilization starts in the community life of the village but does not come to real fruition until the development of the towns, and that in Africa south of the Sahara there seem to have grown up no real towns before the coming of Europeans; this may be the fact that has caused Africa to lag behind China, northern India, the Near East and western Europe in the evolution of true 'civilizations'. Prof. Dart does not intend his little work to be the last word on an immense subject. But, just as he himself is stimulating to talk to, so his book is stimulating to read even if, for the moment, everyone may not agree with all he says.

M. C. BURKITT

Laboratory Testing in Soil Engineering

By T. N. W. Akroyd. (Geotechnical Monograph No. 1.) Pp. xx+233+32 plates. (London: Soil Mechanics, Ltd.). 50*s*. net.

MR. AKROYD'S book has been available long enough for quotations from technical reviews to appear on the cover of this edition. All, quite rightly, welcome it as a comprehensive survey, plentifully illustrated by photographs, line drawings and copies of work-sheets. It will be useful to consulting engineers who need a complete account of the kinds of test available, the problems for which the tests are helpful, and the snags that may arise. It could be useful in soils laboratories—teaching or research—where there is some interest in soil as an agricultural raw material.

H. L. PENMAN

CHROMOSOMES AND THE THEORY OF HEREDITY*

By Prof. C. D. DARLINGTON, F.R.S.
Botany School, Oxford

(1) Morgan's Discovery

THE crisis of the struggle in the scientific world over the chromosome theory of heredity was reached in the 1920's when Morgan's views became the subject of dispute. Morgan, with his collaborators at Columbia University, had carried out breeding experiments with the fly *Drosophila*. He claimed that by these experiments he could show that heredity, as long suspected, was indeed carried entirely by the chromosomes. It followed that these minute bodies in the cell nucleus were to be held responsible for the whole character of every living thing, plant or animal, man or microbe; and the course of evolution from the beginning had been determined by changes in these chromosomes. It was a complete scheme of determinism on Omar Khayyam lines.

This theory aroused misgiving and contradiction in many countries, especially among older men who might know the fly but certainly did not know its chromosomes. Before we look at their arguments, let us see what Morgan, and Mendel before him, had done.

Mendel had found that if he crossed two races of peas differing in two respects, as it might be $AB \times ab$, the hybrid gave germ cells of four kinds in equal numbers: *AB*, *Ab*, *aB* and *ab*. Free assortment, random recombination, independent segregation were the explanations given for this behaviour. Assortment of what? Assortment of certain 'elements' carried in all cells and passed to the germ cells. Morgan, however, beginning in 1910, found that in the fly often less than half the germ cells were of the new types, *Ab* and *aB*. The proportion was characteristic of the particular pair of elements. Assortment was not free. The elements were linked; and, if the hybrid fly happened to be a male, the linkage was complete: the elements were held together in one block.

At this point Morgan recalled that the previous year, the cytologist Janssens at Louvain had made a general proposal about chromosome behaviour. He had noticed that after the pairing of maternal and paternal chromosomes in germ cell formation they fell apart but remained touching or attached at various points which he called "chiasmata". At these points, Janssens suggested, the mating chromosomes might exchange parts by breakage and reunion. Such behaviour would give a statistical association or linkage of elements in the same chromosome of a kind already to be suspected from Bateson's breeding experiments. Conversely it would lead to the formation of new chromosomes by a recombination of parts.

Taking Janssens's hint, Morgan and his collaborators proceeded to make crosses between pairs of flies differing in many pairs of respects. They found that hundreds of elements could on this assumption be fitted into the four observed pairs of chromosomes of *Drosophila*. Moreover, if the proportion of re-grouping or crossing-over was itself assumed to be related to the distance apart of the elements along each chromosome, they found that the whole assembly fitted into fixed linear orders. Thus the elements of heredity, or using Johannsen's word the genes, could be put on a map which, like other maps, showed one how to find one's way about.

It soon seemed reasonable to advance from these direct inferences to more general principles. Morgan argued that all heredity in all organisms was carried by chromosomes as it was in *Drosophila*. Further, all chromosomes were composed of units of crossing-over or mutation which might be known as genes. Hence, he appeared to argue, the genes would add up to give the whole of heredity; and the differences between them would add up to give the whole of variation and of evolution.

(2) The Opposition

Morgan's "Theory of the Gene" appeared in 1926; its reception in England could scarcely have been more unfavourable. Seven men might have been willing to assert their belief in the chromosome theory and give their reasons for it. But against this view there were seven hundred who held a contrary opinion. The supporters felt liberated by the new theory: its opponents felt confined and oppressed by it. The grounds they gave for their opposition were both general and specific.

The general objections were that the theory was naive and mechanical and yet self-contradictory. For it was both statistical and deterministic. It left too much room to chance yet no room to free will. In evolution, moreover, its hard particulate basis shut out the hope of any soft Lamarckian adaptation. The Lamarckian principle, we must remember, was at that time generally maintained by naturalists and physiologists and assumed by medical and social scientists. Even philosophers had their opinions, and they were on the Lamarckian side. Yet there was no room in this picture for the Lamarckian emblems, the giraffe, the salamander, or the midwife toad.

The more specific objections to the chromosome theory were also very various. The assumption that the chromosomes were alone responsible for heredity left a gap in our theory of development. Is not heredity merely a repetition of development? Yet this theory of heredity almost ignored development, and it was based on a single organism—a fly with a most disorderly development of its own. The chromosome theory also left a gap where the cytoplasm should be—where indeed European workers had found evidence of determination. Loeb, with his unfortunate idea that the cytoplasm carried the solid basis of heredity while the nucleus bore only a few frills, provided a line of defence for weaker opponents of the chromosome theory.

---

* Substance of a Royal Society Tercentenary Lecture delivered on July 20.

Again it was pointed out, quite rightly, that the gene mutations of *Drosophila* could not be representative of natural variation for they were in their effects both disadvantageous and discontinuous. In the first respect they contradicted the helpful mutations of the evening primrose, *Oenothera*. In the second respect they failed to explain the universal property of continuous variation. As for the chromosomes themselves, did they not at the end of every cell division dissolve and disappear into that bag of fluid, the nucleus? As for crossing-over, the foundation of Morgan's interpretation, it was supposed to happen only in one sex and not in the other. But who had ever seen it happen anywhere? Crossing-over, like the genes themselves, was a stroke of fancy, a mathematical artefact invented to salvage a broken hypothesis.

With regard to these chromosomes, it was true, there were a variety of accounts of what they did. The two cell divisions known as meiosis, when the germ cells were formed, were especially disputable. Some believed that there were general rules; others that there were many kinds of meiosis in different groups of plants and animals. Most believed that, if there was a rule, it was that the corresponding chromosomes from the two parents paired as threads side-by-side. But a few stoutly maintained that chromosomes in the nucleus were in an endless chain which split up crosswise into segments to give $2x$ single chromosomes at mitosis, x double chromosomes at meiosis, and, by a freak of Nature, $4x$ chromosomes at mitosis making a new tetraploid. Clearly this view was of no help to those who believed that the chromosomes made heredity and were differentiated in linear structure; but it was a help to those who did not think anything of the kind. Such differences of opinion—which were described in text-books, taught in universities and expounded in theses—created a verbal and literary jungle which had to be cleared before any general theory could be discussed.

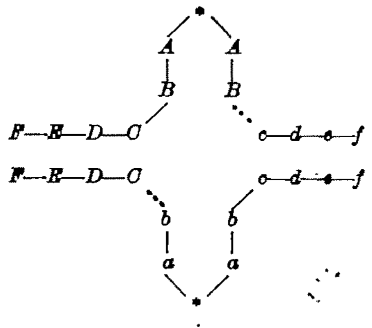
Finally, there was one specific objection which no one seemed to make. It was that genes were inferred to exist from breeding experiments with 'characters'; or more precisely, from studying the inheritance of differences of character when different parents were crossed. Yet the whole of heredity, of the genotype, was supposed to be made up of genes added together. There was a concealed gap between the analytical or differential gene and the integral genotype. In looking at the chromosomes one could see that they added up to make the nucleus. But their differences, their variations, were visibly of many kinds and degrees. The gap was revealed. How could it be bridged? Not, as it seemed to me, by pretending that it did not exist. It was necessary to work out a system of understanding life in terms of chromosomes, a system independent of experimental breeding, a system which would stand on its own feet. In this view I was strengthened by one man's opinion. "Cytology", Karl Belar said to me in 1928, "should not be the *ancilla* of genetics". That was just what I thought.

(3) Crossing-over and the Chiasma

Belar had shown that mitosis and the chromosomes themselves had a universal character, a character which must underlie the uniformity of development of plants and animals and protists. Here was a great and necessary step forward. In genetics, as in geology a century earlier, uniformity was bound up with evolution. Cytologists and geneticists too, so far as they took the chromosomes seriously, therefore liked to think that the same such universal character was true also of meiosis and underlay some uniformity in heredity. But *Drosophila* itself, with crossing-over at meiosis in the female but not in the male, faced us with the gravest objection to this view. It was possible to evade the issue for the time being. It was possible to begin with the simplest material offering experimental tests by purely chromosome criteria. For this purpose polyploid plants with large chromosomes, tulips and hyacinths, were admirably fitted. They revealed several unexpected principles. The important ones, in the present connexion, concern the chiasma.

At a certain stage in the beginning or 'prophase' of meiosis, like chromosomes come together as threads side-by-side in pairs. The association is limited to likes: it is chemically specific; and it was, I found, limited to pairs even when there are three or four of a kind. At a later stage the paired chromosomes reproduce forming double threads and at the same time fall apart. But when they do so they stick at certain points, as Janssens had said, the chiasmata.

Why do they fall apart, in one sense, and stick together, in another? Their structure gave the answer. Contrary to Janssens's view, the chiasmata always had the same structure: they were exchanges of partner between half-chromosome threads, chromatids as we call them. Further, these exchanges could be shown, on internal, cellular, microscopic, evidence to be invariably connected with a previous crossing-over between chromatids of the partner chromosomes. On the simplest assumption, therefore, chiasmata were determined by such crossing-over. The arrangement of four chromatids could be shown in a diagram that was at once genetic and cytological in its implications. With capital and small letters in sequence for the pairing chromosomes, an asterisk for the mechanical centre, and dots for the points of breakage, the diagram would be as follows:



Thus from two chromosomes, *ABCDEF* and *abcdef*, two new chromatids, *ABcdef* and *abCDEF*, had been formed, and the four chromatids would pass as chromosomes into the four germ cells formed by meiosis. The existence of these four cells would, as Janssens had put it, be justified by each of them being a unique combination of available genes different from the rest.

One could not of course prove that this principle was universally true (in those days most biologists believed that propositions ought to be 'proved'); one could merely hope to render it increasingly probable. This hope was gradually realized. The critical configurations of several chromosomes united by, or interlocked with, successive chiasmata, the comparisons of frequencies and distributions of chiasmata and crossing-over in different organisms, in polyploids, in hybrids, with inversions and interchanges of segments of chromosome, in plants with defects of chromosome pairing and of sexual reproduction, these all helped to carry conviction. Even in *Oenothera* the occurrence of chiasmata, the inference of crossing-over, could be used to explain the modes of inheritance and the origins and kinds of mutations.

The solution of the problem of crossing-over was, however, obstructed by another, to me, unexpected but inseparable development. The study I had made of meiosis, and my interpretation of what a hundred others had seen in a great variety of plants and animals, made it clear that the chiasma had consequences which were as important as its causes. People had supposed that the chromosomes were paired at the first metaphase of meiosis because they were, in a mysterious sense, attracted to one another. This was, they thought, the climax of the sexual process. What could be more natural? But I had found that, after pairing as single threads, the chromosomes fall apart as double threads. They do not attract, they repel one another after they become double; and they are held together only by chiasmata, by the exchanges of partner between their chromatids, after crossing-over. When pairs of chromosomes fail to form chiasmata, whatever the cause, the consequence is that they lie on the spindle, unconnected and unorientated. They then fail to pass to opposite poles. Without chiasmata meiosis itself, with Mendelian segregation, the reduction of chromosome number and the alternation of haploid and diploid in the sexual cycle, all these fail to ensue.

Thus there was, in my view, a universal causal sequence: crossing-over ⟶ chiasmata ⟶ chromosome pairing ⟶ segregation and reduction ⟶ sexual reproduction.

This reversal of the mechanical interpretation of meiosis made it possible to describe meiosis in the same physico-chemical terms as mitosis. But what mattered first were its genetic implications. The new principle seemed to be true of all plants and animals (except male *Drosophila*). It therefore meant that meiosis and crossing-over had come in together, at one step. Crossing-over from its origin must have been co-extensive with sexual reproduction. What Morgan had hoped to imply I was now forced to assert. The reason why the chromosomes were divisible into units of genes was that everywhere their division into such units was a condition of meiosis and hence of sexual reproduction. This, of course, made sense in terms of selection, adaptation, and the evolution of sexual reproduction itself. For if the chromosome were not divisible into genes, if it were not capable of crossing-over, it would be inherited as a block and no genes could be revealed either to the geneticist by his experiments or to Nature by her selection. The original system would never have survived.

(4) Evolution and the Cell

It will be seen here that an evolutionary point of view was beginning to force itself into my argument.

There were several reasons why this should have happened to the student of chromosomes, by no stretch of the imagination but by hard necessity. While the experimental breeder could sort out linkage in one species, the chromosomes could reveal chiasmata in a hundred species and in every group of plants and animals. While the experimental breeder himself decided how his plants or animals should breed, the chromosome man had to pick up his cells and discover how Nature had bred them, and why, and with what effect. These were two reasons. But a third was even larger. It was that through the chromosomes there is continuity between successive generations. To the naturalist and to the experimental breeder the organism is an independent discontinuous entity. To the cytologist it is part of a continuous process. Cell division is always a step between the past and future: it is always adapted to meet conditions which do not yet exist, to produce progeny which are irrelevant to their parent's success.

Oenothera first brought this home to me. In its evolution there had been interchanges between different chromosomes, each of which succeeded by virtue of its selective advantage over its predecessors. But success depended on whether plants were inbred or outbred. Thus the hereditary mechanism and the sexual mechanism, the means of distributing and recombining differences and the means of bringing them together, must be bound up together in one system, a genetic system. In a genetic system crossing-over of chromosomes is no good without crossing of germ cells, without outbreeding. The two processes must be adjusted to one another. They must also be adjusted to the needs, not of the individual, but of the breeding group and, more particularly, of its posterity.

A second example was in the male *Drosophila*, with its suppression of crossing-over. In these flies the male, I found, had contrived an anomalous kind of meiosis without crossing-over. The chromosomes paired and separated without needing to form chiasmata. The breeding and the chromosome observations thus agreed. But how had an otherwise universal rule come to break down—and break down in the very species of organism in which the rule was first brought to light?

The reason is obvious as soon as it is pointed out. In the vertebrates or flowering plants the genes in the chromosomes are recombined once in every sexual generation. This may be once in ten months or ten years. But in the short-lived flies it happens once in ten days. That is why from the whole animal kingdom Morgan chose to work with them. But to recombine genes so often does not give any combination a chance of being properly tested. Far better to let the genes recombine in one sex and pass unrecombined through the other sex, down the other line. It is an admirable solution: new things can be made, but good things can be kept.

In the evolution of the flies it was not therefore surprising that a new type of meiosis had been developed in one sex—it had to be the heterozygous sex—in which crossing-over was suppressed. The genetic system would benefit from this modification. The original type of meiosis, on the other hand, was the common ancestral type still found in all species of plants, animals and protista, a type of nuclear division which had arisen at the origin of sexual reproduction, a type with a uniform physico-chemical character.

At the time this speculative conclusion seemed to be rash. To-day, however, we can clearly go further.

The brilliant work that is now being used to reveal the genetic structure of fungi, bacteria, bacteriophages, and other viruses makes it indeed necessary to go further. We have to say now that crossing-over of gene sequences, or nucleotide sequences, is the original property of all systems capable of evolution: and we may add that sexual reproduction, as we ordinarily understand it, is the structure built around crossing-over which has made the higher organisms possible.

This view turned genetics upside down. In the short term one could still see fertilization as the focus of life's processes. For it is at this moment in the higher plants and animals that the individual is created. But in the long term the focus was shifted to the act of crossing-over and the origin of the chiasma. For this is the moment when, we may say, the gene is created. On this event all the processes of evolution converge and from it they all diverge.

(5) Determination and Uncertainty

At an early stage in the discussion of crossing-over, the opponents of the chromosome theory objected that there was no visual or direct evidence that chromosomes did or could cross over at meiosis. When this evidence was provided they objected that there was no reason why it should happen. Fortunately the mechanical reasons were by this time only too evident. Chromosomes which pair as threads always coil around one another. Just as pairs of textile fibres spun under torsion release a part of their torsion by coiling around one another, so do the chromosomes. The part of their torsion released is in equilibrium with the rest which is stored; it is available to break the chromatids and to untwist them to a position where their broken ends can recombine in new combinations. The specificity in pairing of genes and of parts of chromosomes and the observed release of torsion at the chiasma provide for the time, place, and action, of the event inferred in *Drosophila* and of the result seen in the chiasma.

Experiments with nucleic acid starvation later indicated that the nucleic acid component of the chromosomes was the means of developing their torsion. I therefore assumed it to have the structure not of a straight column but of a spiral staircase, an assumption which has been vindicated with beautiful precision by Watson and Crick. How the molecular spiral works in detail, however, is a question we must ask later, when we have a more elaborate molecular model of the paired chromosomes.

What must be discussed now is the fact that this breakage, this crossing-over, can occur at hundreds or thousands of different places along the chromosome: indeed by one definition between any pair of genes in the whole sequence. But in a particular pair in a particular cell it occurs at only a few points, from one to a dozen; and there are conditions, even in *Drosophila* itself, where it seems to be almost fixed.

This situation, in our experience of the statistics of causal relations, seemed to be unique and significant. Its mere mechanics was easily understood. The frequency and distribution of crossing-over is characteristic of the organism. It can be regulated by the organism, by its heredity. If the chromosomes that are going to pair are regularly placed side by side in the nucleus, which sometimes happens, the amount of twisting they develop is regularly distributed and hence the crossing-over. If the chromosomes are irregularly placed, as they usually are, the crossing-over will be irregular and uncertain, as it usually is.

Thus the irregularity of crossing-over, which gives the characteristic variety of progeny in sexually reproducing organisms, is something controlled. Like the weather it shows uncertainty. But, like the weather also, we can predict it so far as we can expect to predict it. Its failure, as well as its normal conditions, show that it is a determined uncertainty. Indeed in asexual reproduction all uncertainty can be removed, and frequently is removed. Its general survival throughout the plant and animal world therefore shows that the uncertainty of crossing-over is original, is organized, and is of adaptive value. Through it indeed meiosis acts as a means of generating uncertainty.

To put the matter in another way: it is a paradox that the gene which is an organ of determinacy in life exists by virtue of a process of apparent indeterminacy. But when we examine it we find that the indeterminacy is spurious. It has been put there (if I may diverge from the present argument) by natural selection and for natural selection. It has been put there as a necessary complement of the uncertainty of the gene's mutation: together they produce adaptive variation.

The discovery of how crossing-over happens had long-range consequences beyond the previous limits of genetics. For it enabled us to split up the processes of life into two parts. First there are those concerned with determining the character of individuals. These are processes of physiology in which the greatest certainty of determination, the strictest predictability in reaction with the environment, a chemical determinism, is achieved; and secondly there are the processes of meiosis. These, reinforced by the chances of fertilization which are derived from them, determine the differences in character of individuals. They are the processes of classical genetics in which the greatest uncertainty of determination is organized and achieved.

This contrast, as I believe, between two kinds of process—the one deterministic, the other spuriously non-deterministic—also provides one of the several ways of splitting genetics into two. It means that instead of speaking of the laws of heredity, as the early Mendelians were fond of doing (making biology echo the physics of the time), we should speak rather of the 'paradoxes' of genetics. For heredity is a relation between parent and offspring which is variably compounded of the certain and the uncertain elements, according to how like the parents or grandparents may have been; indeed according to the effects of their system of breeding.

(6) The Continuing Issue

I have given an eye-witness account of a battle. I believe it is a battle that we won. The pursuit of the enemy has, to be sure, taken us far away from the original site of the conflict; and it could have taken us much further with the elasticity of the gene, the organization of the chromosome or the physiology of the nucleus. But the site of the struggle matters less than its purpose. The enemy, although defeated and dispersed, has not been destroyed. They will, in my opinion, have to be fought many times again. For mankind, if it happens to take note of the argument, will not willingly admit that its destiny can be revealed by the breeding of flies or the counting of chiasmata.

STREAMING IN CYTOPLASM DISSOCIATED FROM THE GIANT AMŒBA, *CHAOS CHAOS*

By Prof. R. D. ALLEN, J. W. COOLEDGE and P. J. HALL
Department of Biology, Princeton University, Princeton, New Jersey, U.S.A.

THE driving mechanism of amœboid movement (and its accompanying cytoplasmic streaming) has always been considered to be a property of the amœboid cell as a whole. We wish to report new findings which demonstrate that the cytoplasm can be removed from an amœba in a state in which it displays continuous and vigorous streaming *in vitro* for periods as long as an hour. Our experiments vividly demonstrate the inadequacy of the sol-gel or ectoplasmic contraction theory of amœboid movement[1,2], and lead to the conclusion that the cytoplasm of amœboid cells is structurally organized into subcellular 'units of streaming', the nature of which will be discussed here.

The phenomenon of persistent, continuous streaming in the cytoplasm of ruptured amœbæ (*Chaos chaos* and *Amoeba proteus*) was described briefly by the senior author in 1955 (ref. 3). Since that time there has been no hypothesis to explain this phenomenon, and a more complete account of it was postponed until a satisfactory hypothesis could be tested. The recent development of the 'fountain zone contraction theory' of amœboid movement has offered for the first time a satisfactory explanation for several perplexing aspects of amœboid movement[4,5]. According to this theory, the endoplasm begins to contract actively (that is, develop tension) as it enters the 'fountain zone' just posterior to the hyaline cap, where it becomes everted to form the ectoplasmic tube. The tension developed between the anchored advancing rim of the ectoplasmic tube and the movable endoplasm displaces the latter anteriorly. Continuous streaming is maintained by propagation of the contraction posteriorly along the endoplasm at the same velocity as that at which the endoplasm advances relative to the pseudopodial tip. At the anterior end of the cell the contraction phase of the contractility cycle expresses water (and solutes) to form the hyaline cap. The hyaline cap fluid must then be returned to the recruitment zone (tail endoplasm), where it is believed that the extension phase of the contractility cycle occurs[5]. The mobility of the plasmalemma with respect to the ectoplasmic tube[4,6] demonstrates the existence of a fluid channel (the hyaline ectoplasm) which could serve to transport the hyaline cap fluid to the posterior portion of the cell. The endoplasm has been shown to possess structure sufficient to transmit tension[7,8]. The details of evidence on which the fountain zone contraction theory is based is being presented elsewhere[6].

With the fountain zone contraction theory in mind, we have re-examined the phenomenon of streaming in cytoplasm dissociated from the amœba and have obtained quantitative data which satisfy many of the predictions of the fountain zone contraction theory.

Cytoplasm is freed from the cell by rupturing the cell membrane while the amœba itself is held in a quartz capillary to prevent the cytoplasm from becoming dispersed. The most successful method is to draw an intact amœba carefully into the fine bore of the capillary and then to shatter the capillary with a sharp scalpel under a pool of paraffin oil. The oil seals the capillary at both ends, thereby trapping the cytoplasm in a closed container isolated from outside forces. The capillary is drawn in two stages under an oxygen flame: first, from 6 mm. inside diameter to 1–2 mm., and then in a smaller flame to 75–200μ.

The experiment is easy to perform; students in the cellular physiology course at Princeton usually succeed after a few attempts in obtaining dissociated cytoplasm preparations which stream continuously

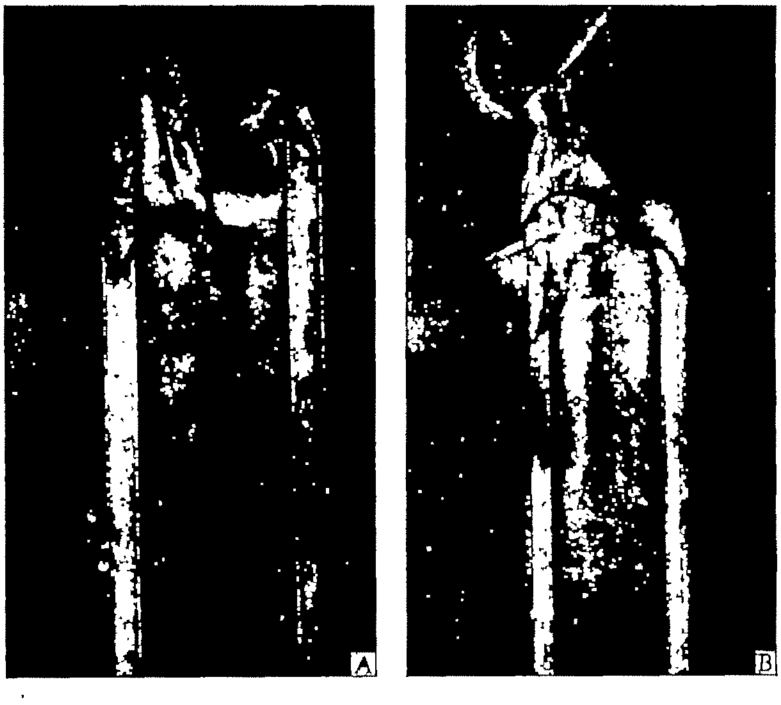


Fig. 1. Photographs of actively streaming cytoplasm dissociated from the giant amœba, *Chaos chaos*, contained in a broken capillary submersed in a pool of paraffin oil. (*A*) a preparation in which the capillary was shattered at the ends of the amœba to form a protoplasm–water interface. The marker is 50μ long. (*B*) similar to *A*, except that the capillary was shattered peripheral to the ends of the amœba. The arrow shows one of the loops of cytoplasm which stream out into the water and return to the main cytoplasmic mass (see text). The marker is 10μ long

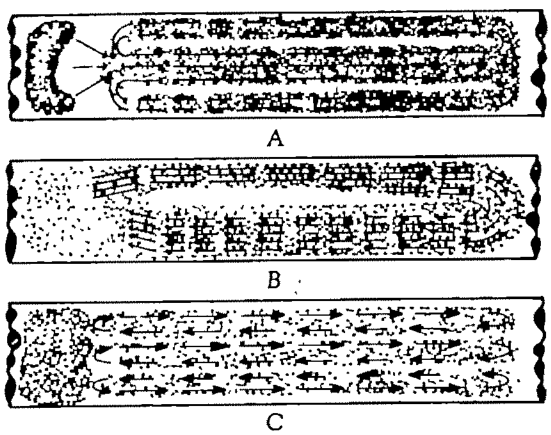


Fig. 2. Diagrams to show: (*A*) the fountain streaming pattern of stage I, note the remnants of the plasmalemma on the left side of the diagram; (*B*) stage II, showing the loop-streaming pattern; (*C*) stage III, after division along the longitudinal axis of some of the loops has occurred to increase the number of streaming units

for a half-hour or more after rupture of the cell. The only difficult part of the procedure is to draw the amœba into a sufficiently narrow capillary without rupturing its membrane prematurely. It is also essential that the cell fill the bore of the capillary, in order to prevent excessive dilution of the cytoplasm with water or other aqueous medium. It seems to make little difference to the outcome of the experiment whether the capillary is shattered directly over the two ends of the amœba (as in Fig. 1*A*) or slightly peripheral to the amœba (Fig. 1*B*), as the shock of breaking the capillary usually is sufficient to rupture the plasmalemma. The dissociated cytoplasm seems to stream equally well whether in contact at the ends with oil or water.

While it is possible to perform this experiment with any large, free-living amœba, *Chaos chaos* cytoplasm displays the most vigorous movement and 'survives' for the longest periods, ranging from 10 min. to an hour. Our best results have been obtained from *C. chaos* which were raised in Pringsheim solution[6], fasted 24 hr., washed in ion-free water, and cooled to 2° C. for about 12 hr. prior to an experiment. Amœbæ treated in this manner begin to stream within minutes after return to room temperature, and for a half-hour thereafter tend to remain monopodial. In this condition they are more readily drawn into capillaries without premature rupture. None of these treatments is absolutely necessary, and, in fact, the experiment will work with amœbæ taken directly from wild cultures. The low-temperature pretreatment renders the cells less fragile during transfer to capillaries, and the ion-free water reduces the tendency of the cytoplasm to become vacuolated following rupture of the plasmalemma.

Whether or not the cell exhibits streaming prior to rupture of the plasmalemma, the shattering of the capillary results in vigorous streaming which may reach a velocity double that in the intact cell.

The pattern of streaming usually goes through at least two of three recognizable stages during its 'survival' within the capillary. In the first stage, the cytoplasm circulates in the 'fountain pattern' typical of that seen in intact cells which are unable to become attached to a solid substratum. During this stage, any remnants of the plasmalemma are transported by the outer or 'ectoplasmic' stream to the former posterior end of the cell, where they can often be seen as a folded structure (Fig. 2*A*).

Within the first few minutes, the second stage of streaming begins by the appearance of an even number of 'units of streaming' which pass back and forth in a more or less orderly manner. Detailed observation of these 'units' shows that they are, in effect, bands or loops of cytoplasm, the bends of which are located usually at the former anterior region of the cell (Fig. 2*B*). It is difficult to determine how the change from the fountain pattern to the loop pattern occurs, but it seems likely that the cytoplasm breaks up into what correspond roughly to radial sectors. The units of streaming are definitely not channels through which 'plasmasol' flows, for solid cylinders of streaming cytoplasm are coherent and do not disperse in moderate amounts of water (see Fig. 1). They exhibit 'plug-flow' velocity profiles remarkably similar to those shown by the endoplasmic stream of the intact cell[7]. Sometimes thin cytoplasmic strands, recognizable only by moving rows of inclusions, come out into the water at the ends of a preparation similar to Fig. 1*B*, and follow a U-shaped course through the water and back into the main mass of dissociated cytoplasm.

During the third stage (Fig. 2*C*), there is a marked retardation of streaming velocity and a tendency (not seen in all preparations) of the units of streaming to divide longitudinally or 'tear'. This 'tearing' of the cytoplasmic structure appears to be a result of the development of unequal tension from contraction in the cytoplasm. The tension is relieved by tearing along a longitudinal fault in each streaming unit, resulting in its division into two units which thereafter move independently. The thinnest streaming units produced by such divisions might be called 'fibrils', although they are visible only as a linear aggregate of particles which move in single file.

If it is assumed that the U-shaped bands of cytoplasm arise from radial division of the fountain streaming pattern, it can then be shown that these units of streaming behave as predicted by the fountain zone contraction theory. In order to relate the behaviour of the units of streaming to the events in the intact cell, we shall refer to the cytoplasm approaching the bend of a loop as the 'endoplasmic arm' of the loop and the cytoplasm receding from the bend as the 'ectoplasmic arm'. This designation appears justified from the velocity profiles across the adjacent ecto- and endo-plasmic arms of a typical unit of streaming shown in Fig. 3. The velocity profile across the endoplasmic arm is remarkably similar in shape to that across the endoplasmic stream of the intact cell, as measured by Allen and Roslansky[7]; that across the ectoplasmic arm is flatter, as expected of a more rigid gel. The different velocity profiles almost certainly indicate a difference of consistency between the less rigid endoplasmic arm and the more rigid ectoplasmic arm of the loop, even though the profiles cannot be interpreted strictly in terms of classical flow theory (cf. ref. 7).

The fountain zone contraction theory predicts that the endoplasmic arm should shorten and thicken in passing through the bend. That endoplasm does shorten is shown by the fact that it is displaced toward the bend at 2–3 times the velocity at which the ectoplasmic arm recedes from the bend. (Velocity ratios of greater than 1 and less than 2 were recorded on film, but the positions at which these ratios were recorded were too far from the bend to be certain that the bend had remained stationary. No case has

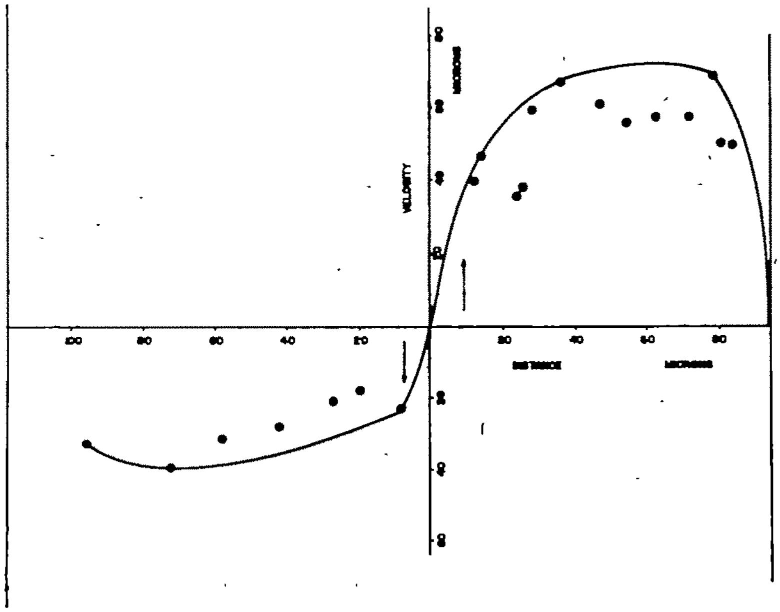


Fig. 3. A velocity profile across the endoplasmic (right) and ectoplasmic (left) arms of a broad, U-shaped loop of cytoplasm, measured approximately 150μ posterior to the bend. Note that the maximum velocity of the endoplasmic arm (streaming toward the bend) was approximately double that of the ectoplasmic arm (streaming away from the bend). The sum of the velocities was about twice the velocity of endoplasmic streaming of intact cells

been found of more rapid streaming away from the bend than toward it. The same velocity relationships hold true in the intact cell (see Fig. 4).) The shortening must occur where the velocity decreases; Fig. 4 shows that this decrease of velocity occurs at the junction between the endoplasmic arm and the bend. In favourable cases it has also been possible to measure a pronounced thickening of the cytoplasm in such a unit of streaming as it passes through the bend. In the example represented by Fig. 3, the cross-sectional area of the ectoplasmic arm was 3·8 times that of the endoplasmic arm, based on measurements of diameter. These changes in length and cross-sectional area are similar to those which have been shown to occur in the intact cell[5].

Besides the geometry changes mentioned above, there are more direct indications that a tension-producing contraction occurs at the bend of these units of streaming. Of particular significance is the fact that when streaming of cytoplasmic loops occurs in spurts, activity can be detected first at the bend of the loop, where a conspicuous shortening occurs. Immediately afterward, the cytoplasm moves toward and away from the bend. Thus the temporal sequence of events indicates that the shortening process at the bend is responsible for pulling the endoplasmic arm toward, and pushing the ectoplasmic arm away from, the bend.

In order to result in streaming, the contraction must remain localized in the vicinity of the bend. This can be accomplished only if the contraction is propagated posteriorly along the endoplasm of the intact cell (or endoplasmic arm of a streaming unit) at the same velocity as that at which the endoplasmic stream advances relative to the bend. Ordinarily, the contraction is inconspicuous because it remains at the bend. Occasionally, however, the contraction is seen to be propagated along straight sections of cytoplasm from one end of the capillary to the other. Occasionally also, the bend itself moves with the contraction, especially if the ectoplasmic arm is held in place. When this occurs, the bend is 'whipped' along the capillary by the propagated contraction.

A further manifestation of contractile activity is a 'twitching' movement which occurs just prior to cessation of streaming. Localized contractions may also give rise to very complicated rotatory and other movements.

There is evidence of a syneresis associated with the contraction at the fountain zone (stage I), or at the bends of cytoplasmic loops (stage II), which is probably analogous to hyaline cap formation in the intact cell. In the presence of traces of calcium ions, an increasing number of clear vacuoles forms after the membrane of the cell is ruptured. The vacuoles form as tiny tear-shaped bodies which suddenly 'blow up' like balloons in the fountain zone (stage I) or at the bend of a streaming unit (stage II). If the formation of these clear vacuoles is the result of syneresis, then the argument that hyaline cap formation results from syneresis associated from the fountain zone contraction is strengthened. It is then reasonable to suppose that this syneresis occurs also when insufficient calcium is present to cause the formation of a visible vacuolar membrane around the fluid expressed from the interstices of the contracting cytoplasm.

The streaming of amœba cytoplasm in the absence of the plasmalemma and ectoplasmic tube as structures completely eliminates the sol-gel or ectoplasmic contraction theory as a possible explanation for

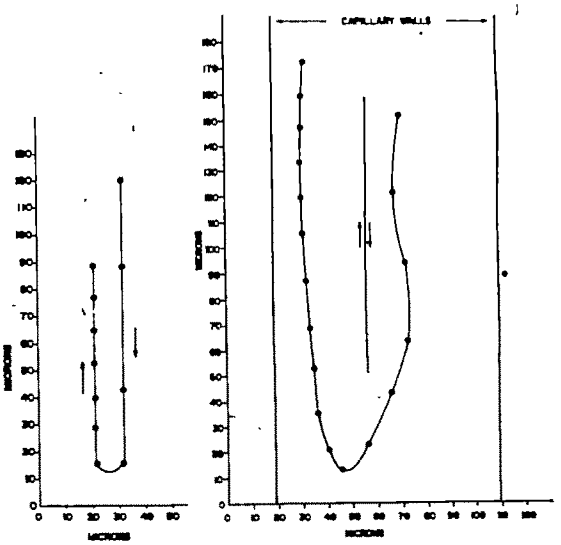


Fig. 4. Left: the positions occupied at intervals of 1 sec. by an inclusion as it moved forward in the endoplasm and backward in the ectoplasm relative to the tip of a pseudopod in an intact *Chaos chaos*. Right: the same for an inclusion carried in a U-shaped loop of dissociated cytoplasm. Note in both cases the retardation at the junction between the endoplasmic arm (streaming toward the bend) and the bend itself

streaming in cytoplasm dissociated from amœboid cells. This theory demands the presence of an intact ectoplasmic tube to convert ectoplasmic shortening into a pressure gradient.

The results of the present work provide additional evidence that the endoplasm of the amœba is not a structureless sol, but rather a material which is structurally and physiologically organized and capable of carrying on cytoplasmic streaming at the sub-cellular level. The partial disintegration of cytoplasm dissociated from giant amœbæ into motile 'units of streaming' provides evidence which is not only compatible with, but also provides further verification for, the fountain zone contraction theory of amœboid movement[4]. Each unit of streaming consists of a U-shaped loop or band of cytoplasm with a bend at which a contraction occurs. The two arms of the loop show a difference of consistency; the contracted or ectoplasmic arm is more rigid. Therefore, when the bend is held stationary and the contraction is propagated in one direction, the cytoplasm of the loop streams through the bend in the opposite direction.

We believe that the principle upon which the movement of amœba cytoplasm has been shown to depend may be widely applicable to many other cases of cytoplasmic streaming, and that the demonstration of this principle at the sub-cellular level represents an important step toward an understanding of the mechanism of amœboid movement and cytoplasmic streaming.

This investigation was supported by a Research Grant, C-3022, from the National Cancer Institute, National Institutes of Health, U.S. Public Health Service.

---

[1] Pantin, C. F. A., *J. Mar. Biol. Assoc. U.K.*, 13, 24 (1923).

[2] Mast, S. O., *J. Morph. Physiol.*, 41, 347 (1926).

[3] Allen, R. D., *Biol. Bull.*, 109, 339 (1955).

[4] Allen, R. D., "Amœboid Movement", in Vol. 2 of "The Cell", edit. by Brachet, J., and Mirsky, A. E. (Academic Press, in the press).

[5] Allen, R. D., *Exp. Cell Research* (in the press).

[6] Griffin, J. L., and Allen, R. D., *Exp. Cell Research* (in the press).

[7] Allen, R. D., and Roslansky, J. D., *J. Biophys. Biochem. Cytol.*, 6, 437 (1959).

[8] Allen, R. D., *J. Biophys. Biochem. Cytol.* (in the press).

[9] Andresen, N., *C.R. Trav. Lab. Carlsberg, Sér. Chim.*, 30, 435 (1956).

THE NATIONAL ENGINEERING LABORATORY, 1960

OPEN DAYS

THE third open days of the National Engineering Laboratory (formerly the Mechanical Engineering Research Laboratory), East Kilbride, Glasgow, held on June 15 and 16 and the evening of June 17, were attended by more than 2,200 representatives of industry, universities, technical colleges and other research organizations. All the work at East Kilbride and Thorntonhall was on display, and about a hundred items were specially featured. There was also a display describing the facilities available for carrying out sponsored investigations for individual firms.

The behaviour of metals under stress is the concern of the Materials Division, where the aim is to provide the designer with basic data on the strength of materials, particularly under fatigue and creep. In many components and structures, fatigue cracks can form very quickly, and it is necessary to know the conditions under which these will grow if the component is to be designed efficiently with economic use of material. Investigations, using 10-in. wide sheets under tensile fatigue loading, have shown that low stresses ($5 \pm 1\frac{1}{4}$ tons/in.^{2} for mild steel) are sufficient to cause cracks to grow, and this growth may be continuous or intermittent. When growth is continuous, for overall crack-lengths up to one-eighth of the total width of the sheet, the rate of growth is dependent on the cube of the alternating stress and on the current crack-length.

Fundamental studies of the mechanism of growth of fatigue cracks in mild steel indicate that the growing crack is made up of many small independent cracks which have no relation to the initial cracks found in brittle fracture or to the inclusion cavities of ductile fracture. It is thought that elementary fatigue cracks form as a result of the development of a sub-grain structure, the sub-grains being an essential feature of cyclic dislocation movement.

Under stress at high temperatures, materials undergo a slight continuous elongation, known as creep. To provide data for the adequate design of components which will operate under these conditions, as, for example, in steam-power plant, the Laboratory is examining the creep characteristics of typical engineering metallic alloys. Their properties, under simple and generalized loading conditions, under relaxation conditions where the total strain is kept constant, and under conditions leading to actual fracture, are being studied and the relation between creep-rate, stress and time has been established for several materials.

The development of techniques and apparatus for the accurate measurement of large water-flows in pipes is necessary for the efficient design and operation of hydraulic machinery. One technique employs propeller current meters, mounted in a predetermined pattern over the cross-section and each rotating at a speed proportional to the local velocity of flow. In conventional propeller meters, bearing friction at low flow-rates makes the meter calibration non-linear and dependent on time. The Fluids Division at the Laboratory has developed a frictionless meter incorporating a hydrostatic pressurized bearing which provides a dynamic film of water between rotating and fixed parts. Static friction is eliminated and linear calibration is now obtained over a wide range of flow-rates. It is hoped that precision moulding of the impeller will eliminate the need for calibration of individual meters when the first one or two impellers have been calibrated.

A robust dual-element thermometer has been devised to measure temperature between 0 and 50° C. to within a few millidegrees centigrade under industrial conditions. It is used in conjunction with an a.c. bridge having transformer ratio arms, and the circuit can be arranged to eliminate the effect of long supply leads and bridge outer leads. The temperature is obtained from the ratio of the temperature coefficients of resistance of the copper and minalpha elements, and the need for a highly stable external resistor (and consequent temperature-controlled enclosure) is eliminated.

Heat transfer is an essential process in the operation of a wide range of mechanical engineering equipment, and it is part of the concern of the Heat Division to obtain more accurate data for use in the design of such equipment. A particular example of fundamental importance in this field is the flow of heat between a pipe and a fluid passing through it. Studies of the effect of abrupt changes of section and right-angled bends in pipes have shown that for low flow-rates, and particularly for laminar flow, there is an increase in the heat-transfer coefficient after the discontinuity (in one instance the coefficient rose to ten times its normal value). This increase may extend up to 50 pipe diameters downstream of the discontinuity. For higher flow-rates, the increase in the heat-transfer coefficient is comparatively small and does not extend far along the pipe.

To enable heat-exchange apparatus to be designed more efficiently, there is need for a more accurate knowledge of the properties of the gases to be used, and the Division is producing tables of thermodynamic and transport properties of technically useful gases. The National Engineering Laboratory is the United Kingdom representative in the preparation of an internationally acceptable set of steam tables; a new skeleton table, extending up to 1,000 atmospheres and 800° C., is being drawn up. To reconcile the different experimental data and to keep them consistent with the thermodynamic relations, an equation of state, valid for the vapour state, has been devised, based on P-V-T data; this equation represents pressure as a double-power series in density and temperature, and all the other properties can be derived from it.

One of the aims of the Metrology Division is to improve the accuracy and performance of machine tools and mechanisms such as gears, lead screws, ball-bearings and universal joints; as part of the Division's work, new types of precision measuring instruments, using optical, mechanical, electronic and pneumatic techniques, are developed. Particular attention is being given to the application of moiré fringes to precision measurement, and automatic control of machine tools (moiré fringes are produced when light is shone through two similar gratings placed face to face with their lines not quite parallel). Using a photo-electric pick-up, linear or rotary movement can readily be converted into a corresponding electrical signal, and this system can be used as a basis for comparing the relative motion of two elements in a mechanism—the signal representing the error in relative motion can then be used to actuate a correction mechanism. A system of this type is now providing continuous and automatic correction of the errors in rotation of the worktable of a commercial gear-hobbing machine. A photographic process is used to produce the lines on the precision radial gratings for this and other applications; previously the lines were ruled on an aluminium-coated glass plate, using a circular dividing machine. A small segment of the grating is first ruled and is then mounted concentrically with a photographic plate secured to the table of the dividing machine. By alternate exposure of the plate to a beam of light passing through the master segment, and indexing of the table through an integral number of grating pitch spaces, a complete photographic copy is obtained. This method eliminates short-term periodic errors in the grating, and the time required for production can be reduced considerably (for a radial grating with 10,800 lines, from 4 days to about 3½ hr.).

Pressurized air bearings are being employed to reduce friction in instruments and machine tools. They can be used to provide a high-precision axis of rotation in journal bearings, or to enable a carriage to travel accurately in a straight line along a slideway. A typical application of the second type has been the development of a flat air bearing to support the ¼-ton worktable of a horizontal milling machine. Cutting performance of the machine is unimpaired, while it has been possible to reduce the size of the traverse motor from 2 to 1/50 h.p.

A clear understanding of the processes of lubrication and wear is essential if machines are to run efficiently and have a long service life. The Lubrication and Wear Division is studying one of the major forms of wear in machinery—the abrasive action of hard fine particles. This may occur, for example, in internal combustion engines, if the air is not properly filtered at intake, and in agricultural machinery, under the action of soil particles. Work on the resistance to abrasion of a wide range of carbon steels and cast irons has shown that in general an increase in hardness of the material improves the resistance, but in some cases other factors, such as graphite or eutectic cell-size in cast irons, may be equally or even more important. Other work has shown a correlation between resistance to abrasive wear and to fretting corrosion (the wear occurring between two contacting surfaces subject to repeated relative oscillatory motion), and it may ultimately become possible to predict fretting corrosion resistance from abrasive wear tests.

Under unsteady loads, such as are encountered in internal combustion engines and in high-speed turbo-machinery, the position of the shaft in a journal bearing varies in the bush, and excessive vibration and bearing failure may result. Inductive transducers are being used to detect and trace the shaft movement under the action of various loads, including a combined gravity load and unbalanced rotating load. The rupture of the lubricant film in the unloaded part and the consequent change in the hydrodynamic conditions in the bearing appear to be responsible for the observed variations in shaft movement.

The work of the Plasticity Division is directed towards obtaining a better understanding of the behaviour of metals during plastic deformation. This will lead to more effective utilization of metals, and in metal-working processes to improved techniques and more efficient machine tools.

In forming operations the temperature distribution within the metal must be known and controlled to avoid excessive rises of temperature which may cause undesirable changes in the properties of the product —for example, 'hot shortness' in extruded material. A combined theoretical and experimental technique is being used to determine the rates of rise of temperature in a material during extrusion, and a programme has been prepared for the Laboratory's *Deuce* computer to obtain the temperature distribution as a function of time under various extrusion conditions.

Investigations have shown that under high hydrostatic pressure, materials behave in a more ductile manner than at atmospheric pressure, and that some normally brittle materials, for example, bismuth and magnesium, can be successfully cold-extruded inside a chamber containing fluid at high pressure; a superimposed hydrostatic pressure of 2–3 tons/in.² may be sufficient to prevent cracking of the extruded product for low reductions in area. This technique may have several commercial applications, particularly in the working of new and difficult materials.

Apparatus to generate pressures up to 100,000 atmospheres in conjunction with temperatures up to 3,000° C. has also been built. This will be used to investigate the forming of new materials of technical and scientific interest under simultaneous high pressure and high temperature. Typical effects of such conditions are the transitions of graphite to diamond and hexagonal boron nitride to borazon. In the case of borazon, its great hardness and resistance to oxidation at high temperature give it considerable industrial potential.

R. I. LITHGOW

NEWS and VIEWS

Psychology at Leicester: Prof. S. G. McK. Lee

DR. S. G. McK. LEE, who has been elected to the new chair of psychology in the University of Leicester, is a South African by birth and gained his early education and teaching experience in psychology at the University College of Natal. His war service, during 1940–46, included four years as navigator with the South African Air Force and the Royal Air Force. Dr. Lee has a close knowledge of the language and culture of the Zulus, among whom he carried out studies in social psychology and cultural influences on personality. His reports on the 'crying hysteria' of Zulu women and the cultural significance given to their dreaming are well known. He has standardized intelligence tests and a version of the thematic apperception test for Africans. After taking his Ph.D. at Birkbeck College, London, where he also held a teaching post, Dr. Lee became in 1955 senior lecturer in psychology at the University College of Fort Hare, where, however, he reluctantly decided that political restrictions on African education would soon make his work nugatory. He returned to London, to join the staff of Bedford College, where he has taught for the past four years. In his recent research work he has brought together his training as an experimental psychologist and his experience in clinical psychology by investigating experimentally, in collaboration with Dr. D. W. Forrest, the effects of repressed interest and emotion on perception. He is now (in association with Dr. G. M. Carstairs, of the Medical Research Council) applying one of the experimental techniques developed for that purpose to a study of psychological aspects of hypertension.

C.S.I.R.O. Division of Physical Chemistry: Dr. S. D. Hamann

DR. S. D. HAMANN has been appointed chief of the Australian Commonwealth Scientific and Industrial Research Organization's Division of Physical Chemistry at Fishermen's Bend, Victoria. He succeeds Dr. K. L. Sutherland, who has resigned to become director of research for the Colonial Sugar Refining Co., Ltd. Dr. Hamann was born in Christchurch, New Zealand, in 1921. He graduated M.Sc. with honours at Canterbury College, having specialized in chemistry and physics. He spent more than four years in the Royal New Zealand Navy, being engaged almost continuously for three years in operational and technical research on radar. At the conclusion of the War, Dr. Hamann studied at the University of Manchester, and was awarded a Ph.D. degree in 1950. Having returned to Australia, he immediately joined the Commonwealth Scientific and Industrial Research Organization's High-Pressure Laboratory in the Chemical Engineering Department of the University of Sydney. He has been in charge of this Laboratory since 1952. Dr. Hamann has represented Australia at meetings of the International Union of Pure and Applied Chemistry in Zurich (1955) and Munich (1959).

C.S.I.R.O. Division of Forest Products: Mr. S. A. Clarke

MR. STANLEY A. CLARKE, chief of the Division of Forest Products of the Australian Commonwealth Scientific and Industrial Research Organization, retired from active duty on August 26. Born in Perth, Western Australia, in 1900, an engineering graduate of that State and an associate member of the Australian Institute of Engineers, Mr. Clarke has been associated with the Division of Forest Products since 1929. In that year he was seconded to the newly formed Division of Forest Products as officer-in-charge of seasoning and utilization. The following year he transferred to the permanent staff of the Division, and in 1931 was appointed as deputy chief of the Division. He held this position until 1944, when he succeeded the late Mr. I. H. Boas as chief of Division. Mr. Clarke has won the esteem and confidence of the Australian timber industry, and has established a reputation both in Australia and overseas for his ability to apply his engineering and scientific outlook to problems in the utilization of forest products. Devoting himself in the first instance to the problems of saw-milling, timber seasoning and timber grading, he afterwards became an authority on such widely diverse activities as those of the pulp and paper, fibre board and particle board industries. Since 1930 he has participated actively in the work of the Timber Industry Committee (formerly Timber Sectional Committee) of the Australian Standards Association, being appointed as chairman to the Committee in 1944. His advice has been widely sought by such countries as New Zealand, India and the United Kingdom. Mr. Clarke has taken a keen interest in the United Nations Food and Agriculture Organization's work in relation to forest products, and in addition to being chairman of the Asia–Pacific Regional Committee of Forest Products Research he is a permanent member of the Technical Panel on Wood Technology of the Organization.

Reflexion of Signals from *Echo* 1

A TEAM of scientists from the Post Office and the Royal Radar Establishment, Malvern, succeeded on the evening of August 29 in receiving signals at Malvern reflected from the Earth satellite *Echo* 1 (see *Nature*, August 27, p. 741). The signals, which included both unmodulated carrier waves and speech transmissions, were transmitted from the Bell Telephone Laboratories at New Jersey, U.S.A. Prof. A. C. B. Lovell, of the Jodrell Bank Radio Astronomy Station, announced that signals from New Jersey had been received about a week ago, using the 250-ft. radio telescope. The present tests at Malvern are of particular interest since the radio aerial used was only 20 ft. in diameter.

The National Chemical Laboratory

THE report of the National Chemical Laboratory, 1959 (London: H.M. Stationery Office, 1960. 4*s*. 6*d*. net), begins with a report of a steering committee set up in October 1958, which made several recommendations. Thus the Committee proposed the transference of the collection of industrial bacteria to the Torry Research Station and the disbanding of the research section. The greater proportion of the National Chemical Laboratory's effort is to be devoted to work on the thermodynamic properties of pure materials. Work on high polymers is reduced to the investigation of certain aspects. Work on selective membranes is to be continued. There will be closer co-operation with the National Physical Laboratory. The work on corrosion, always a valuable part of the research in the National Chemical Laboratory, is continuing. A Radio-Isotope Applications Group works at Harwell. The report as a whole contains some interesting material, usually presented in sufficient detail to be intelligible to non-specialists.

Science Horizons

COMMENCING with the August issue, the title of the monthly review of scientific progress in the United States of America, *Atoms for Peace Digest*, issued by the United States Information Service, American Embassy, London, W.1, has been changed to *Science Horizons*, to reflect the broadened editorial content of the journal. For some time now the journal has been reporting developments in space research, electronics and technology generally, in addition to specific developments in nucleonics, and these are now to become regular features. Topics discussed in the August issue include ram-jet engines for supersonic airliners; a world-wide, all-weather navigation system, based on Earth satellites; and the 'laser', a light amplifier. *Science Horizons* is to be published during the third week of every month, but will be dated a month ahead, that is, for example, the October issue will be distributed during the third week of September.

International Scientific Radio Union

THE thirteenth General Assembly of the International Scientific Radio Union (U.R.S.I.) is being held at University College, London, during September 5–15. The Union is in the nature of a federation of national scientific bodies interested in the radio aspects of scientific research and development. The present assembly is being held at the invitation of the Royal Society which, through its British National Committee for Scientific Radio, is responsible for making the arrangements for this meeting, under the chairmanship of Mr. J. A. Radcliffe. The previous General Assembly was held at Boulder, Colorado, in 1957 (see *Nature*, 181, 465; 1958), and Dr. L. V. Berkner, head of Associated Universities, Inc., New York, was elected president of the Union for the current term, and is presiding over the plenary meetings in London. The scientific programme of the forthcoming assembly is organized under seven commissions, the titles and chairmen of which are: I, Radio Measurements and Standards (Dr. B. Decaux); II, Radio and Troposphere (Dr. R. L. Smith-Rose); III, Ionospheric Radio (Dr. D. F. Martyn); IV, Radio Noise of Terrestrial Origin (Prof. R. A. Helliwell); V, Radio Astronomy (Prof. A. C. B. Lovell); VI, Radio Waves and Circuits (Prof. S. Silver); and VII, Radioelectronics (Prof. W. G. Shepherd).

The British Pteridological Society

DURING the latter half of the last century, searching for and growing wild varieties of British ferns were wide-spread pastimes. In 1891 a group of Lakeland hunters formed themselves into the Northern British Pteridological Society and attracted members from all over Britain. During those early years, the emphasis was on varieties and their cultivation, and this is still regarded as an important and integral part of the activities. In recent years, the scientific side has gradually developed and increased in importance. This movement has been greatly accelerated during the past year, which has seen big changes and re-organization in the Society. The importance of operating in a much wider field has been realized and the Society's aims now include the study of world ferns and fern allies. The recording and dissemination of information on the British Pteridophyta still remain, of course, a major activity. In addition, an attempt is being made to build up a herbarium of varieties in existence to-day. An annual excursion for a week to parts of the country where ferns abound has long been a popular institution in the Society. Additional meetings are held during the year to cater for members whose interests are taxonomic rather than horticultural. Day field meetings and indoor meetings are held in the London area, and a separate northern meetings secretary and committee organize field meetings for members in the north of England and in Scotland. The current annual subscription is 10*s*. Members receive the *British Fern Gazette*, published annually, and, occasionally, other publications. The secretary is Mr. J. W. Dyce, 46 Sedley Rise, Loughton, Essex.

Mushroom Growing

THE Ministry of Agriculture, Fisheries and Food is to be congratulated on the new edition of its bulletin on "Mushroom Growing" (Bull. No. 34, seventh ed., price 6*s*. H.M.S.O., London, 1960). The sixth edition was issued some six years ago, and, as noted in the foreword, both before then and since, the mushroom-growing industry has seen many important changes, specializations and refinements in its practices. Indeed, "Changes in practice are occurring so rapidly that no account can be reasonably up to date for very long". It is in the light of the many recent and contemporary changes and innovations that the present guide has been written under the chairmanship of Mr. F. W. Toovey, director of the Glasshouse Crops Research Institute. The essential facts and procedures are well and fully set out, and are illustrated by some excellent photographs.

Botanical Garden in Tashkent

A NEW botanical garden was founded in 1950 in Tashkent's northern suburb. Of the total projected area of 80 hectares, 40 hectares are now occupied by a dendro park containing 1,300 species of trees and shrubs belonging to the local, European, Far Eastern, Chinese and North American flora. The dendro park contains several artificial ponds and it is traversed by 12 km. of roads. As described by F. N. Rusanov (*Priroda*, 7, 61; 1959) the dendro park contains many well-acclimatized, rare and valuable plants and hybrids. The park is at the service of the whole of Central Asia.

Submarine Oil Drilling

According to M. K. Kalinko (*Priroda*, 11, 25; 1959), the first attempt to extract petroleum from rocks underlying the bottom of the Caspian Sea were made in the region near Baku in the beginning of the nineteenth century. The workings, protected by two wooden frames lowered at the bottom of the sea, were destroyed by a storm in 1825. In 1910, in an attempt to infill a shallow bay, petroleum was discovered, which led to drilling in the region; but planned survey and undersea petroleum extraction began only in 1935. At the present time, undersea extraction is carried out on a large scale in eight separate areas in the region of Baku, and in 1958 this work extended to the eastern part of the Caspian Sea. Outside Russia, the submarine extraction of petroleum began in Japan in 1888, but it reached its maximum development in the Gulf of Mexico, California, Venezuela, and the Persian Gulf. Special surveying and prospecting methods are now employed for the investigation of the possible offshore petroleum provinces or 'aquatories'. The author of this article gives a general survey of the world's offshore petroliferous provinces, which in his opinion may yield more petroleum than the overland provinces.

Use of Gamma-Radiation Sources for the Sterilization of Pharmaceutical Products

A report issued by the Association of the British Pharmaceutical Industry (B.M.A. House, Tavistock Square, London, W.C.1. Pp. 17) describes the findings of a working party set up by a number of pharmaceutical firms and other interested bodies, including the Atomic Energy Research Establishment, to investigate whether pharmaceutical products and containers could be usefully sterilized on a commercial scale by using gamma-radiation. The results of the tests are summarized in a convenient form in this report. A dose of $2{\cdot}5 \times 10^6$ rads (from cobalt-60) appeared to be adequate to achieve sterility, but it caused changes in many of the substances tested, and in many cases rendered them unsuitable for use. It is suggested that the method may be usefully applied in particular cases, but the results, in general, are not considered sufficiently encouraging to justify continuation of the present investigation on a group basis.

Molecular and Crystal Structure Models

A bibliography on molecular and crystal structure models used extensively in research and as teaching aids has recently been published (U.S. Department of Commerce: National Bureau of Standards. Monograph No. 14: Bibliography on Molecular and Crystal Structure Models. By Deane K. Smith. Pp. iv+7. Washington, D.C.: Government Printing Office, 1960. 15 cents). The references are grouped into four broad classifications—models in general, static models, dynamic models, and constructional devices—and the static model classification is, in addition, subdivided into closed molecular (Stuart type), closed packing, open molecular, open crystal structure, open with parallel rods, polyhedral, and miscellaneous models. The list of references is preceded by brief explanations of the various types of model which indicate the more significant articles relating to them.

Hæmatology of the Central Australian Aborigine

Various hæmatological observations on central Australian aborigines have been made by J. R. Casey-Smith, of the Department of Anatomy, University of Adelaide (*Austral. J. Exp. Biol. and Med. Sci.*). One group contained some thirty nomadic males living under primitive conditions for most of the year. The second group consisted of about twenty males and fifteen females living under urban conditions, on an almost European diet. The nomadic group's diet had a high iron content. The hæmoglobin-levels of a control group of Europeans in Central Australia were also measured. Hæmoglobin and hæmatocrit values of the nomads were higher than those of the 'urban' males; neither sex of the 'urban' community differed significantly from the European controls. The erythrocyte counts showed no significant difference between the two male groups. Hæmoglobin-levels of sixteen Europeans living at Alice Springs were almost the same as those of the 'urban' males. The mean corpuscular volumes and the mean corpuscular hæmoglobins of the nomads were just greater than those of the Europeans, but the 'urban' natives did not differ significantly from either the nomads or Europeans. The mean corpuscular hæmoglobin concentrations did not differ significantly between the groups or from European standards. Erythrocyte osmotic fragilities showed an increase in hæmolysis at 0·5 *N*, but otherwise were not significantly different from those of Europeans. The aborigines did not differ significantly among themselves. The erythrocyte sedimentation-rates were greater in all groups of aborigines when compared with Europeans, but the nomads' values were less than those of the urban groups.

Virus-Streak Disease of Tomatoes

The syndrome of the streak disease of tomatoes in Ontario has been shown to be double-virus in nature, resulting from the synergistic action of tobacco mosaic virus and potato virus *X* (MacNeill, B. H., and Ismen, Hikmet, *Canad. J. Bot.*, 38, 9; 1960). Expression of the disease was found to depend on both virus components of the complex, a variation in strain characteristics of either tobacco mosaic virus or potato virus *X* being reflected in the intensity of their interaction in the tomato. The extreme severity of streak in the greenhouse and field tomato crops in Ontario is associated with what appears to be a geographical strain of tobacco mosaic virus. This virus is characterized by the induction of primary local lesion in petunia without subsequent systemic invasion of that host. Air temperature profoundly affects the development of streak, symptoms being masked above the critical temperature of 26° C. This phenomenon is a true masking effect with both viruses becoming latent in the tomato host.

Excavation of La Grotte de Rochereil

It is a pleasure to direct attention to a straightforward cave excavation where the finds are of prime importance and are not dependent on a statistical or other theory which has to be demonstrated ("La Grotte de Rochereil", by P. E. Jude, *Mém.* 30, *Arch. Inst. Paléont. Humaine*. Masson et Cie., Paris).

The site is not far from Périgueux, and the cultures present are the late Magdalenian (mostly *M*6) and Azilian. The fauna indicates a very cold period during the Magdalenian occupation, succeeded by an unpleasant period of transition leading to a more temperate climate. The implements, both in flint and bone, are numerous and characteristic, and many of the bone tools are decorated. Human remains occur in each culture-level. A distribution map of Azilian finds in south-west France is given, and it would seem to rule out the theory that there was direct connexion between the Azilian of south-west France and the early Mesolithic cultures (Obanian, etc.) of Ireland and western Scotland, linked by a series of cultural sites now under the sea. Actually, Azilian sites are conspicuously absent from the coastal areas of south-west France. "La Grotte de Rochereil" is a worthy volume to add to the other *Mémoires* of the Institute of Human Palæontology; it is well illustrated.

Research on Tinplate in Australia

The Broken Hill Proprietary Company, the sole producer of tinplate in Australia, has made a grant of £6,000 per annum to support tinplate research in the Commonwealth Scientific and Industrial Research Organization. The grant will be used to support investigations at the Organization's Division of Food Preservation and Transport at Homebush, New South Wales; this is the main centre in Australia for research on tinplate packaging problems. One project to be undertaken will be a study of the reasons why certain foods sometimes cause intense corrosion or deep pitting of tinplate. Until 1957, when the Broken Hill Proprietary Company opened its new plant at Port Kembla, Australian supplies of tinplate were all imported; now, however, the Company supplies hot-dipped tinplate for the majority of the food cans manufactured in Australia, and it will be possible for research workers to trace the history of the plate right back to the steel ingot; this will be very useful in corrosion studies.

Physiological Role of Fast Transfer Reactions

To inquire into the possible physiological role of fast transfer reactions in eliciting specific interactions in ordered macromolecular structures, a series of seminar lectures was held at the Massachusetts Institute of Technology during the spring term of 1960. Included were lectures on electron and energy transfer mechanisms and on current concepts of proton transport mechanisms of immediate biophysical and biochemical significance. Properties of water and ice crucial for proton transfer were reviewed. Six lectures of a more general nature dealt with aspects of macromolecular interaction properties. Abstracts of these lectures and pertinent references are available free of charge. Requests should be sent to Prof. Francis O. Schmitt, Department of Biology, Massachusetts Institute of Technology, Cambridge 39, Mass.

Foundation of Plant Geography

Students of the history of botany will note with interest and appreciation the production of a facsimile edition of the essay by Alexander von Humboldt and A. Bonpland on the "Géographie des Plantes", dated Paris 1805, but believed not to have been issued until two years later. This work, the original of which is not readily accessible, has been issued by the Society for the Bibliography of Natural History, as Sherborn Fund Facsimile, No. 1 (c/o British Museum (Natural History), London, S.W.7; price 10*s*.). Humboldt is generally regarded as the founder of modern plant geography, and here, in the boldly printed pages of his "Essai", some of his original comprehensive observations and ideas are set out.

Society for Applied Bacteriology: Officers

At the annual meeting of the Society for Applied Bacteriology, the following officers were elected: *Hon. President*, Mr. G. Sykes; *Hon. Secretary*, Dr. Ella M. Barnes; *Hon. Treasurer*, Mr. G. Elis Jones; *Hon. Editors*, Dr. S. E. Jacobs and Dr. D. J. Jayne-Williams; *Hon. Publications Manager*, Mr. A. H. Walters; *Hon. Advertising Manager*, Mr. E. J. Mann; *Members of Committee*, Dr. Eve Billing, Mr. N. J. Butler, Mr. B. M. Gibbs, Dr. N. D. Harris, Dr. J. R. Norris, Dr. Jane Meiklejohn, Dr. A. M. Paton, Dr. Joan Taylor, Dr. G. C. Ware; (*ex-officio*), Dr. C. A. E. Briggs, Mr. D. A. McKenzie.

The Animal Health Trust: Educational Awards

The following Animal Health Trust educational awards for 1960–61 have been announced: *Wellcome Fellowships*: R. B. Taylor (University of Liverpool), to undertake research into tolerance and the development of immunity in animals at the Department of Zoology, Cambridge; I. J. F. Stobo (University of Edinburgh), to study problems of the early weaned calf, with particular reference to nutrition and the development of the digestive organs, at the National Institute for Research in Dairying, Shinfield, Reading. *Research Training Scholarships*: R.A.S.E. Research Training Scholarship to R. M. Connan, of the Royal Veterinary College, to study general pathology at the Department of Animal Pathology, Cambridge; A. D. Allen Memorial Scholarship to G. W. Osbaldiston, of the University of Queensland, to study animal nutrition and general husbandry at Cambridge; Dr. W. N. M. Foster, of the University of Edinburgh, to undertake research into the problem of 'quidding' in Border Leicester sheep and to complete his veterinary degree at the Royal (Dick) School of Veterinary Studies, Edinburgh; R. M. Griffin, of the Federal Department of Veterinary Research, Northern Nigeria, to continue investigations into contagious bovine pleuropneumonia and to attend the course for the diploma of bacteriology at the London School of Hygiene and Tropical Medicine; I. F. H. Purchase, of the University of Pretoria, for work in the field of animal anæsthesia at Cambridge.

University News: London

Mr. G. Belyavin, senior lecturer at University College Hospital Medical School, has been appointed to the University chair of bacteriology tenable at that School.

Mr. E. J. Ambrose, senior lecturer at the Institute of Cancer Research: Royal Cancer Hospital, has been appointed to the University readership in physical chemistry tenable at that Institute. Dr. F. A. Holton, a member of the scientific staff of the Experimental Radiopathology Research Unit of the Medical Research Council at Hammersmith Hospital, has been appointed to the University readership in veterinary biochemistry tenable at the Royal Veterinary College.

The title of reader in chemistry has been conferred on Mr. G. M. Timmis in respect of his post at the Institute of Cancer Research: Royal Cancer Hospital; and that of reader in mechanical engineering on Dr. C. R. Webb in respect of his post at Queen Mary College.

Pittsburgh

The following appointments have been announced: Dr. Theodore Holstein, to be professor of physics; Dr. Robert L. Wolke, to be associate professor of chemistry; Dr. David S. Feingold, to be assistant professor of bacteriology; and Dr. Robert Silverman, to be assistant professor of mathematics.

Announcements

Dr. Maurice Ewing, director of the Lamont Geological Observatory at Columbia University, has been awarded the John Fleming Medal of the American Institute of Geonomy and Natural Resources.

Mr. F. E. Shotton, deputy county advisory officer, Norfolk, in the National Agricultural Advisory Service, has been appointed director of Terrington and Kirton Experimental Husbandry Farms, Terrington St. Clement, King's Lynn, Norfolk, in succession to Mr. A. C. Owers, who is resigning on November 1.

Dr. W. M. Hampton is retiring this month from the position of managing director of Chance Brothers Ltd., Glass Works, Smethwick, Birmingham, after 43 years with the company. He joined the firm as a chemist in the then newly formed research laboratories, and has been successively manager of the Optical Glass Department, director of research, technical director, 1940, and managing director, 1953. Dr. Hampton will remain a member of the Chance Brothers board.

Dr. N. E. Odell, of Clare College, Cambridge, has been appointed by the South East Asia Treaty Organization to the chair of geology in the University of Peshawar, which is tenable for a year or more.

Dr. John D. Kendall has been appointed director of European research laboratories to be established by the Minnesota Mining and Manufacturing Co., Ltd. Dr. Kendall, who is a graduate of the Imperial College of Science and Technology, London, has been responsible for many years for the direction of organic chemical research at Ilford, Ltd., and is known for his work on photographic sensitizing dyes and developers.

A symposium on "Flow Measurement in Closed Conduits" will be held at the National Engineering Laboratory, East Kilbride, Glasgow, during September 27–30. Attendance is by invitation.

The first International Congress of Food Science and Technology will be held in London during September 18–21, 1962, under the presidency of Lord Rank. Further information can be obtained from Col. Francis J. Griffin, 14 Belgrave Square, London, S.W.1.

The Nutrition Society (Scottish Group) is to hold a symposium on "Food Habits in Britain" at the Institute of Physiology, University of Glasgow, on September 24. Further information can be obtained from Dr. J. Davidson, Rowett Research Institute, Bucksburn, Aberdeen.

A postgraduate course on "Recent Advances in Steroid Chemistry" is being organized by the Kingston Technical College. There will be eleven weekly evening lectures by distinguished visitors commencing on September 28. Further information can be obtained from N. Lindop, Department of Chemistry, Biology and Geology, Kingston Technical College, Fassett Road, Kingston-upon-Thames.

Prof. W. T. Astbury, professor of biomolecular physics in the University of Leeds, will deliver the ninth Procter Memorial Lecture of the Society of Leather Trades Chemists at Leeds on September 23. The annual meeting of the Society is being held in the University of Leeds during September 23 and 24.

The Institute of Physics and the Physical Society is arranging a conference on "Diamond Physics", to be held at the J. J. Thomson Physical Laboratory, University of Reading, during September 22–23. During the meeting Prof. R. V. Jones will deliver the Duddell Medal address; he will speak on "Some Developments of the Optical Lever".

An informal discussion on the "Ultracentrifugation of Biological Macromolecules", organized on behalf of the Colloid and Biophysics Committee of the Faraday Society, will be held at the Medical School, University of Birmingham, during September 14–15. Details can be obtained from Dr. D. R. Stanworth, Department of Experimental Pathology, Medical School, Birmingham 15.

A four-day course for trade union officials on "The Industrial Uses of Radioisotopes" is to be held at the United Kingdom Atomic Energy Authority's Isotope School, Wantage, Berks, during September 20–23. Provision is also being made to accommodate students. Further information can be obtained from the General Secretary, Trade Union Congress, Congress House, Great Russell Street, London, W.C.1.

The first joint symposium, under the auspices of the Internation Union of Biochemistry and the International Union of Biological Sciences, has been organized by Profs. O. Lindberg and T. W. Goodwin and will be held at the Wenner-Grens Institut, Stockholm, during September 12–17. The subject will be "Biological Structure and Function". Further information can be obtained from Prof. T. W. Goodwin, Department of Agricultural Biochemistry, University College of Wales, Aberystwyth.

A new approach to training senior scientists and technologists in administration, based on case studies, has been developed at the Northampton College of Advanced Technology, London. This serves as a basis of the advanced course on "Direction and Supervision of Scientific and Engineering Personnel", which will begin on October 12 and will consist of meetings at fortnightly intervals, for a whole day at a time, until June 7, 1961. The organizers and tutors are Mr. A. C. Leyton, Mr. Z. M. T. Tarkowski and Miss Avice V. Turnbull. Further information can be obtained from Mr. Z. M. T. Tarkowski, 703 Frobisher House, Dolphin Square, London, S.W.1.

Erratum. In the obituary notice of Prof. Max von Laue in *Nature* of August 27, p. 738, a misunderstanding led to an alteration being made in the reference to von Laue's obituary of Haber. The full quotation is: "Themistokles ist in die Geschichte eingegangen nicht als der Verbannte am Hof des Perserkonigs, sondern als der Sieger von Salamis. Haber wird in die Geschichte eingehen als der geniale Erfinder desjenigen Verfahrens, Stickstoff mit Wasserstoff zu verbinden . . ." (*Naturwiss.*, **22**, 97; 1934).

BRITISH COLONIAL TERRITORIES

"THE Colonial Territories, 1959–1960", while still providing the convenient compendium of information to such publications as "Colonial Research", is of slighter interest to the scientist and technologist than previous issues (pp. vi+147. Cmnd. 1065. London: H.M. Stationery Office, 1960. 6s. 6d. net). The section, "Research and Surveys", has been omitted and also that dealing with international relations, and information on the latter topic is now scattered through the other chapters. Recruitment to the public service in overseas territories through the Colonial Office decreased during the year: 1,083 appointments were made as against 1,335 in 1958, and of these, 250 were teachers, 48 agricultural officers, 93 engineers and 100 doctors. Vacancies at the end of the year totalled 866, compared with 964 at the end of 1958. Training courses and attachments were arranged for 2,239 officers of overseas governments, a decrease of 196. Expenditure on development and welfare schemes and on research was about £24·4 million, and the estimated cost of approved technical assistance projects in British dependent territories in 1960 under the United Nations Expanded Programme of Technical Assistance is 1·1 million dollars compared with 1·06 million dollars in 1959. Under this programme 120 experts and 20 fellowship holders were provided, of whom 71 experts and 1 fellowship holder were provided by the World Health Organization, 23 experts and 11 fellowship holders by the Food and Agriculture Organization, 9 experts and 4 fellowship holders by the Bureau of Technical Assistance, and 6 experts and 1 fellowship holder by the United Nations Educational, Scientific and Cultural Organization. On March 31 some 30 specialists from the United States were serving in the African territories, and the United Nations Special Fund has approved grants of 700,000 dollars for a survey of a multi-purpose dam site on the Niger River, 850,000 dollars for the engineering faculty of the University College of the West Indies and 250,000 dollars for a survey of siltation conditions of Demerara River, British Guiana.

The number of students at the universities and university colleges, apart from the 330 at the University College of Sierra Leone, which was not included last year, increased by 385, and of the total 213 are at the Royal University of Malta, 1,268 at the University of Hong Kong, 695 at the University College of the West Indies, 1,112 at the University College, Ibadan, and 880 at the University College of East Africa. The Royal Technical College of East Africa admitted 288 students, and there are more than 1,000 students at the Nigerian College of Arts, Science and Technology. Under the Fulbright agreement, nine American teachers were attached to schools in British Guiana, Malta, Western Nigeria, Northern Rhodesia, Uganda, Zanzibar and the West Indies, two senior American research workers were attached to university and research institutions in Kenya and Northern Rhodesia, and one scientist continued work on the preservation of wild life in Uganda. Fulbright travel grants enabled lecturers from University College, Ibadan, and the University College of East Africa, and a graduate from Kenya to visit the United States for research and lecturing, and sixteen students from Cyprus, Malta, Jamaica, Hong Kong, Kenya, Nigeria, Tanganyika and Uganda were awarded grants for one year of study in the United States. The use of the services of the Overseas Visual Aids Centre has grown rapidly.

Under medical and health services the report records a localized outbreak of 117 cases of typhoid fever in North Borneo, but otherwise the incidence of communicable disease fell, though in an outbreak of cerebro-spinal meningitis in Northern Nigeria there were 1,450 deaths. Major schemes for the complete eradication of malaria continued, and extended trials of recent drugs for treatment of leprosy continued in Nigeria, Kenya, Uganda and elsewhere. Studies of acute anterior poliomyelitis have indicated a very high degree of natural immunity among the locally born population of the Seychelles and St. Lucia. Mass campaigns against yaws using penicillin have been strikingly successful, but despite intensive and persistent attempts to maintain safe vaccination-rates, smallpox remains endemic in Africa.

SCIENCE AND EDUCATION IN BRITAIN

TWO short but interesting debates on science and education were held in the House of Commons on July 27. The first of these, arising out of a prayer to withhold assent to University Court Ordinance No. 350 (Universities of St. Andrews, Glasgow, Aberdeen and Edinburgh) governing regulations for research students and the appointment of research Fellows, related to the part of the universities of Scotland in the revival and stimulation of industrial activity. Mr. A. Woodburn, who moved the prayer, questioned whether they are doing enough and quoted opinion that neither Scottish industry nor the Scottish universities had quite come to terms with this age of science and technology. While 17 per cent of students in Scotland took a first degree in science, for science and technology the figure was only 11 per cent, and research students in science and technology were only 8 per cent of those in Great Britain, and only 10 out of 17 Department of Scientific and Industrial Research awards to advanced course students were taken up in 1960 compared with 251 out of 344 in the United Kingdom, and grants in support of special researches at Scottish universities, while amounting to £267,000, were only 7 per cent of the total for Great Britain. This latter figure was attributed to the lack of applications and proposals, and not to any restrictions on the part of the Department. Mr. Woodburn also remarked that only 2·7 per cent of research and development in private industry proceeds in Scotland, and that the Department of Scientific and Industrial Research is responsible for 81 per cent of research in shipbuilding and engineering. Some 58 per cent of engineering students in the University of Glasgow found work out of Scotland; for Edinburgh the figure was 69 per cent, and for Aberdeen 64 per cent.

Lady Tweedsmuir, who supported the Ordinance, asked for more information about university expenditure on research and on teaching. At Aberdeen in 1959–60 there were 91 full-time and 24 part-time postgraduate research students, compared with 77 and 22, respectively, in 1954–55. Research Fellows were very few, and the Scottish universities asked of this Ordinance that they should have the same facilities as English universities enjoyed to attract research workers. Mr. G. M. Thomson, who also asked for further information, questioned whether the pattern of professorships in the Scottish universities is appropriate to modern needs. He also stressed the importance of adequate finance, and suggested that more provision is required for the training of postgraduate students, better facilities for those with a technological qualification to qualify for research awards and a free flow of information between the universities, Parliament and the interested public. Sir Myer Galpern challenged some of these views, and suggested that much information is already available; he claimed that the Scottish universities already produce research students of very high calibre. The Joint Under-Secretary of State for Scotland, Mr. Niall Macpherson, intervened to point out that the Government regards the matter as one for the universities alone, and stressed its desire not to infringe their independence in matters of academic policy. Miss M. Herbison, referring to applications for grants for special researches from the Department of Scientific and Industrial Research, pointed out that of 25 in 1959–60 from Scottish universities, 13 came from the Royal College of Science and Technology, Glasgow. Dr. A. E. Thompson also supported this plea for more co-operation between the universities and the technical colleges, and for much greater facilities for exchange of staff between universities and other research institutions.

Another debate, on an adjournment, was opened by Mr. T. F. Peart, who raised specifically the responsibilities of the Minister for Science and his relation to the Ministry of Education. After stressing the importance of the contribution which British scientific man-power should make to Colonial development, Mr. Peart urged the full implementation of the De La Warr report on higher education in agriculture, stressed the need for adequate teaching of science in the teacher-training colleges and for a good supply of graduates in science from the universities who would take a teacher's diploma. He said he is concerned about the teaching of science in girls' schools and the supply of science teachers and equipment for such schools, and asked for a major debate on the place of science in our economy and the functions and responsibilities of the Minister for Science and the Minister of Education. The Parliamentary Secretary to the Minister of Education, Mr. K. Thompson, replying for the Government, welcomed the debate, but claimed that much is already being done to relieve the shortage of science teachers. He said that a very large proportion of the expansion of the teacher-training colleges would be in the numbers of teachers qualified to teach science at various levels in the schools. He agreed that we could also use part of this expanded output to provide an introduction to science in the primary as well as secondary modern and grammar schools. In the main, there are, he said, three levels of teacher-training for science courses in the training colleges: the ordinary curriculum; one providing for a main study of a science subject; and the advanced specialist course in a science subject. The number of teacher-training college students in mathematics and science has increased from 600 in 1956–57 to more than 1,100 in 1959–60, and the net increase in mathematics and science graduates in 1959 was 612. Plans for university expansion should provide an 80 per cent increase in science graduates in the period up to 1960.

ADULT EDUCATION

A HEARTWARMING tribute to the work of local enthusiasts for continued education has been paid by the Joint Committee for Adult Education of Queen's University of Belfast. In its twenty-eighth annual report it states that "it is commonplace, when adult education is discussed to-day, to lament the crusades of the founding fathers. It is even commoner to deprecate the decline of local responsibility and initiative, and the abdication of sustained and particular studies, in favour of the armchair and the printed or televised magazine. The experience of the Joint Committee and its officers is in contrast to all this".

These words, to the University Council for Adult Education, are in general borne out by the reports of other extra-mural departments*.

In spite of problems of finance, the total number of courses shows a slight increase, from 4,612 in 1957–58 to 4,741 in 1958–59. The volume of work has remained almost stationary for the past three years, but these figures mask the continued decline of tutorial classes, a trend which has gone on steadily for several years, as is shown by the figures:

1954–55	1955–56	1956–57	1957–58	1958–59
963	959	950	904	851

Its decline must cause disquiet, but it is encouraging that tutorial classes organized in collaboration with the Workers' Educational Association have shown a less-sharp fall (from 619 to 600) than others (from 285 to 241).

Television has been regarded as a serious rival to adult education, and blamed for the decline in tutorial classes. It is therefore interesting to find the University College of North Wales, Bangor, postulating the possibility that the coming of television may prove an advantage to adult education in so far as its better programmes tend to encourage "viewers to seek further enlightenment on the topics treated in them while the inferior programmes drive the more intelligent citizen to seek better pastures".

---

* Universities Council for Adult Education. Report on the Year 1958–1959. Pp. 34. (Bristol: W. E. Salt, Honorary Secretary and Treasurer, The University, 1960.)

The number of residential courses shows a 12 per cent increase over the 1957–58 figure, although, as last year's total was smaller than the 1955–56 and 1956–57 figures, the gain in part represents a recovery in lost ground. The increase is entirely in the shorter residential courses, that is, those of not more than seven days in length. At Cambridge, where Madingley Hall has been used to the full extent of its availability, the most interesting and promising developments are thought to be those in residential courses.

Table 1. TRENDS IN ADULT EDUCATION, 1953–59

	1953–54	1954–55	1955–56	1956–57	1957–58	1958–59
Religion	180	211	222	252	251	270
Biology	245	258	252	274	274	294
Language and literature	636	685	675	681	689	719
Visual arts	—	—	—	370	383	421

Table 1 confirms certain trends which have become discernible in adult education during the past few years. The reasons for these changes are not clear, but speculation indicates that the hydrogen bomb and affairs in Africa throw up moral problems that turn the minds of some men and women to a deeper study of the religious beliefs which have been a formative force in Western civilization. The Dead Sea scrolls combine the excitement of archæological discovery with the higher criticism. The contraction of the world prompts the serious and sympathetic study of religions that become less strange the more they are understood. It is possible that courses with a religious content satisfy some of the interests that previously found an outlet in the study of philosophy and of international affairs. The upward trend of courses in the visual arts has become clearly discernible.

There has been a marked improvement during the past few years in much of the accommodation in which extra-mural work takes place. Gradually, it is being recognized that adult education needs, and deserves, accommodation of its own, and the number of adult education centres steadily increases, some provided by universities, some by local education authorities, and some by voluntary organizations. The University of Leeds has established non-residential centres for extra-mural work at Bradford and Middlesbrough, each under the oversight of a member of the Department's teaching staff acting as warden. The University of Liverpool has made the Royal Institution available as a centre for extra-mural courses.

The tendency towards meeting the needs of special groups is discernible in the class programme of extra-mural departments, as well as in residential courses. The Edinburgh report contains an apposite comment on this development: "There is a considerable demand for classes of a semi-vocational nature but in this field extra-mural educational activities are limited to work for which the university is particularly suited. Classes in Agricultural Law, Income Tax, Estate Duty and Company Administration, Industrial Law, Advanced Management, Effective Reading and Programming for Digital Computers indicate a change in the pattern of extra-mural work but they should be regarded as a widening of the scope of such work rather than a change of emphasis". Oxford has embarked on a scheme, with support from the Leverhulme Trust, for the preparation of relevant and conveniently accessible teaching material—hitherto lacking—in trade union education. Special studies are being undertaken in three industries in Oxford's area—coal mining, engineering, and road passenger transport—in the hope that the resulting material will be suitable for publication for use by classes throughout Great Britain.

THE MELLON INSTITUTE

THE annual report on research, by the chairman, Mr. M. B. Ridgway, to the Board of Trustees of the Mellon Institute for the year ended February 29, besides a review of activities and of independent research during the year, of the research services and research for public welfare, includes a list of research personnel and of publications of Mellon Institute members during the year*. Fundamental research now represents about 20 per cent of the Institute's research effort, and two new fundamental research groups, one in continuum mechanics and visco-elasticity and the other in theoretical chemistry, began activity during the year. Among the continuing groups, expansion was chiefly in polymer science, metal physics and radiation, while in the applied research groups those in the science of metals also expanded. The independent research staff increased from 56 to 77, and 16 groups are now engaged in fundamental research. At the end of the year there were 42 industrially sponsored fellowships and projects in applied science with a staff of 210. Research services employed 26 professional scientists, and exclusive of part-time employees the total staff of the Institute was 536; expenditure for fundamental and applied research during the year was 5,781,000 dollars.

In studies on enzymatic hydroxylation a third hydroxylating co-factor has now been isolated from cultures of *Mycobacterium* 607 which reverses the inhibition of hydroxylation caused by tetracycline and also that caused by 2:4-dinitrophenol. In inorganic chemistry osmium and ruthenium complexes were characterized and investigations started on the co-ordination complexes of rhenium, iridium and platinum, while many basic compounds have been prepared in polycrystalline form by homogeneous hydrolysis in the range 170–300° C. Investigations of the structure and properties of macromolecules continued, and the stress–strain curves for a wide variety of cross-linked polymers revealed substantial agreement with the theoretically predicted form when measurements were made under conditions permitting reasonable approach to equilibrium. In metal physics an improved method was developed for evaluating the lattice spacings of gold-based and silver-based alloys, and the study of strain-induced transformation in silver–zinc alloys in the β-phase range was completed, using metallographic and X-ray procedures. In organic chemistry, triphenyl-, trimethyl- and tributyl-phosphonium-fluorenylides, as well as triphenylarsoniumfluorenylide and dimethylsulphoniumfluorenylide were prepared and their properties and reactions studied, as well as the protonation of weak bases by sulphonic acid type of ion-exchange, while in physical chemistry exciton theory was applied to the vibrational spectra of molecular crystals, and the atomic co-ordinates and anisotropic thermal vibration parameters of α-quartz at room temperatures were precisely determined with accurate X-ray intensities from an almost ideally imperfect single crystal.

---

* Mellon Institute Research 1959–1960: The Annual Report of the Chairman, Matthew B. Ridgway, to the Board of Trustees of the Institute for the Fiscal Year ended February 29, 1960. Pp. vi+88. (Pittsburgh: Mellon Institute, 1960.)

Other work on the science of metals included the study of the solubility of nitrogen in the iron–manganese system, basic high-temperature strengthening mechanisms for ferrous alloys, the evolution of new ultra-high strength steels with a total alloy content not exceeding 9 per cent and the research and development of solid state devices for power utilization. Research for public welfare ranged over such fields as air purification, the protection of artists' materials from discoloration and deterioration, treatment of effluents, industrial hygiene, abatement of water pollution and examination of the toxicology of new organic chemicals. Among general research fellowships and projects may be mentioned those concerned with the development of new solid catalysts and the improvement of existing granular absorbents from bone products, the fundamental properties of porcelain-enamel glasses, computer components, special films and film-forming starch products, determination of the critical requirements for the ideal industrial felt fabric, the synthesis of new insecticides of the methylenedioxyphenyl group for use in combination with pyrethrins, the synthesis and evaluation of textile resins and softeners and the synthesis of lubricants and hydraulic fluids with improved stability to oxidation and heat. Chemical work on the genesis of petroleum continued, thermal degradation studies of the polyene pigments were initiated and work continued on the preparation and properties of novel types of silicone polymers and co-polymers, on organo-functional silicone chemistry and studies of the structure and properties of organosilicone compounds.

THE NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

In an official Government publication of a generation ago dairy research was defined as "the study by scientific methods of the dairy industry and its products, and of the fundamental principles underlying its operations". It is now almost fifty years since the National Institute for Research in Dairying was founded at Reading, and its annual report for 1959* illustrates how thoroughly that conception of the all-embracing nature of dairy research has been developed at what has undoubtedly become one of the most famous research stations in the world.

The dairy industry begins at the farm with the management of grassland and the production of feeding-stuffs for milk production, with the breeding, management, nutrition and health of the dairy stock and with the actual production and handling of the milk itself. When the milk leaves the farm, other important sections of the dairy industry are concerned with its transport and distribution, its manufacture into dairy products and with the engineering and machinery required for these purposes ; of course, the dairy industry in all its branches is concerned that milk and the products made from it should be bacteriologically sound and of the highest possible nutritive value. In all this there is immense scope for scientific research, both fundamental and applied, and at the National Institute, where there is now a total staff of about 370, of whom 114 are scientific or experimental officers : the three principal departments which deal mainly with milk production problems are the Dairy Husbandry, Feeding and Metabolism and Physiology Departments. The remaining seven principal Departments — Bacteriology, Chemical Microbiology, Chemistry, Physics, Radiobiochemistry, Nutrition and Engineering—are concerned partly with milk production and partly with the quality and handling of milk and with the nature and properties of milk products and the scientific principles underlying their manufacture. The main part of the report, occupying about 100 pages, gives an account of the work of each of these ten Departments and also of the Statistics Section and the Experimental Dairy, but for those who prefer to see at a glance what an important contribution to knowledge the Institute makes even in the relatively short period covered by this report, a brief outline is given of some of the most recent research findings. This outline occupies only three pages, but it includes some 23 separate items ranging from subjects such as haymaking with a forage harvester, rumen development in calves and work on teat-cup liners of various different designs, to the part played by certain hormones in lactation, the ultra-high-temperature sterilization of milk and problems associated with the manufacture of Cheddar cheese.

The research of a basic nature includes work in which radioactive isotopes have been used to investigate some of the enzyme mechanisms in the mammary gland mitochondria and also to obtain information on the proportions in which various lower fatty acids are formed from hemicellulose and α-cellulose in the rumen. It includes also the establishment of an infusion technique whereby solutions of lower fatty acids can be introduced into the rumen continuously for long periods and relationships worked out between the amounts and nature of the fatty acids in the rumen and the yield and composition of the milk. In research of a more applied nature, studies have been made of matters such as the circulation-cleaning of pipe-line recorder milking equipment and the development of a rapid method of determining lactose in separated milk and condensed whey which depends on infra-red absorption. Studies have been made also of the effect of mastitis on the yield and composition of milk.

---

* University of Reading. Report of the National Institute for Research in Dairying, 1959. Pp. 154. (Shinfield, Reading: National Institute for Research in Dairying, The University, Reading, 1960.) 4s.

Towards the end of the report a list is given of nearly 200 papers published by members of the staff during October 1958–September 1959. In the notes which deal with staff matters, reference is made to the fact that in 1959 Prof. R. G. Baskett took up his appointment as director of the Institute, and a brief but well-deserved reference is made to the retirement of Dr. A. T. R. Mattick, who has served the Institute and the dairy industry with distinction for some forty years.

J. A. B. SMITH

NEW AMERICAN OBSERVATORIES

IN order to make astronomical research facilities available to those many universities which cannot themselves afford the necessary expensive equipment, the National Science Foundation is providing financial support for the construction of two major observatories, the National Radio Astronomy Observatory at Green Bank, and the Kitt Peak National Observatory near Tucson, Arizona.

Green Bank, in Deer Creek Valley, West Virginia, is at an elevation of 2,600 ft., ringed by mountains rising to 4,000 ft., effectively shielding the site from man-made radio noise. The climate is mild, and there are no high winds which would make operation of a large radio telescope difficult. An 85-ft. telescope was brought into operation in October 1958, and since then construction of a 140-ft. telescope, laboratories, residences and workshops has been under way. The reflecting surface of the 85-ft. telescope, made of aluminium sheet, is accurate to ¼ in. and operates down to wave-lengths as short as 3·5 cm., at which the telescope beam width is 7 min. of arc. Both telescopes are on equatorial mountings. The moving mass of the 140-ft. telescope will exceed 2,000 tons, yet it will be capable of being steered with a precision of a fraction of a minute of arc and will also have a surface accurate to ¼ in. In addition to other small telescopes there is a horn 120 ft. long; the energy which this collects can be calculated from its dimensions and it is fixed so that it can observe the radio source in Cassiopeia each day, thus providing a standard calibration source in the sky available to many radio astronomers. A variety of receivers covering the wave-length range of 3·75–75 cm. is available, and three separate receivers working on different wave-lengths can be used simultaneously on the 85-ft. telescope. Besides being displayed on the chart of a pen recorder, the receiver outputs are digitized together with telescope position and time. Extensive use of digital computer techniques is already being made in analysing and reducing the observations.

Among the first observations made at the National Radio Astronomy Observatory were a study of the radio emissions from Jupiter and a survey of the central regions of the Galaxy at a wave-length of 3·75 cm. showing remarkable detailed structure. In addition, studies are being made of planetary nebulæ and ionized hydrogen clouds, supernovæ remnants and peculiar galaxies.

Three years were devoted to testing the seeing conditions at a number of places before Kitt Peak was chosen as the site for the National Observatory in March 1958. An agreement with the Papagos Indians (who call astronomers "the People with the Long Eyes") leased 200 acres to the Observatory, and construction of an 80-in. telescope is under way. This will have a coudé focus as well as prime and cassegrain, and will be equipped for direct photography, photoelectric photometry and spectroscopy. There is also a 36-in. telescope with a cassegrain spectrograph, and two 16-in. telescopes which will be used for bright star work. The University of Arizona is also moving a 36-in. telescope to the site.

On Kitt Peak there will be an optical workshop with some of the best testing facilities in the world, together with an office and laboratory building, dining hall and dormitory, houses and a shop. But the headquarters are adjacent to the University of Arizona in Tucson, and the staff and visiting astronomers will spend most of their time in the research offices there.

It has recently been decided to build a large solar telescope on Kitt Peak. The heliostat will have an 80-in. plane mirror feeding a 60-in., 300-ft. focal length concave mirror at the bottom of a tunnel 500 ft. long. The image of the Sun, 34 in. in diameter, will be reflected on to the slit of a large vacuum spectrograph. The outside of the building will be maintained at ambient temperature to prevent disturbing convection currents.

The National Observatory and the National Radio Astronomy Observatory will be valuable additions to the research facilities of universities which could not, alone, have provided them.

V. C. REDDISH

BIOLOGICAL EFFECTS OF EXPOSURE TO INTENSE RADIATION

A UNIQUE and important experiment to determine the biological effects of acute and high-level radiation exposure has recently been completed under the auspices of the International Atomic Energy Agency at the Boris Kidrich Institute at Vinca, near Belgrade, Yugoslavia. Details of the experiment were given at a press conference held at Vinca on April 27 by the international team of scientists responsible for its organization and execution, and a brief report of the experiment and the conference is published in the *International Atomic Energy Agency Bulletin*, 2, No. 3, 3 (July 1960).

It will be recalled that on October 15, 1958, during an accident to the nuclear reactor *RB* at the Institute, six persons in the immediate vicinity of the unshielded reactor were subjected to high doses of neutron- and gamma-radiation, and two others, farther away, received radiation doses in excess of the permissible level. After first-aid treatment at the Institute, they were transferred to the Centre for Professional Diseases in Belgrade. The six heavily irradiated patients were flown the following day to the Curie Hospital in Paris to receive special treatment by Dr. H. Jammet. One of the patients was cured by conventional treatment, including blood transfusions; but the other five, who had had blood-forming tissues in their bone marrow destroyed by the radiation, were given treatment involving the grafting of healthy bone marrow obtained from donors matched as closely as possible with the patients by detailed blood tests. This method of treatment had been tried before on an experimental basis but had not proved particularly successful. One of the five, presumably the one who had received the highest radiation dose, died before the treatment could take effect. The four others were gradually but successfully cured. A full report of the treatment has not yet been published. The success, however, represents a landmark in medical history and will intensify research in this field.

It was recognized that if the effects produced on the irradiated persons could be related to the exact doses of radiation they had received, valuable knowledge about the biological consequences of acute and high-level radiation exposure on a quantitative basis would be obtained. Although the Institute estimated that the irradiated persons received a total average whole-body dose of 683 rems of neutron- and gamma-radiation, these were not precise enough data, and accordingly the director-general of the International Atomic Energy Agency suggested to the Yugoslav authorities that a dosimetry experiment be conducted by an international team of scientists at Vinca. A formal agreement between the Agency and the Federal Nuclear Energy Commission of Yugoslavia was concluded on February 2, 1960, under which the Agency assumed responsibility for organizing and carrying out the experiment. Yugoslavia agreed to place the reactor and the laboratory at Vinca at the disposal of the Agency and to provide personnel, instruments and services. Experts from Saclay re-designed the control equipment of the reactor and were responsible for the reactor start-up and operation. The 6·5 tons of heavy water needed as moderator were provided free of charge by the U.K. Atomic Energy Authority and arrived at Vinca at the end of March. Twelve French experts, led by J. Weill and J. Furret, arrived with their special equipment from Saclay at the beginning of April, and an American team of seven health physicists from the Oak Ridge National Laboratory, together with their highly specialized equipment, including four 'phantoms' or plastic dummies of men filled with a salt solution, reached Vinca soon afterwards. The reactor first became critical on April 20. On April 22 it was operated at a power of 1 kW. and on April 25 at 5 kW. Simultaneous measurements of the neutron- and gamma-doses were made at points where the persons in the accident in October 1958 were located. The energy distribution of the radiation at these points was investigated, particularly the ratio of the various components.

At the press conference at Vinca, the scientists who had taken part in the experiment, and Dr. Jammet, were present. In response to questions, Dr. G. S. Hurst, of the American team, stated that there was one accident in the United States (that at Oak Ridge in June 1958) in which investigations comparable to those at Vinca were possible. It was not necessary to reconstruct the exact conditions of the incident of October 1958 for the dosimetry experiment, because the techniques of dosimetry did not depend on it—in any event it would have been impossible to do so because of certain unknown factors. It was, however, important to ensure that the configuration of the reactor room was exactly the same as during the accident.

Dr. Jammet explained during the press conference that not all the Yugoslav patients had received the same medical treatment, nor had the results been identical. The Curie Hospital had no fixed programme of treatment of radiation injury. There were always some unknown factors in specific cases and the problem was to make the treatment fit the specific needs of the case. Nevertheless, the experiment at Vinca was "another stone in the edifice of our research in the medical field".

AVIATION HYGIENE AND SANITATION

GENERAL provisions in the International Sanitary Regulations which were adopted by the Fourth World Health Assembly in 1951 require health administrations *inter alia* to ensure so far as is practicable that airports in their territories have at their disposal sufficient organization and equipment for the application of the regulations and are provided with supplies of pure drinking water and effective systems for the removal and safe disposal of excrement, refuse, waste water, condemned food, and other matter dangerous to health. Certain airports (designated as sanitary airports) should also be equipped with an organized medical service and facilities to combat infection. There are no specific provisions, however, on such matters as how pure drinking-water is to be supplied or an effective waste-disposal system organized, health administrations being left to make their own arrangements (*WHO Chronicle*, 14, No. 6; June 1960).

The Assembly outlined several measures that should be taken, in conjunction with the International Civil Aviation Organization, to assist Member States to introduce high standards of hygiene and sanitation. Among them was the preparation of a guide to hygiene and sanitation in the operation of airports open to international traffic. This guide was prepared by a World Health Organization Committee on Hygiene and Sanitation in Aviation. It makes specific recommendations on water, food, and waste. All water for drinking and other personal use by crews and passengers, whether in the air or on the ground, should be free from chemical substances and micro-organisms that might cause illness in any form, and should not only be safe but also attractive, lacking turbidity, colour and disagreeable taste or odour. Preferably, it should come from well-operated public supply systems conforming with acceptable standards. Samples should be taken at least once weekly from representative points, and the results of bacteriological analysis reported to the airport health and operating authorities and used to determine whether the airport water meets the bacteriological standard, and, if not, what corrective measures are required. The water supply should be inspected by a competent sanitary engineer at least once a year and whenever changes are made in the system that might affect the quality of the water.

If water must be drawn from a supply of inferior or unknown quality for use by crews or passengers, it should be given sufficient treatment to destroy cysts of *Entamoeba hystolytica* and the virus of infectious hepatitis; all the other disease organisms generally found in contaminated water will be destroyed by this treatment.

Food should be of good sanitary quality, placed in refrigerators as necessary, and kept scrupulously clean. All meat and fish should be thoroughly cooked before serving. In tropical countries infection with *Ascaris* is widespread, so that raw foods such as green salads and chopped raw vegetables should be avoided. All food should be carefully handled and protected from contamination by insects and other animals, soiled hands, and dirty surfaces. To prevent chemical poisoning, vessels and utensils containing such elements as cadmium and lead should be avoided, the strictest precautions observed regarding the use of poisons around food areas, and only food of the highest quality purchased. Because of the special hazards of foods like cream, milk and milk products, cracked eggs (especially duck's), 'shellfish', gravies and meat salads and dressings, preference should be given to plain, simple foods requiring the minimum of handling. Raw oysters and other shellfish should not be used unless it is certain that they are fresh, uncontaminated, and come from clean areas. Milk and milk products should be sterilized and kept in bottles; and the opened bottles should remain in refrigerators.

Special cleansing and germicidal treatment should be given to dishes and utensils before use.

The guide contains a detailed description of the handling and disposal of toilet wastes, sewage, air-sickness containers, and refuse, at airports and on the aircraft. Particular care should be taken to avoid spillage or open exposure, since this leads to fly and rat infestations. If practicable, the final disposal of garbage should be at a point remote from the airport; if not, it can be burned, buried, or ground and discharged into a sewer; open pits or dumps are unsatisfactory because of flies and rats. On aircraft, the provision of watertight receptables, easily cleanable floorings, soil-cans, tanks and wash-basins is important.

Rooms used by crews and passengers in transit at international airports should be effectively mosquito-proofed in areas where mosquitoes and flies are prevalent. Every day, any mosquitoes that may have gained entrance should be destroyed. Walls and ceilings, particularly in sleeping quarters, should be sprayed regularly with residual insecticide, in accordance with the recommendations of the WHO Expert Committee on Insecticides.

To carry out this work, airports must have adequate staff, equipment and premises. The adequacy and efficiency of ground installations are of interest and concern to many groups; to increase efficiency and co-operation, committees, such as national and local facilitation committees, should review procedures and practices and study possible improvements.

CENTENARY CELEBRATIONS OF W. M. BAYLISS AND J. S. HALDANE IN MOSCOW

A JOINT meeting of the U.S.S.R.–Great Britain Society and the Moscow Physiological Society was recently held at the Friendship House in Moscow. The meeting was devoted to the centenary of the births of W. M. Bayliss and J. S. Haldane.

The meeting was opened by Prof. V. Parin, president of the Physiological Society. Prof. K. Koshtoyants, a prominent Soviet physiologist and head of the Department of Physiology of the Moscow State University, discussed the life and research work of Prof. Bayliss. "Bayliss's name is one of the brightest in the history of world physiology", he said. Among other things, Prof. Koshtoyants said that soon after the Civil War a State Publishing House was set up in the Soviet Union. It planned the publication of a number of major works of world science, and one of the first in the list of these works was Bayliss's famous book "Principles of General Physiology". In 1927, Russian translations of two monographs by Bayliss were published. Prof. Koshtoyants went on to speak of the profound mutual interest in, and respect for, each other of Bayliss and the equally great Russian physiologist Ivan Pavlov. It so happened that Pavlov in Russia and Bayliss and Starling in Britain did parallel research on the regulation of the activity of the pancreas, but came to opposite conclusions. According to Pavlov, the gland produced its secretion as a result of nervous signals, whereas according to Bayliss the gland was made to function by an active chemical agent contained in the blood. A thorough joint investigation of the experiments showed that the Russian and the British physiologists were both right, and as a result a comprehensive modern conception of the regulation of pancreatic secretion was formed.

Prof. L. Shik then spoke of the research work done by J. S. Haldane. As a result of Haldane's researches, he said, basic conceptions were formed of the physiology of respiration. Haldane's experiments were distinguished for their remarkable outward simplicity, which was actually the result of a good deal of thought and precise preliminary calculations. Unlike many representatives of the so-called 'pure science', Haldane was interested in the problems of applied physiology, and his research on the physiology of divers and airmen provided scientific grounds for modern practical measures ensuring man's safety in the conditions of changing barometric pressure. Many of his experiments, some of which were quite dangerous, he conducted on himself. No wonder that when the well-known Russian physiologist, A. Samoilov, urged young research workers to investigate directly the human organism, he always referred to Haldane's successful experiments.

Some of the members of the U.S.S.R.–Britain Society prepared for the jubilee meeting an exhibit with the portraits of Bayliss and Haldane and a display of Russian translations of their books.

D. A. SAKHAROV

IS HYPERCONJUGATION NECESSARY?

MULLIKEN, Reike and Brown[1] proposed a new type of conjugation, 'hyperconjugation', based on the fact that the heat of hydrogenation of an olefin is appreciably decreased by the presence of alkyl substituents on the unsaturated carbon atom. A necessary effect of hyperconjugation would be to change the lengths of the C—H bond in the alkyl group and the C—C bond adjacent to a double or triple bond. The C—Me distance in toluene[2] is 1·51 Å. and in methyl acetylene and acetonitrile[3] it is 1·46 Å., compared with the normal C—C distance of 1·54 Å. in ethane. It was pointed out that part of these bond shortenings was due to the change in the atomic radius from tetrahedral to trigonal or digonal carbon and about one-half of the observed shortening was due to hyperconjugation[4].

Hyperconjugation was considered to be responsible for the dipole moment of alkyl benzenes. The ionization potentials of methylated ethylenes[4,5] and the absorption spectra[5,6] were also given as evidence for hyperconjugation. The view that C—H hyperconjugation is the predominant mode of electron release by alkyl substituents when attached to an electron-demanding system was originally proposed by Baker and Nathan as an explanation of certain rate and equilibrium data. The Baker–Nathan effect was in the order Me > Et > *i*-Pr > *t*-Bu, which is exactly the reverse of what one would expect if the electron release were by the inductive mechanism.

Although a great deal of physical and chemical evidence has been accumulated in support of the idea of hyperconjugation, recently there have been a number of observations which cannot be explained in a simple fashion by hyperconjugation, and the situation has become controversial.

Recent molecular structure investigations[6,7] in several laboratories, on derivatives of acetonitrile and methyl acetylene, have conclusively shown that the length of a carbon–carbon single bond adjacent to a triple bond (that is, a bond between sp and sp^3 carbon atoms) is always close to 1·46 Å., independent of the substituents on the sp^3 carbon. So it is concluded that the shortenings in the C—C bonds between sp and sp^3 carbon atoms (0·08 Å.) or sp^2 and sp^3 carbon atoms (0·04 Å.) may not result from any kind of conjugation, and that it is likely that these bond contractions are entirely due to the changes in the covalent radius of carbon with hybridization. The bond-lengths in relation to hyperconjugation have been discussed in fair detail by Sutton[8]. The evidence for hyperconjugation from calorimetric data is no longer valid, since the change in the C—C bond energies with bond-lengths (that is, with hybridization) was not taken into account in these calculations. So the effects attributed to hyperconjugation of the alkyl groups may equally be due to the introduction of a stronger C—C bond. In general, the stabilization of an unsaturated system by alkyl substitution has been found to be essentially independent of the nature of the alkyl group and cannot be accounted for in terms of steric effects[9].

The evidence for hyperconjugation from dipole moment data also needs to be re-interpreted. Since the electronegativity of an sp or sp^2 carbon is different from that of an sp^3 carbon, the resulting bonds (between any two differently hybridized carbon atoms) should have different polarities. In fact, Petro[10] has reported excellent agreement between the observed and calculated dipole moments of C—C bonds between two differently hybridized carbon atoms. He concludes that hyperconjugation structures do not explain the non-zero dipole moment of toluene. Recently, Brown[11] has studied the dipole moments of alkyl benzenes and the results are not conclusive.

The earlier evidence for hyperconjugation on the basis of ionization potentials and absorption spectra was not unambiguous because these deal with both the electronic ground-states and the excited states of molecules. The ionization potentials of the alkyl groups are actually found to be in the inductive order[12]. However, a simple molecular orbital treatment by Streitwieser and Nair[13] seems to indicate that the methyl group can be treated as a 'heteroatom' donating two electrons to the π-system. The evidence from absorption spectra has met with a number of objections[14–16]. An explanation based on steric hindrance to solvation of the electron-deficient sites in the vicinity of the alkyl substituent has been suggested.

In general, it may be said that the effect of alkyl groups on the near ultra-violet absorption spectra of aromatic compounds is not consistent. A recent study of the $n \rightarrow \pi^*$ transitions of aliphatic ketones and nitro compounds in different types of solvents by Rao *et al.*[17] seems to show the predominant role of resonance interaction of the alkyl groups in the excited states of these molecules. An earlier investigation by Rao, Goldman and Lurie[18] of the infra-red carbonyl frequencies in aliphatic ketones had indicated that mainly inductive effects were important in the ground-states of these molecules.

The chemical evidence for hyperconjugation has been a subject of controversy. The Baker–Nathan order Me > Et > *i*-Pr > *t*-Bu, has been found in a number of reactions and has been explained in terms of the C—H hyperconjugation[19]. The importance of C—C hyperconjugation in the *t*-butyl group has also been pointed out[20]. The relative importance of C—H and C—C hyperconjugation in aliphatic and aromatic series has been evaluated by the application of the linear inductive energy relationship[21,22]. McCaulay and Lien[23] have shown that C—H hyperconjugation must be an important mode of electron release in the methyl-substituted aromatic cations. De la Mare[24] has discussed the possibility of OH and NH hyperconjugation. Shiner[25], Lewis[26] and Taft and co-workers[27] have shown that hyperconjugation is one of the important sources of secondary isotope effects. Shiner[25] considers three possible effects on hyperconjugation: steric, substituent and solvent effects. Brown[28] has recently discussed the relative importance of the dispersion and induction forces in alkyl benzenes. Berliner[19] is of the opinion that although the effect of the alkyl groups in individual reactions can be interpreted in different ways (based on solvent or steric or inductive effects), hyperconjugation appears to be the most satisfactory general explanation for the behaviour of remote alkyl groups on the benzene ring where the Baker–Nathan order is observed.

The information from chemical reactivity regarding the possible role of hyperconjugation is not consistent, and does not distinguish such a contribution in the ground-state from that in the transition state of the molecule. Further, there is no clear evidence for any marked degree of hyperconjugation from physical measurements on the ground-states of molecules. These arguments have been forcefully expressed by Dewar and Schmeising[29], who have developed a new method for calculating bond-lengths and resonance energies for conjugated systems taking the σ-bond compression into consideration. They argue that if the π-electron resonance is unimportant in ordinary conjugation (as in the case of butadiene), it should be much more so in hyperconjugation. But Mulliken[30] has found it desirable explicitly to classify conjugation and hyperconjugation into two types: isovalent and sacrificial (ordinary). He also suggests further classification of isovalent conjugation and isovalent hyperconjugation into sub-types. Isovalent hyperconjugation has been suggested as being more important than ordinary hyperconjugation. The Baker–Nathan effect has been described as differential hyperconjugation. Apparently there are no theoretical reasons for expecting differences between C—C and C—H hyperconjugation[30].

In my view, the present status of hyperconjugation may be summarized as follows: while the contribution from hyperconjugation seems unimportant in the electronic ground-states of molecules, it may be prominent in the excited or the transition states of molecules.

I have benefited greatly from stimulating discussions with colleagues in Purdue University and the University of California. Many of the papers referred to as appearing in *Tetrahedron* were published in a special issue of that journal containing the proceedings of a Conference on Hyperconjugation held at Indiana University in June 1958.

C. N. R. Rao*

* Department of Inorganic and Physical Chemistry, Indian Institute of Science, Bangalore.

[1] Mulliken, R. S., Rieke, C. A., and Brown, W. G., *J. Amer. Chem. Soc.*, **63**, 41 (1941).
[2] Kiedel, F. A., and Bauer, S. H., *J. Chem. Phys.*, **25**, 1218 (1956).
[3] Zell, W., and Pfrommer, J. F., *Z. Elektrochem.*, **61**, 938 (1957).
[4] Coulson, C. A., "Valence" (Clarendon Press, Oxford, 1952).
[5] Baker, J. W., "Hyperconjugation" (Oxford Univ. Press, 1952).
[6] Matsen, F. A., Robertson, W. W., and Chuoke, R. L., *Chem. Rev.*, **41**, 273 (1947).
[7] Muller, N., and Pritchard, D. E., *J. Amer. Chem. Soc.*, **80**, 3483 (1958).
[8] Sutton, L. E., *Tetrahedron*, **5**, 118 (1959).
[9] Turner, R. B., *Tetrahedron*, **5**, 127 (1959).
[10] Petro, A. J., *J. Amer. Chem. Soc.*, **80**, 4230 (1958).
[11] Brown, T. L., *J. Amer. Chem. Soc.*, **81**, 3232 (1959).
[12] Hammond, V. J., Price, W. C., Teegan, J. P., and Walsh, A. D., *Discuss. Farad. Soc.*, **9**, 53 (1950).
[13] Streitwieser, jun., A., and Nair, P. M., *Tetrahedron*, **5**, 149 (1959).
[14] Platt, J. R., and Klevens, H. B., *Chem. Rev.*, **41**, 301 (1947).
[15] Bowden, K., and Braude, E. A., *J. Chem. Soc.*, 1068 (1952).
[16] Schubert, W. M., Craven, J. M., Minton, R. G., and Murphy, R. B., *Tetrahedron*, **5**, 194 (1959).
[17] Rao, C. N. R., *et al.*, *Tetrahedron Letters*, 2 (1960); *Canad. J. Chem.* and *Chem. Indust.* (in the press).
[18] Rao, C. N. R., Goldman, G. K., and Lurie, C., *J. Phys. Chem.*, **63**, 1311 (1959).
[19] Berliner, E., *Tetrahedron*, **5**, 202 (1959).
[20] Brown, H. C., Brady, J. D., Grayson, M., and Bonner, W. H., *J. Amer. Chem. Soc.*, **79**, 1897 (1957).
[21] Taft, jun., R. W., and Lewis, I. C., *Tetrahedron*, **5**, 210 (1959).
[22] Baker, J. W., *Tetrahedron*, **5**, 135 (1959).
[23] McCaulay, D. A., and Lien, A. P., *Tetrahedron*, **5**, 186 (1959).
[24] De la Mare, P. B. D., *Tetrahedron*, **5**, 107 (1959).
[25] Shiner, jun., V. J., *Tetrahedron*, **5**, 243 (1959).
[26] Lewis, E. S., *Tetrahedron*, **5**, 143 (1959).
[27] Love, P., Taft, jun., R. W., and Wartik, T., *Tetrahedron*, **5**, 116 (1959).
[28] Brown, T. L., *J. Amer. Chem. Soc.*, **81**, 3229 (1959).
[29] Dewar, M. J. S., and Schmeising, H. N., *Tetrahedron*, **5**, 166 (1959).
[30] Mulliken, R. S., *Tetrahedron*, **5**, 253 (1959).

THE 'GBR EXPERIMENT': A TRANS-ATLANTIC FREQUENCY COMPARISON BETWEEN CÆSIUM-CONTROLLED OSCILLATORS

By J. A. PIERCE
Cruft Laboratory, Harvard University, Cambridge, Mass.

G. M. R. WINKLER
U.S. Army Signal Research and Development Laboratory, Ft. Monmouth, New Jersey

AND

R. L. CORKE
Post Office Research Branch, Dollis Hill, London, N.W.2

For several years the temporal variation of phase, and hence the frequency, of a 16-kc./s. signal from Rugby, England, has been observed at Cambridge, Massachusetts[1,2]. During this period the transmission has been controlled by an Essen ring crystal oscillator and the reference at Cambridge has been one of several crystals or, since early 1958, an Atomichron.

The problem of resolving the observed fluctuations of phase into components caused on the propagation path and those produced by one or both oscillators has been attacked by choosing short periods (usually 4 or 5 days) when operation seemed especially stable. For these short lengths of time, internal evidence seemed to indicate that the oscillators were behaving in a consistent way and the observed deviations were taken as representing primarily variations in transmission time. The results of this somewhat dubious procedure indicated standard deviations of phase of about 1 or 2 μsec. When observations were extended over 24 hr., the corresponding precision of frequency measurement should have been about two parts in 10^{11}.

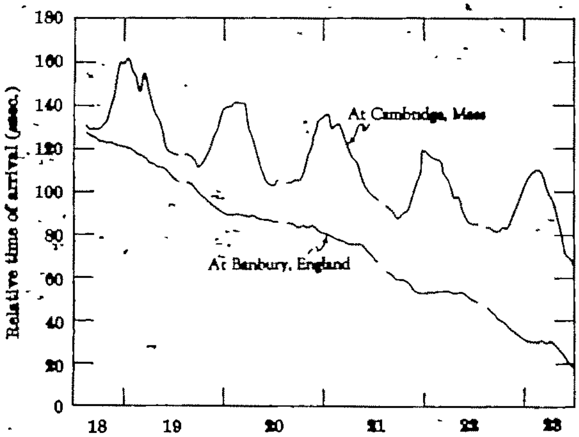


Fig. 1

Unfortunately, all long-term frequency comparisons have yielded standard deviations of 2 or 3 parts in 10^{10}. The source of this discrepancy of ten times in precision has been assumed to be frequency uncertainty in crystal oscillators. Proof, however, was lacking, and the corollary assumption that the long-distance transmission is more stable than very good oscillators has not been easily accepted in some quarters.

In this dilemma, a simple experiment was performed during September and October 1959. A photographic record of the phase of the Rugby signal was made at Banbury, Oxfordshire, England, where transmission vagaries on the 24-mile path from Rugby could be assumed to be unimportant. This record was, in every way, exactly similar to one simultaneously made in Cambridge, Massachusetts. The Banbury record was referred to Atomichron No. 111 and the Cambridge record was made in terms of Atomichron No. 112. Thus, by subtraction, the effects of the fluctuations of the crystal controlling the transmitter could be removed.

An example of the observed phase (or time of arrival) variations is given in Fig. 1. The Cambridge data show the normal day-to-night propagational variation of some 34 μsec. Both curves indicate some crystal oscillator variation, and the gradual divergence between the curves indicates that there was some frequency difference between the two Atomichrons.

It was hoped that this experiment would yield at least a month of continuous operation at both receivers. This hope was not realized, because of a number of minor interruptions which caused loss of continuity of phase at one point or the other. There were, however, two periods of ten days or so when operation was entirely satisfactory. During the first of these, the difference in phase between Cambridge and Banbury is shown in Fig. 2. Here it can scarcely be denied that the frequency of one of the Atomichrons was shifting with respect to the other, as shown by the gradual change in slope of the curve, when diurnal variation is removed. In spite of this effect, excellent day-to-day consistency is observed.

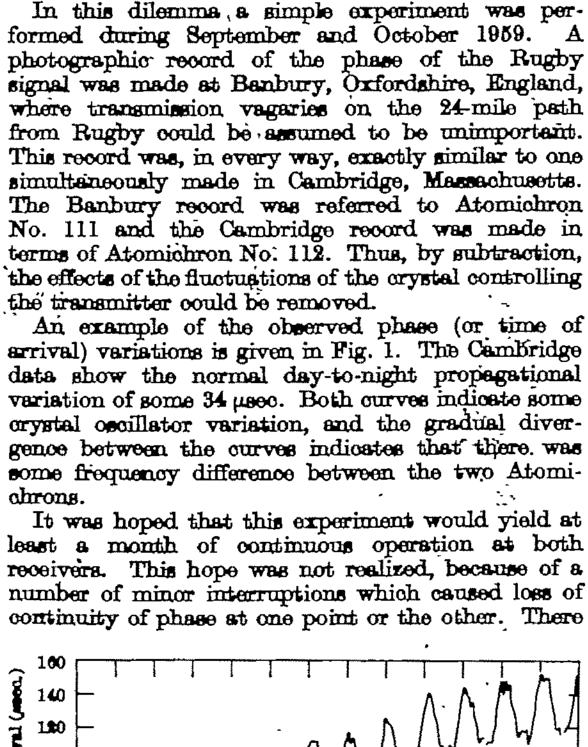


Fig. 2

The other period of satisfactory operation gave the difference record of Fig. 3. In this case the sense of the frequency difference between the Atomichrons had reversed, but the difference seems small and quite stable.

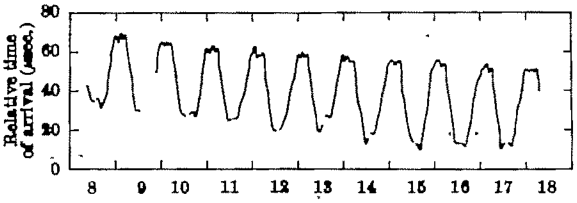


Fig. 3

In a record of this sort, any chord has a slope that is a measure of the frequency difference for the interval between its end points. The scale of the figures exhibited is such that even the steep slopes at sunrise and sunset represent frequency variations of only about two parts in 10^9. To remove the diurnal variation it is simple to take measurements over 24 hr. or multiples thereof. This might be done, for example, from noon to noon. In this article, however, each day's record (from 15h. U.T. to 13h. U.T. on the following day) is reduced to a single value by averaging together the 23-hourly values.

The time-of-arrival values thus obtained are shown in the second column of Table 1. Values are missing for October 8–10 (although some are shown in Fig. 3)

Table 1. FREQUENCY DIFFERENCES BETWEEN ATOMICHRONS

Date 1959	No. 111 relative to 112 Mean relative phase (in μs.)	Frequency difference in parts (in 10^{10})	Deviation of frequency difference* in parts (in 10^{10})	No. 111 relative to 117 Frequency difference† in parts (in 10^{10})	Deviation of frequency difference* in parts (in 10^{10})
Sept. 14	32·7			0·7	+0·4
15	41·3	−1·0	+0·5	0·2	−0·1
16	56·0	−1·7	−0·3	0·2	−0·1
17	66·7	−1·2	+0·1	0·2	−0·1
18	80·7	−1·6	−0·4	0·3	0·0
19	90·5	−1·1	0·0	0·3	−0·1
20	96·9	−0·7	+0·3	0·2	−0·2
21	104·3	−0·9	+0·1	0·3	−0·1
22	117·1	−1·5	−0·6	0·3	−0·1
23	123·3	−0·7	+0·1	0·4	0·0
24	128·0	−0·5	+0·2	0·4	0·0
25	132·0	−0·5	+0·1	0·8	+0·4
26					
Oct. 10	42·6			1·2	−0·1
11	41·2	+0·2	−0·1	1·2	0·0
12	38·7	+0·3	+0·1	1·3	+0·2
13	39·1	0·0	−0·3	1·1	+0·1
14	36·1	+0·3	+0·1	0·8	−0·1
15	33·8	+0·3	+0·1		
16	32·5	+0·2	0·0		
17					
Mean‡		−0·4		0·6	
Root mean square‡		0·8		0·7	
Standard deviation*			0·26		0·17

* With respect to best straight lines.
† Sense of difference unknown, but taken as positive.
‡ Including a few values for intervening and subsequent dates.

because of a recording failure on October 9 which lost some of the 23 hourly values on that day. Column 3 of Table 1 gives the frequency difference derived from the successive phase values of column 2. Because of the curvature shown in Fig. 2, which may have been caused by the incipient failure of the klystron in Atomichron 112 that occurred on September 27, a progressive change in frequency has been assumed. The deviations of column 4 of Table 1, therefore, imply a linear change in frequency or a parabolic change in time of arrival. It will be seen that the frequencies are consistent to a few parts in 10^{11}.

At the time of these observations a second Atomichron, No. 117, was also operating at Banbury. It was not involved in the measurements hitherto discussed, but beats were counted between the two local outputs. These were not continuously reported, and the sense of the frequency difference was not determined. The values shown in column 5 of Table 1 have been assumed positive, for computation of the deviations in column 6.

It is perhaps significant that the r.m.s. differences at the bottom of Table 1 are so similar in magnitude. This value seems to represent the precision with which two Atomichrons can be expected to produce the same frequency.

The standard deviations show the accuracy with which the Rugby signal can be measured, in Cambridge and in Banbury, in an interval of 24 hr. This precision is, at least on the average, inversely proportional to the duration of measurement. Although there is no firm reason to assume that the frequency fluctuations of three Atomichrons are identical, the similarity between the two standard deviations is striking. It appears, as suggested initially, that the actual fluctuations in transmission time are of the order of two microseconds and the corresponding contribution to the errors of trans-Atlantic frequency measurement is about two parts in 10^{11}, for a duration of measurement of 24 hr.

Acknowledgment is made to the Engineer-in-Chief of the British Post Office for the facilities made available at the Post Office Radio Measuring Station, Banbury, Oxfordshire, England. We thank Mr. W. N. Genna and the staff at Banbury for their assistance.

---

[1] Pierce, J. A., Mitchell, H. T., and Essen, L., *Nature*, 174, 922 (1954).

[2] Pierce, J. A., *Proc. Inst. Rad. Eng.*, 45, 794 (1957).

CHEMICAL AND PHYSICAL PROPERTIES OF THE SMALL DEOXYRIBONUCLEIC ACID COMPONENT OF CRYSTALLINE CYTOCHROME B_2

By Dr. M. D. MONTAGUE and Prof. R. K. MORTON

Department of Agricultural Chemistry, Waite Agricultural Research Institute, University of Adelaide

THE recent report by Kit[1] concerning the fractionation of deoxyribonucleic acid on columns of 'Ecteola-cellulose' prompts us to report our experience with the deoxyribonucleic acid component associated with crystalline cytochrome b_2 from baker's yeast.

Cytochrome b_2 crystallized by the procedure of Appleby and Morton[2] is a flavohaemoprotein[2,3] containing a deoxyribonucleic acid component[4] and having L(+)-lactate dehydrogenase activity. The deoxyribonucleic acid component was dissociated from the enzyme, which had been crystallized three times, by anaerobic dialysis at pH 8·0 against 0·7 saturated ammonium sulphate solution[4] containing 0·15 *M* sodium lactate and 10^{-4} *M* ethylenediamine tetraacetate. The solution of nucleic acid was dialysed against several changes of 0·01 *M* potassium phosphate buffer, pH 7·0 and about 500 μgm. of the nucleic acid were loaded on to a column (3·5 × 1 cm.) of 'Ecteola-cellulose' (type 20, Brown Co., Berlin, New Hampshire). A gradient of sodium chloride in 0·01 *M* potassium phosphate buffer, pH 7·0, was used to elute the components. Approximately 85 per cent of the material absorbing at 260 mμ was eluted as a single peak between 0·5 and 0·7 *M* sodium chloride. Re-chromatography on the same column using a less-steep gradient of sodium chloride gave a single peak between the same limits of salt concentration. Alternate dialysis and freeze-drying was used to concentrate the material and to avoid possible denaturation due to high concentrations of salt. Table 1 shows the optical properties of the deoxyribonucleic acid from cytochrome b_2.

Table 1. OPTICAL PROPERTIES OF THE DEOXYRIBONUCLEIC ACID COMPONENT OF CRYSTALLINE CYTOCHROME b_2

	λ_{max} (mμ)	ε(P) (max.)	λ_{min} (mμ)	ε(P) (min.)	$\frac{E_{250\ m\mu}}{E_{260\ m\mu}}$	$\frac{E_{280\ m\mu}}{E_{260\ m\mu}}$	$\frac{E_{290\ m\mu}}{E_{260\ m\mu}}$
In sodium acetate (0·01 *M*) pH 7·0	260	6,600	233	2,620	0·82	0·51	0·19
In NaOH (0·05 *N*)	260	7,800	235	4,300	0·80	0·46	0·12
In HCl (0·01 *N*)	260	8,650	232	2,740	0·76	0·56	0·27

After removing most of the ribonucleic acid by fractionation with sodium chloride, Kirby's[5] procedure was used to isolate the bulk deoxyribonucleic acid of yeast extracted from the same type of baker's yeast as used for preparation of the cytochrome b_2. The bulk deoxyribonucleic acid was chromatographed on the same column as was used for the deoxyribonucleic acid from cytochrome b_2. A component (fraction 6–7), comprising 15 per cent of the total material absorbing at 260 mμ, was eluted with 0·6–0·7 *M* sodium chloride. It will be noted that the deoxyribonucleic acid component from cytochrome b_2 was eluted between 0·5 and 0·7 *M* sodium chloride under similar conditions.

Table 2 shows the base compositions of the deoxyribonucleic acid from cytochrome b_2, of the bulk

Table 2. BASE COMPOSITIONS OF DEOXYRIBONUCLEIC ACID PREPARATIONS FROM BAKER'S YEAST*

Preparation	Guanine	Cytosine	Adenine	Thymine	(Adenine + Thymine) / (Guanine + Cytosine)
Bulk	17·4	16·6	32·2	33·8	1·9
DNA	17·2	16·2	32·6	33·9	2·0
Fraction 6–7					
from	17·4	14·9	33·5	34·1	2·2
bulk DNA†	16·6	14·8	33·9	34·7	2·2
DNA from	14·5	14·0	33·7	37·8	2·5‡
cytochrome	15·1	14·4	33·9	36·6	2·4
b_2	15·0	14·5	34·7	35·8	2·4

* The procedures are described elsewhere (refs. 4, 6). The results are expressed as a percentage of total bases; the recovery was 92–96 per cent in each case.

† Fraction eluted between 0·6 and 0·7 *M* sodium chloride from 'Ecteola-cellulose' column.

‡ Appleby and Morton (ref. 4) found a base ratio of 2·6 from analyses on whole enzyme.

deoxyribonucleic acid from yeast, and of fraction 6–7 from this preparation.

There was a 30 per cent increase in extinction at 260 mμ after digestion of 250 μgm./ml. of the deoxyribonucleic acid from cytochrome b_2 in 0·02 *M* magnesium chloride with 2 μgm./ml. of crystalline pancreatic deoxyribonuclease at *p*H 7·0; there was no initial lag in the reaction, in contrast to the reaction of the same enzyme with the bulk deoxyribonucleic acid of the yeast. The component from cytochrome b_2 was not degraded by snake venom phosphodiesterase.

Work on the end-group of the deoxyribonucleic acid from cytochrome b_2 has been carried out, the deoxyribonucleoside components at the ends of the chains terminated by 5′-phosphate groups being released by enzymic degradation. All incubations were carried out at room temperature (about 20° C.). A solution containing 270 μgm. of the nucleic acid from cytochrome b_2 in 0·02 *M* magnesium chloride at *p*H 7 was incubated for 16 hr. with potato phosphomonoesterase (free of phosphodiesterase activity) and then heated at 100° C. for 2 min. to destroy the phosphatase activity. It was then digested with crystalline pancreatic deoxyribonuclease for 10 hr. The solution was adjusted to *p*H 8·9 and then incubated for 12 hr. with snake-venom phosphodiesterase (free of phosphomonoesterase activity). The solution was then heated at 100° C. for 1 min., and the clear supernatant obtained after centrifuging was chromatographed on Whatman paper using water-saturated *n*-butanol (100 ml.)–ammonia (1 ml. of solution, specific gravity 0·880). Two components, with R_F values of 0·22 and 0·30, were identified by their ultra-violet absorption spectra as derivatives of guanine and cytosine respectively. Neither adenine nor thymine derivatives were detected. The amounts of nucleosides isolated were too small to determine the quantities of each present with high accuracy, but from the estimates of the amounts released, the molecular weight of the nucleic acid is 10,000–12,000.

The sedimentation coefficient of the deoxyribonucleic acid from cytochrome b_2 was measured using a 'Spinco' model *E* ultracentrifuge fitted with ultraviolet optics. At a concentration of approximately 0·003 per cent of nucleic acid in 0·01 *M* potassium phosphate, 0·078 *M* sodium chloride at *p*H 7·0 ($\Gamma/2$, 0·10) values for $S_{20,w}$ of 5·6–5·9 svedbergs were obtained. A preliminary diffusion experiment using the ultracentrifuge with a synthetic boundary cell indicated that the molecular weight of the nucleic acid is 10,000–20,000. No marked heterogeneity of the sedimenting nucleic acid was observed. We are grateful to Mr. J. McD. Armstrong for these measurements.

Since nucleotide and hæm analyses of crystalline cytochrome b_2 indicate that the minimum molecular weight of the deoxyribonucleic acid component of the enzyme is about 5,000[4], the end-group assays and work on sedimentation establish that the actual molecular weight in solution is approximately 10,000.

The work by Kit[1] on the fractionation of various deoxyribonucleic acid preparations on 'Ecteola-cellulose' (type 20, Brown Co.) has shown that the elution pattern depends markedly on the method of isolation of the nucleic acid. Much of the deoxyribonucleic acid of low molecular weight eluted by neutral salt solution appears to result from the degradation of larger molecules by a number of mechanisms including heat denaturation, action of deoxyribonuclease and mechanical cleavage when the cells are ruptured. Nevertheless, if precautions are taken to eliminate or reduce these degradative processes, the deoxyribonucleic acid still contains material of low molecular weight, and so far no bulk deoxyribonucleic acid has been isolated which does not contain at least 5 per cent of small components. Thus the possibility that the cell normally contains a complement of deoxyribonucleic acid of low molecular weight has still to be considered.

The function of the deoxyribonucleic acid of crystalline cytochrome b_2 is not known. It is not necessary for enzymic activity[4]. Under conditions of low ionic strength, the enzyme does not crystallize in the absence of this component[4] and it may be that the nucleic acid provides the necessary rigidity for crystallization of this protein. It is significant that the ratio of (adenine + thymine) to (guanine + cytosine) for the nucleic acid of cytochrome b_2 is consistently 2·4–2·6, as compared with the value of 1·95 for the bulk deoxyribonucleic acid of the same yeast (Table 2).

The constancy of composition indicates that the deoxyribonucleic acid of crystalline cytochrome b_2 is a specific component of the yeast cell rather than a small molecule formed by random degradation of larger nucleic acid molecules; in the latter case, the base composition of the nucleic acid would be expected to vary among different preparations. The base ratio found in the component (fraction 6–7) from the bulk deoxyribonucleic acid of yeast (Table 2) emphasizes this conclusion.

The constancy in behaviour of different preparations during chromatography on 'Ecteola-cellulose', the sedimentation and diffusion characteristics, and the end-group assay all indicate that the deoxyribonucleic acid component from crystalline cytochrome b_2 is probably a homogeneous material of low molecular weight (10,000). It therefore appears to represent a suitable material with which to investigate the sequence of nucleotides in naturally occurring deoxyribonucleic acid. A detailed account of these investigations and of further work with this material will be reported elsewhere.

[1] Kit, S., *Arch. Biochem. Biophys.*, 87, 318 (1960).

[2] Appleby, C. A., and Morton, R. K., *Nature*, 173, 749 (1954); *Biochem. J.*, 71, 492 (1959).

[3] Appleby, C. A., and Morton, R. K., *Biochem. J.*, 73, 539 (1959).

[4] Appleby, C. A., and Morton, R. K., *Biochem. J.*, 75, 258 (1960).

[5] Kirby, K. S., *Biochem. J.*, 66, 495 (1957).

[6] Wyatt, G. R., in "The Nucleic Acids", edit. by Chargaff, E., and Davidson, J. N., 1, 243 (Academic Press, New York, 1955).

MECHANISM OF STARCH BIOSYNTHESIS

By DR. MARIA A. RONGINE DE FEKETE*, DR. LUIS F. LELOIR and DR. CARLOS E. CARDINI

Instituto de Investigaciones Bioquímicas "Fundación Campomar", and Facultad de Ciencias Exactas y Naturales, Obligado 2490, Buenos Aires

SINCE the classical work of Hanes[1] some workers consider that starch synthesis *in vivo* is catalysed by phosphorylase. Nevertheless, others have raised doubts on this hypothesis. Thus Ewart *et al.*[2], from measurements of the ratio of inorganic phosphate to glucose-1-phosphate, concluded that: "phosphorylase is not involved in the synthesis of starch . . . but the role of phosphorylase in the normal metabolic breakdown . . . is not questioned" (cf. also Rowan and Turner[3]). Furthermore, Stocking[4] reported that starch synthesis in leaves is initiated in the chloroplasts, where phosphorylase could not be detected.

The problem of starch synthesis is similar to that of glycogen synthesis in animal tissues. The synthetic role of phosphorylase *in vivo* has been challenged on the basis of the following facts: (*a*) the unfavourable ratio of inorganic phosphate to glucose-1-phosphate in tissues; (*b*) agents which increase the concentration of phosphorylase, such as epinephrine and glucagon, produce glycogen breakdown[5]; and (*c*) in certain diseases phosphorylase is absent in the muscles, although normal or increased amounts of glycogen are present[6].

If these facts are sufficient to rule out phosphorylase as the enzyme responsible for glycogen synthesis, the only enzyme which can take its place, so far as we know, is glycogen synthetase[7], which catalyses the transfer of glucose from uridine diphosphate glucose to glycogen forming a new α-1 : 4 linkage. On the other hand, it is known that uridine diphosphate glucose acts as glucose donor in plants. Thus enzymes catalysing the synthesis of sucrose[8], sucrose phosphate[9], and callose[10] have been described. The latter is a β-1 : 3 glucan[11] discovered many years ago and believed to have a role in the physiology of sieve tubes and in wound reaction in plants[12].

All this suggests that uridine diphosphate glucose should be involved in starch synthesis. Although incubation of radioactive uridine diphosphate glucose with different plant materials usually resulted in the incorporation of radioactivity in the polysaccharide fraction, the product formed was insoluble in hot water, was not hydrolysed by β-amylase and was presumably callose.

Since glycogen synthetase has been found to be strongly adsorbed on glycogen (ref. 7*c*), we have looked for a starch-synthesizing enzyme in starch granules. In preliminary experiments, radioactive uridine diphosphate glucose was incubated with freshly prepared potato starch and it was found that there was some incorporation of radioactivity in the fraction which became soluble by the subsequent action of α-amylase. More active preparations were obtained from beans as follows. Freshly harvested immature dwarf string beans (*Phaseolus vulgaris* var. Bountiful) were used. The cotyledons and the embryos were ground in a mortar with two volumes of water. The suspension was filtered through cheesecloth and centrifuged 5 min. at 3,000 rev./min. The precipitate was resuspended in several volumes of water and recentrifuged three times. The white precipitate was then suspended in four volumes of acetone at − 15° C., centrifuged at 0° C.; this procedure was repeated three times, after which the precipitate was dried *in vacuo*. This preparation could be stored for months at − 15° C. with no decrease in activity.

The bean starch fraction (2 mgm. containing 6 μgm. of protein) was incubated at 37° C. for 3 hr. with 0·21 μmole of uridine diphosphate glucose containing 7,850 counts/min. of carbon-14 in the glucose moiety, 2 μmoles of glycine buffer of pH 8·4, 0·05 μmole of ethylenediamine tetraacetate in a final volume of 15 μl. After incubation, 0·5 ml. of 80 per cent ethanol was added. The soluble fraction was spotted on paper and chromatographed with ethanol–ammonium acetate of pH 7·5 (ref. 15). The uridine diphosphate and uridine diphosphate glucose spots were eluted from the paper and the absorbancy at 260 mμ, radioactivity and uridine diphosphate were measured. The insoluble fraction was washed with ethanol and counted. Blanks without and with uridine diphosphate glucose added after incubation were run at the same time. Furthermore, it was found that the bean starch fraction did not destroy added uridine diphosphate.

The changes occurring on incubation of the bean starch fraction with radioactive uridine diphosphate glucose are shown in Table 1; these results indicate a correspondence between disappearance of uridine diphosphate glucose, formation of uridine diphospate and incorporation of glucose into the starch fraction.

Table 1. ANALYSIS OF SUBSTRATES AND PRODUCTS

	μmole	μmole
Disappearance of uridine diphosphate glucose	0·02*	0·016†
Formation of uridine diphosphate	0·017*	0·015‡
Glucose-U-^{14}C incorporated into starch		0·017‡

* Calculated from absorbancy at 260 mμ.
† Calculated from radioactivity.
‡ Estimated with pyruvate kinase (ref. 7*c*).

The identity of the product formed was investigated as follows. The starch fraction after incubation with radioactive uridine diphosphate glucose was thoroughly washed with aqueous ethanol, suspended in water, heated for 10 min. at 100° C. and then treated with β-amylase. Wheat β-amylase was allowed to act for 12 hr. at 37° C., and 3 volumes of methanol were added. The soluble fraction was evaporated, spotted on paper and chromatographed with butanol/pyridine/water (6 : 4 : 3 v/v)[13] as solvent. As shown in Fig. 1*a* the radioactivity was found to migrate like maltose. For further confirmation of the identity of the substance, the 'maltose' eluted from the paper after chromatography was submitted to electrophoresis with borate buffer[14]. As shown in Fig. 1*b*, the radioactivity migrated with the 'maltose'. Under these conditions, cellobiose, laminaribiose and gentiobiose are neatly separated from maltose.

Similar results were obtained with α-amylase. Saliva (0·1 volume) was allowed to act for 30 min. at 37° C. and the samples processed as described for β-amylase. The results were similar except that radioactivity appeared also in the maltotriose spot.

---

*Post-Doctoral Fellow of the University of Buenos Aires.

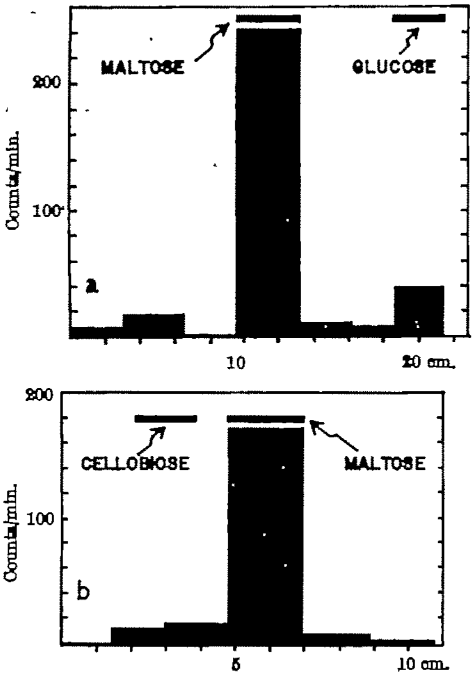


Fig. 1 (*a*) Paper chromatography; and (*b*) paper electrophoresis of reaction product after treatment with β-amylase

These results are consistent with the following formulation:

$$\text{uridine diphosphate glucose} + \text{acceptor} \rightarrow \text{uridine diphosphate} + \alpha\text{-glucosyl-1,4-acceptor} \quad (1)$$

in which the acceptor is starch.

Other experiments were carried out in order to study the specificity of uridine diphosphate glucose as glucose donor. As shown in Table 2, glucose phosphates and sucrose showed some incorporation of radioactivity but much less than uridine diphosphate glucose.

Table 2. Donor Specificity

Bean starch fraction (8 mgm.) incubated 1 hr. under conditions similar to those indicated in Table 1 with about 0·2 mole of substrates indicated

Donor	Counts/min. added	Counts/min. recovered in 'starch' fraction
Uridine diphosphate glucose	5,300	590
Glucose-1-phosphate	8,000	190
Glucose-6-phosphate	10,000	210
Sucrose	8,500	180
Glucose	10,000	0

Sucrose has been tested as glucose donor in other experiments with various plant tissue preparations with negative results. The well-known ready conversion of sucrose into starch *in vivo* might take place indirectly with uridine diphosphate glucose as an intermediate. The formation of uridine diphosphate glucose from sucrose has been detected (refs. 8, 9) and may be written as follows:

$$\text{sucrose} + \text{uridine diphosphate} \rightleftharpoons \text{uridine diphosphate glucose} + \text{fructose} \quad (2)$$

The addition of reactions (1) and (2) would result in the formation of starch from sucrose.

This investigation was supported in part by a research grant (No. *G*-3442) from the National Institutes of Health, U.S. Public Health Service and by the Consejo Nacional de Investigaciones Cientificas y Técnicas.

[1] Hanes, C. S., *Proc. Roy. Soc.*, B, 128, 421 (1939).

[2] Ewart, M. H., Siminovitch, D., and Briggs, D. R., *Plant Physiol.*, 29, 407 (1954).

[3] Rowan, K. S., and Turner, D. H., *Aust. J. Biol. Sci.*, 10, 414 (1957).

[4] Stocking, C. R., *Amer. J. Bot.*, 39, 283 (1952).

[5] Sutherland, E. W., *Ann. N.Y. Acad. Sci.*, 54, 693 (1951).

[6] Larner, J., and Villar-Palasi, C., *Proc. U.S. Nat. Acad. Sci.*, 45, 1234 (1959). Mommaerts, W. F. H. M., Illingworth, B., Pearson, C. M., Guillory, R. J., and Seraydarian, K., *ibid.*, 45, 791 (1959). Schmid, R., Robbins, P. W., and Traut, R. R., *ibid.*, 45, 1236 (1959).

[7] (*a*) Leloir, L. F., and Cardini, C. E., *J. Amer. Chem. Soc.*, 79, 6340 (1957). (*b*) Leloir, L. F., Olavarría, J. M., Goldemberg, S. H., and Carminatti, H., *Arch. Biochem. Biophys.*, 81, 508 (1959). (*c*) Leloir, L. F., and Goldemberg, S. H., *J. Biol. Chem.*, 235, 919 (1960).

[8] Cardini, C. E., Leloir, L. F., and Chiriboga, J., *J. Biol. Chem.*, 214, 149 (1955).

[9] Leloir, L. F., and Cardini, C. E., *J. Biol. Chem.*, 214, 157 (1955).

[10] Feingold, D. S., Neufeld, E. F., and Hassid, W. Z., *J. Biol. Chem.*, 233, 783 (1958).

[11] Aspinall, G. O., and Kessler, G., *Chem. and Indust.*, 1296 (1957), Kessler, G., *Ber. schweiz. bot. Ges.*, 68, 5 (1958).

[12] Currier, H. B., and Strugger, S., *Protoplasma*, 45, 552 (1956).

[13] Jeanes, A., Wise, C. S., and Dimler, R. J., *Anal. Chem.*, 23, 415 (1951).

[14] Consden, R., and Stanier, W. M., *Nature*, 169, 783 (1952).

[15] Paladini, A. C., and Leloir, L. F., *Biochem. J.*, 51, 426 (1952).

ANALYSIS OF METABOLIC RATES AT THE CELLULAR LEVEL

By L. G. LAJTHA, R. OLIVER, R. J. BERRY and ELIZABETH HELL

Radiobiology Laboratory, Department of Radiotherapy, Churchill Hospital, Oxford

DURING the course of autoradiographic work with iron-59 and tritium, carbon-14, or sulphur-35 labelled compounds in human bone marrow cells, Ehrlich mouse ascites cells, or in mouse thymus, spleen, and intestine, it was noticed that the grain counts over labelled cells showed a considerable spread. This spread was significantly greater than that for a Poisson distribution about a single mean corresponding to the statistical variation of radioactive disintegrations. In short-term incubations the grain counts over the labelled cells measure uptake during unit time per cell (that is, uptake rate per cell), and some biological variation is natural even in a homogeneous population of cells, so this finding was not unexpected. However, variations in the observed spread warranted a closer analysis of the distributions of grain counts, and these have indicated certain qualitative differences in the uptake pattern of various labelled compounds and in different cell types.

Theoretical Considerations

(1) If the uptake rate is constant throughout the cell population the same amount of radioactive material will be incorporated into each cell, and the variation in the grain count over cells will be entirely due to the statistical fluctuation in the number of disintegrations occurring during the time of exposure. This would lead to a Poisson distribution about a mean value with a standard deviation equal to the square root of the mean. As the number of grains over each cell is necessarily small, this deviation will be appreciable. Thus for a typical mean of 45 grains the standard deviation would be $\sqrt{45}$ or 6·7, that is, about 15 per cent. This distribution is shown in Fig. 1*A*.

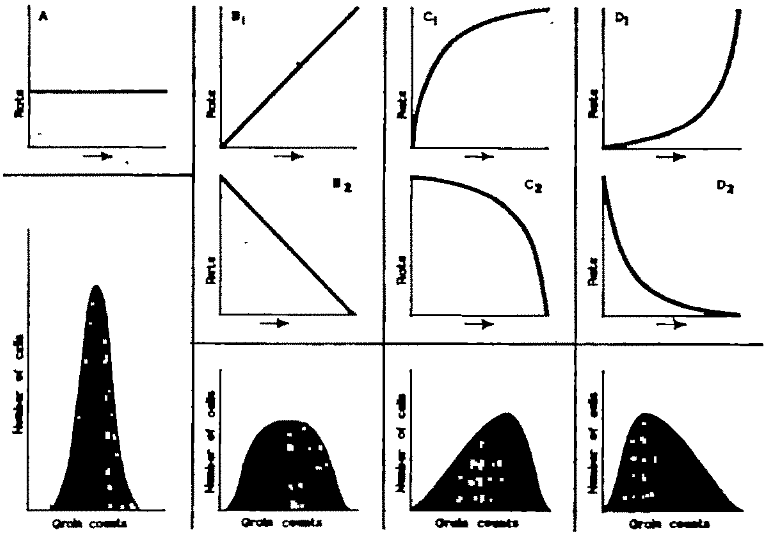


Fig. 1

In a non-growing population of cells a constant rate of uptake may indicate a steady rate of turnover or synthesis of a compound. However, some biological variation would be expected, especially between the young and the senescent members of the population, so that the observed spread would exceed that of the ideal Poisson distribution (Fig. 1*A*) and depend partly on the relative proportions of 'normal' and 'senescent' cells.

In a non-synchronous growing population of cells, theoretically a number of possible variations in the rate of uptake may be considered. A constant rate of uptake would lead to the type of distribution of grain count discussed above.

A linear increase or decrease of the rate of uptake would result in an even distribution of low and high rates and the grain count distribution would ideally follow the symmetrical type of curve shown in Fig. 1*B*. If, however, the rate of uptake increases or decreases exponentially, then the resulting grain count distribution would be asymmetrical as illustrated in Figs. 1*C* and *D*.

(2) In a growing cell population the cells increase their mass during interphase from a '2*n*' to a '4*n*' value to yield two '2*n*' cells after mitosis. Therefore a constant uptake-rate in such a population would imply a synthesis of a compound (or structure) which would not be functional until after mitosis, or a turnover of a compound (or structure) which does not reduplicate until mitosis.

A linear increase in uptake rate would correspond to a constant rate of production of new, for example enzyme, molecules (responsible for the uptake of the compound investigated); however, it would also mean that the 'producer' of the new enzyme molecules is not reduplicated (or if so then is not functional) until mitosis. A linear decrease would imply a similar constant rate of production of an inhibitor of uptake.

Such processes leading to linear changes in uptake rate would seem to be unlikely where the function is continuous throughout the interphase—a condition which would be indicated by effectively all cells of the population being labelled in short-term incubations (100 per cent 'positive' cells). However, where significantly fewer than 100 per cent of the cells are labelled, it can be concluded that the function is active only during part of the interphase. In such cases reduplication can occur in the remaining period, and linear rate changes may be conceivable.

Of the possible forms of exponential type of variations in uptake rate the simplest system would correspond to Fig. 1D_1, where the rate of uptake of a material is proportional to the amount of that material already present in the cell. In such a case a doubling of the rate during interphase would be expected, that is, a 1 : 2 change.

The contrasting situation is represented in Fig. 1D_2, where the rate of uptake of a material is reduced proportionally to the amount of the material in question present in the cell. In such a case a halving of the rate during interphase may be expected.

It is possible to differentiate between these two situations as, although the expected grain count distribution curves would be identical as shown in Fig. 1, the distribution curves for the content of the material in the cell would have the same form as the grain-count distribution curve in case of D_1, but of opposite asymmetry in D_2.

A situation where the uptake rate is limited exponentially, possibly by an exponentially decaying inhibitor, is illustrated in Fig. 1C_1, while an exponential build-up of an inhibitor of uptake rate is represented in Fig. 1C_2. Although the grain-count distribution curves are similar, the content distribution curves would again differentiate between the two situations; for C_1 the asymmetry of the two curves would be similar, for C_2 opposite.

Situations C_1 and C_2 for functions occupying the whole of the interphase (100 per cent positive cell population) would imply birth of an inhibitor during mitosis with subsequent decay in C_1; and build-up of an inhibitor with explosive disappearance during mitosis in the case of C_2. While such situations may exist, neither of them is considered as likely for the majority of cell functions as situations D_1 and D_2. Furthermore, in situations C_1 and C_2 there is no *prima facie* reason why the rate change should be limited to 1:2; in fact, rate changes considerably in excess of this could be expected.

In practice, the cell processes may lead to other types of curves (for example, sigmoid or other composite curves), but the above general conclusions on grain-count distribution would still apply. In any event, if the rate changes involved are only of the order of 1:2 it may not be possible—as is shown later—to differentiate between linear and exponential or other types of curves. In cases, however, where the rate changes are significantly greater (for situations C_1 and C_2, and also probably in the case of a sigmoid curve), the differences between the various types of curves may become appreciable.

Two special cases, where uptake is related to cell surface area, may be considered. If uptake rate is proportional to total cell surface, then during one duplication of the cell mass uptake rate would increase from 1:1·6 only. If, however, uptake rate depends on surface area per unit mass (or mass per unit area) then it would decrease from 1:0·8 (or increase from 1:1·26) during one duplication of the cell mass. Consequently, if in a growing population of cells a change of uptake rate less than 1:2 is observed, this may indicate an uptake dependent on surface area, but changes from 1 : 0·8 or 1 : 1·26 are almost certainly indistinguishable from a constant rate.

Master Curves

The curves shown in Fig. 1 are exaggerated for the sake of illustration of the problem. A master curve was therefore drawn for normal distribution with a standard deviation of 30 per cent, corresponding to standard deviations of 15 per cent for a mean grain count of 45 grains per cell, and of 25 per cent for biological variation. This was likely to represent the greatest spread of grain count distribution which could be expected for a population having a nominally uniform uptake rate.

In order to represent the conditions with a linear or exponential increase or decrease in uptake rate the only case considered was for doubling of the rate during the period of uptake. A composite curve was constructed by the summation of five normal distributions with means at 1·1, 1·3, 1·5, 1·7, and 1·9, and standard deviations of 30 per cent, the relative peak ordinates corresponding to the proportion of cells which would, in each case, lie ideally within that range of uptake rate (1·0–1·2, 1·2–1·4, etc.). This procedure, of course, blurs the clear difference between the types of grain count distribution curve shown in Fig. 1, but was more likely to provide distributions similar to those expected in biological material. The two curves thus calculated for situations *B* and *D* respectively are illustrated in Fig. 2. The asymmetry in the exponential case, although still present, is less marked, and differentiation in practice is unlikely.

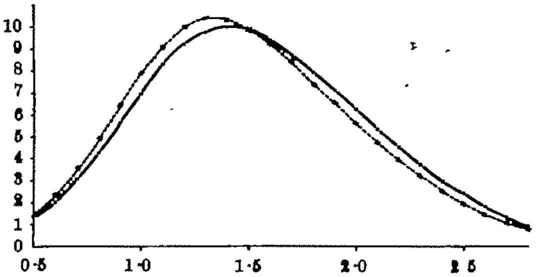


Fig. 2. —, linear *S.D.* 30 per cent; – – –, exponential *S.D.* 30 per cent

In making comparison between these theoretical curves and distributions observed in practice the absolute values of the abscissæ have no significance, only their relative variation. Therefore, to facilitate matching with experimental curves, all the theoretical curves have been re-drawn with linear ordinate scale and a peak value of 10, and with a semilogarithmic abscissa scale along which the curves can be moved without changing their shape.

Experimental Examples

Autoradiographs were prepared from smears of (*a*) human bone marrow cultures after two hours incubation with iron-59, (*b*) human leukæmic lymphocytes after three hours incubation with methionine sulphur-35, and (*c*) mouse thymus imprints 30 min. after administration of thymidine labelled with hydrogen-3. The autoradiographs were exposed long enough to give a mean grain count of 30–50 grains per labelled cell (the optimum grain count depends on the size of the cell and on the background), and grain counts were performed on 300–900 cells of the same type (that is, basophilic normoblasts, small lymphocytes, large thymocytes).

As only a limited number of cells was counted in each experiment the grain count distribution curve obtained was, in general, not smooth. In order to provide a 'best' smoothed distribution the results were considered in ranges of grain count 1–10, 11–20, etc. For each group the total number of cells was plotted against the actual mean value of grain count for that group. For comparison with the theoretical curves the final curve obtained was plotted on semilogarithmic paper with a peak (linear) ordinate of 10. Where more than 500 cells were counted it was still possible to obtain a smooth curve in this way considering ranges in grain count of 5, thus giving a more accurate form of the distribution.

In cases where the proportion of labelled cells in a population is significantly below 100 per cent, it is advisable to over-expose some slides to differentiate between the truly negative and 'false negative' cells. The latter may occur in populations with great ranges in uptake rate.

Caution is indicated with histological sections, as loss of parts of cells may affect the apparent range of uptake rates.

Figs. 3 and 4 show the experimental curve obtained with iron-59 in basophilic normoblasts (dividing population). It is clear that the iron-59 curve does not fit the normal distribution curve with 30 per cent *S.D.* (Fig. 3) but fits the exponential curve (situation *D*) remarkably well (Fig. 4). This, in conjunction with the early appearance of heavily labelled reticulocytes which is observed after a tracer dose of iron-59 (Suit *et al.* (1957); Lajtha and Oliver (1960)) is taken as indication of an exponentially increasing rate of

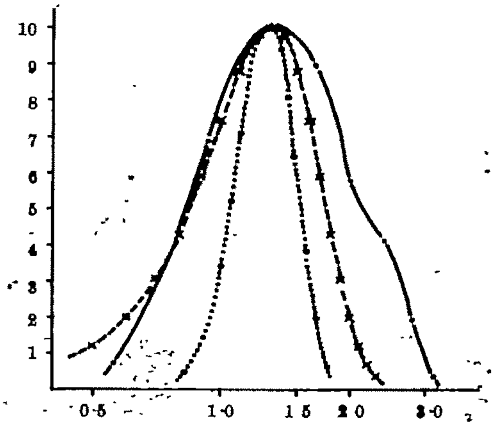


Fig. 3. · · · ·, Poisson (mean 45); – – –, normal (*S.D.* 30 per cent); ——, iron-59 experimental

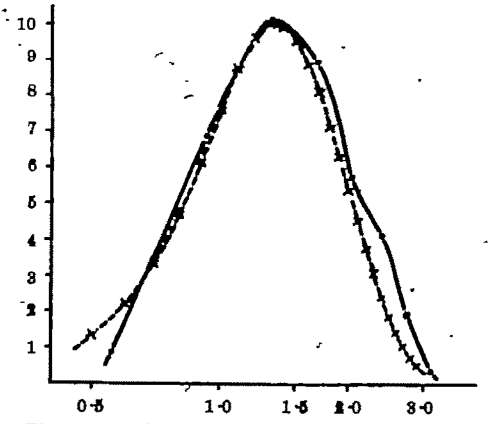


Fig. 4. ——, iron-59 experimental; – – –, exponential

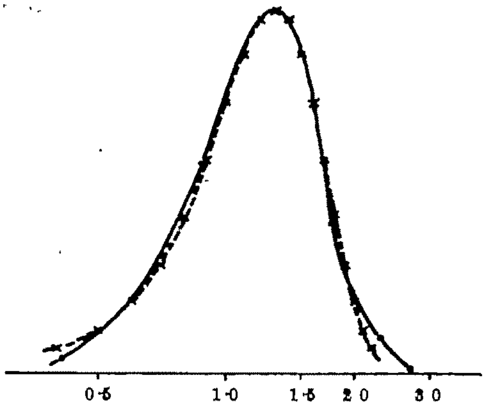


Fig. 5. ·—·, sulphur-35 methionine; ×---×, normal (*S.D.* 30 per cent)

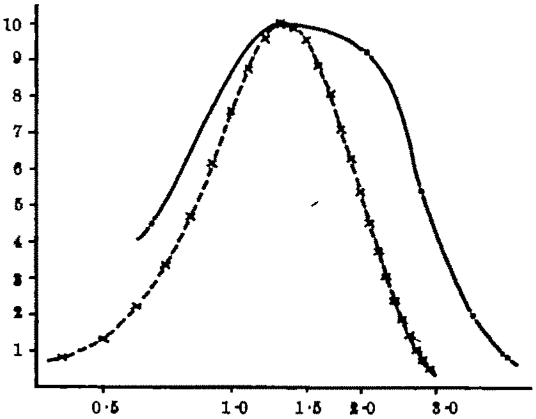


Fig. 6. ——, thymus deoxyribonucleic acid; ---, exponential

uptake of iron-59 (hæmoglobin synthesis) in the dividing population of basophilic normoblasts.

Fig. 5 shows the findings with methionine labelled with sulphur-35 in the small lymphocytes of human leukæmic blood. This experimental curve fits the normal distribution remarkably well, suggesting that the rate of methionine sulphur-35 uptake is constant (? turnover) in this apparently non-growing population of cells (these cells do not synthesize deoxyribonucleic acid).

An entirely different grain-count distribution curve is obtained with thymidine labelled with hydrogen-3 (a deoxyribonucleic acid label) in the large thymocytes (Fig. 6). This curve is considerably broader than the exponential increase from 1 : 2 ; in fact, it indicates a rate difference of the order of 1 : 5. On consideration this finding may not be unexpected ; even if synthesis of deoxyribonucleic acid proceeded at a constant rate along the length of every chromosome, there are significant differences in length between individual chromosomes. In a non-synchronized population of cells with 40 chromosomes (mouse), therefore, cells may occur in which at a given time all 40 chromosomes are in deoxyribonucleic acid synthesis, and others in which, for example, only the last ends of the longest chromosomes. Findings similar to that of Fig. 6 have been obtained with Ehrlich mouse ascites cells (thymidine labelled with hydrogen-3) as well as human bone marrow cells in which formate labelled with carbon-14 was used as deoxyribonucleic acid label (46 chromosomes).

Conclusions

The examples illustrated above indicate that autoradiographic grain-count distribution curves (coupled in some cases with content distribution curves) may be usefully employed in analysis of nature and rates of metabolic processes at the cellular level, information not easily obtained by other methods. Investigations with different labelled precursors in various normal and abnormal cells are in progress ; detailed results will be published elsewhere.

REFERENCES

Salt, H. D., Lajtha, L. G., Oliver, R., and Ellis, F., *Brit. J. Haemat.*, 3, 166 (1957).

Lajtha, L. G., and Oliver, R., in "Ciba Symp. Hæmopoiesis" (Churchill, London) (in the press).

TERMINOLOGY IN PLANT- AND SOIL-WATER RELATIONS

By DR. R. O. SLATYER
Division of Land Research and Regional Survey, Commonwealth Scientific and Industrial Research Organization, Canberra

AND

PROF. S. A. TAYLOR
Department of Agronomy, Utah State University, Logan

AT the recent symposium on plant–water relations in arid regions, organized by Unesco at Madrid (*Nature*, 185, 435 ; 1960), the terminology currently used in this field aroused much interest. The following notes summarize the main points brought forward at a special discussion on this subject. Because of the interest created, the delegates suggested that these notes be published for the information, use and comment of all biological and physical scientists interested.

(1) The water relations of soils and plants have long been described by terms which are thermodynamic in nature, but which have usually been expressed in terms of equivalent pressures. This has led to what can be described as a 'hydraulic' terminology with the terms 'total soil moisture stress' (*TSMS*)[1] and 'diffusion pressure deficit' (*DPD*)[2] being the most common in soil and plant studies respectively. Alternative terms for diffusion pressure deficit, which are commonly used in Europe, include 'suction force'[3] and 'suction pressure'[4]. Alternative terms for *TSMS* include '*pF*' (ref. 5).

(2) While this terminology has frequently provided a satisfactory description of the phenomena observed, its value is limited for the following reasons :

(*a*) The use of pressure terms and units is misleading because in soil and plant systems situations normally exist where a high equivalent pressure or suction can be measured. However, this value represents a potential energy only and no water movement can be expected unless *gradients* of potential energy exist.

(*b*) With reference to the vacuolated plant cell the simple equation :

$$DPD = OP - TP$$

where OP is osmotic pressure and TP turgor pressure, has been in use for many years and has provided a useful interpretation of the cell-water relations of adult mesophytic leaves. Ideally, however, it only refers to a cell which is completely vacuolated. In many plants, the volume of cell wall can reach significant proportions and in xerophytic and sclerophytic tissue the volume of the vacuole can be less than one-half of the total cell volume. Accordingly, rigid use of this simple terminology can introduce errors and may prevent an accurate interpretation and description of the phenomena observed.

(c) Even though the most common terms in the present terminology—'total soil moisture stress' and 'diffusion pressure deficit'—are regarded as pressures and expressed in pressure terms, not only are they thermodynamic in nature but also they are measured by thermodynamic methods—for example, by measuring equilibrium vapour pressure or osmotic potential.

(3) Because of these weaknesses in the present terminology it is thought that a definite step forward would be achieved by adopting more basic thermodynamic terms and units which would enable all the factors contributing to the thermodynamic state of water to be adequately described and assessed. Both diffusion pressure deficit and total soil moisture stress are conceptually expressions of the Gibbs free energy of the water in plant and soil systems respectively. To this extent the reversion to thermodynamic terms and units is a simplification rather than a complication. Several authors, notably, Edlefsen[6], Edlefsen and Anderson[7], Broyer[8-10] and Taylor[11], have already suggested appropriate thermodynamic terminologies.

(4) The free energy function is considered to be the most appropriate thermodynamic function and the most appropriate term is considered to be 'water potential', that is, the chemical potential of the water in the plant or soil. Thus, water potential is the difference between the partial specific Gibbs free energy of water in the system under consideration and of free pure water at the same temperature (which is the reference state). There are several alternative methods for expressing water potential, as can be seen from the thermodynamic identity:

$$\Delta\mu_w = R_w T \ln a_w = R_w T \ln p/p_0 = V_w(P - P_0)$$

where $\Delta\mu_w$ is the water potential, R_w the gas constant per gram of water, T the absolute temperature, a_w the activity of water, p/p_0 the relative vapour pressure, V_w the specific volume of water and $(P - P_0)$ the pressure difference that can be associated with, for example, hydraulic head or turgor pressure.

(5) If we choose pressure (P) and mass fractions of water (n_w) and of solutes (n_j) as independent variables, the differential form of the Gibbs equation for the component water (μ_w) can be written for the homogeneous isothermal state as follows:

$$d\mu_w = \left[\frac{\partial\mu_w}{\partial P}\right]_{n_w,n_j} dP + \Sigma_j \left[\frac{\partial\mu_w}{\partial n_j}\right]_{P,n_w(n_j-1)} dn_j + \left[\frac{\partial\mu_w}{\partial n_w}\right]_{P,n_j} dn_w$$

where the subscripts outside the brackets indicate the variables that are held constant in the evaluation. The component $\left[\frac{\partial\mu_w}{\partial P}\right]_{n_w,n_j}$ is the specific or molar volume of water (V_w), and is found by plotting the change of μ_w with respect to changes in P for the water in the soil and plant system. It can be identified as the turgor pressure in plants or as hydraulic pressure in saturated soils. The component

$$\left[\frac{\partial\mu_w}{\partial n_j}\right]_{P,n_w(n_j-1)}$$

is the slope of the curve found by plotting water potential as a function of the concentration of one solute, with pressure, water content and all the other solute concentrations held constant. It is summed over all the j components to give a complete osmotic potential. Following the notation of Guggenheim (ref. 12, p. 207) the term is given the symbol $D\mu_w \left[= \Sigma_j \left(\frac{\partial\mu_w}{\partial n_j}\right)_{P,n_w} dn_j \right]$. This term is analogous to that of 'osmotic pressure' now in use. The term $\left[\frac{\partial\mu_w}{\partial n_w}\right]_{P,n_j}$ is the slope of the curve found by plotting the water potential μ_w against water concentration at constant pressure and solute concentration. This is the moisture retention curve and is associated with the soil moisture tension or soil suction as now used. The term will also describe the condition of water within the cell walls or the colloidal system of the protoplasm which cannot be accounted for by turgor pressure or osmotic potential. It is effectively measured as a 'water-release' relationship for plant tissue.

(6) As written, the above expression refers only to isothermal situations. If required, an entropy term can be introduced to permit description of non-isothermal situations:

$$d\mu_w = \left[\frac{\partial\mu_w}{\partial P}\right]_{T,n_w,n_j} dP + \Sigma_j \left[\frac{\partial\mu_w}{\partial n_j}\right]_{P,T,n_w(n_j-1)} dn_j + \left[\frac{\partial\mu_w}{\partial n_w}\right]_{P,T,n_j} dn_w + \left[\frac{\partial\mu_w}{\partial T}\right]_{P,n_w,n_j} dT$$

where T is temperature and $\left[\frac{\partial\mu_w}{\partial T}\right]_{P,n_w,n_j} = -S_w$, where S_w is the specific or molar entropy of the soil or plant water.

(7) Although the differential form of these expressions is more comprehensive and descriptive, the integral form is more straightforward and provides a more direct transition from the existing terminology. For example, one can write:

$$\Delta\mu_w = V_w \Delta P + D_x\mu_w + \int_1^{n_w} \tau . dn_w$$

when $\Delta\mu_w$ is the water potential, V_w is the specific volume of water, ΔP is turgor pressure or hydrostatic pressure, $D_x\mu_w = \int_0^{n_j} D\mu_w$ is the osmotic potential, and $\int_1^{n_w} \tau . dn_w$ is the matric (adjectival form of 'matrix') potential, τ is the slope of the water-release curve and n_w the water content expressed as a mass fraction, but which can be expressed in any concentration unit that is consistent with the units used for expressing τ.

Normally $\Delta\mu_w$ will be negative since the potential of soil or plant water is less than that of free pure water which is the reference. In plant and soil systems ΔP will normally be positive since turgor pressure and hydraulic pressure are usually greater than atmospheric pressure. In applications to unsaturated soil ΔP can be either positive as in the pressure membrane apparatus or negative as with water inside a tensiometer. The osmotic potential ($D_{\pi}\mu_w$) will be negative or zero since the concentration of solutes in soil or plant solutions is never less than in free pure water. The water content (n_w) will always be less than pure water since the soil or plant will dilute the water and the complete matric potential will be negative.

As systems become more complex and more independent variables are necessary to describe the status of water in the system; additional terms may be added to the thermodynamic equation to include the new variables. Likewise, external force fields such as those of gravity and electricity can be accounted for by adding terms to the equation (ref. 12, pp. 403, 410).

(8) While these expressions may appear more complicated than the more straightforward hydraulic equations, it is apparent that the same components can be identified and the same techniques can be employed in measurement. For example, the water potential ($\Delta\mu_w$) may be measured in plant tissues using the same methods as are at present employed for measuring *DPD* [8–10]. It may be measured in soil by determining the equilibrium vapour pressure of soil cores[14–16] or by measuring the several components separately and adding them together. The osmotic potential ($D_{\pi}\mu_w$) will be measured in plant systems in the same manner as the osmotic pressure of the cell sap is at present measured[13]. Likewise, it may be measured in soil systems by determining the osmotic potential of the extract at saturation and adjusting the value to actual soil water contents[16]. The hydrostatic or turgor pressure (ΔP) is not easily measured in plant tissues. In soils it is measured with piezometers. The slope of the water-release curve (τ) can be obtained by simultaneous measurements of $\Delta\mu_w$ and water content. This may be effectively obtained for soils by the use of pressure membranes, pressure plates or tensiometers that are permeable to solutes. Vapour pressure equipment[17,18] may also be used, providing adjustments are made for the solutes that are present. Weatherley and Slatyer[19] have described an effective method for plants.

(9) At present the most common units of expression are the pressure units of atmospheres or bars. In order to interpret these values in free energy units, it is desirable that a unit of similar numerical size be adopted. The unit of joules kgm.$^{-1}$ is suggested, although ergs gm.$^{-1}$ could be used without difficulty. One erg gm.$^{-1}$ is equivalent to a pressure of one dyne cm.$^{-2}$ multiplied by the specific volume of water (which is unity). The numerical conversion from units of pressure to units of energy may be made as follows:

$$1 \text{ atm.} = 1{\cdot}013 \text{ bars} = 1{\cdot}013 \times 10^6 \text{ dynes cm.}^{-2} = 1033{\cdot}2 \text{ cm. water}$$

$$1 \text{ joule kgm.}^{-1} = 10^4 \text{ ergs gm.}^{-1} \doteq 10^4 \text{ dynes cm.}^{-2} = 10^{-2} \text{ bars} = 1 \text{ centibar}$$

$$1 \text{ bar} = 10^6 \text{ dynes cm.}^{-2} \doteq 100 \text{ joule kgm.}^{-1} = 10^6 \text{ ergs gm.}^{-1} = 1019{\cdot}7 \text{ cm. water}$$

---

[1] Richards, L. A., and Wadleigh, C. H., in "Soil Physical Conditions and Plant Growth", ed. Shaw, B. T., 73 (Academic Press, Inc., New York, N.Y., 1952).

[2] Meyer, B. S., *Plant Physiol.*, 20, 142 (1945).

[3] Ursprung, A., and Blum, G., *Ber. deut. bot. Ges.*, 34, 88 (1916).

[4] Stiles, W., *Biochem. J.*, 16, 727 (1922).

[5] Schofield, R. K., Trans. Third Int. Cong. Soil Sci., 2, 37 (1935).

[6] Edlefsen, N. E., Amer. Geophys. Union Trans. of 1941, Part 3, 22, 917 (1941).

[7] Edlefsen, N. E., and Anderson, A. B. C., *Hilgardia*, 15, 31 (1943).

[8] Broyer, T. C., *Bot. Rev.*, 13, 1 (1947).

[9] Broyer, T. C., *Plant Physiol.*, 26, 589 (1951).

[10] Broyer, T. C., *Plant Physiol.*, 26, 665 (1951).

[11] Taylor, S. A., *Soil Sci.*, 86, 83 (1958).

[12] Guggenheim, E. A., "Thermodynamics", third ed. (North Holland Publishing Co., Amsterdam, 1957).

[13] Crafts, A. S., Currier, H. B., and Stocking, C. R., "Water in the Physiology of Plants" (The Ronald Press Co., N.Y., 1949).

[14] Spanner, D. C., *J. Exp. Bot.*, 2, 145 (1951).

[15] Slatyer, R. O., *Aust. J. Biol. Sci.*, 11, 349 (1958).

[16] Richards, L. A., "Diagnosis and Improvement of Saline and Alkali Soils", U.S. Dept. Agric. "Agric. Handbook", No. 60 (1954).

[17] Richards, L. A., and Ogata, Gen, *Science*, 128, 1089 (1958).

[18] Monteith, J. L., and Owen, P. C., *J. Sci. Instr.*, 35, 443 (1958).

[19] Weatherley, P. E., and Slatyer, R. O., *Nature*, 179, 1085 (1957).

A GENETICALLY DETERMINED ENZYME IN THE PIG

By DR. K.-B. AUGUSTINSSON and DR. B. OLSSON

Institute of Organic Chemistry and Biochemistry, University of Stockholm, and
Department of Animal Nutrition, Genetics and Hygiene,
Royal Veterinary College, Stockholm

PIG blood plasma contains two esterases, an acetylarylesterase and a butyrylcholinesterase[1,2]. Both enzymes hydrolyse aromatic esters, for example, phenyl acetate, arylesterase being approximately 100 times more active toward this substrate than cholinesterase when hydrolysis rates are compared on a nitrogen content basis. In contrast to the activity of cholinesterase, the arylesterase activity exhibits considerable individual variation[2] with activity values ranging from 0 to 200. In previous reports[2,3] the values for arylesterase activity were expressed per 0·1 ml. plasma (instead of 0·02 ml., as in this communication) and were not corrected for cholinesterase activity. These values, therefore, are not directly comparable with those given above; they may be recalculated, however, by dividing previous values by 4 and subtracting with 10, which is the mean activity value per 0·02 ml. plasma for cholinesterase hydrolysing phenyl acetate.) These values were obtained with whole plasma and phenyl acetate in the presence of prostigmine, which selectively inhibits cholinesterase. Plasmas from all new-born piglets so far studied had very low activity in hydrolysing phenyl acetate. We have recently demonstrated[3] that the low activity at birth and also of certain adult animals is almost entirely due to cholinesterase, and is not due to the presence of an inhibitor. Previous experiments also demonstrated that the increase in plasma arylesterase activity of some piglets during the first weeks of life runs parallel with the increase in plasma albumin concentration, and that this increase in activity is gene-controlled. It was not possible, however, to explain how the various activity-levels are genetically determined and/or which type of gene interaction is most likely.

The results obtained recently in work with a great number of cross tests, including back-crosses, with pigs of various phenotypes have confirmed our proposal that the synthesis of plasma arylesterase is genetically controlled and made it possible to put forward the following hypothesis for gene interaction in the formation of this enzyme. The various phenotypes of adult animals are produced by the interaction of multiple allelic genes:

Allelic gene	Activity-level
a	0
A_1	25
A_2	50
A_3	75
A_4	100

Each allelic gene determines a certain plasma arylesterase activity and the distinguishable phenotypes among adult animals (at least two months of age) are produced as the manifestation of additive effects of two allelic genes, for example:

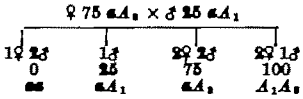
Genotype	Phenotype
aa	0
aA_2	50
A_1A_1	50
A_1A_3	100
A_3A_4	175

This hypothesis is strongly supported by the experimental results obtained, as will be briefly reported in the following. A full report will be published in *Hereditas*.

Matings were performed with animals of both Swedish Landrace (*Svensk lantras*) and Yorkshire breeds. No differences in gene interaction for the synthesis of plasma arylesterase have been observed between these breeds, pure or mixed. There is no sex influence upon this synthesis.

In our first experiments the phenotypes could be divided into three groups, corresponding to the esterase activities 75, 25 and 0. One sow from each group of the offspring obtained after crossing a boar of phenotype 0 (zero) with sows of various phenotypes was used in back-cross tests. A sow of phenotype 100 segregated into two phenotypes, 75 and 25. In back-cross tests, sows of either of these phenotypes again segregated into two groups, 75 and 0, and 25 and 0, respectively. It was concluded that the father was homozygous for the gene a responsible for 0 (zero) activity and that two allelic genes, A_3 and A_1, determined the activity of phenotypes 75 and 25, which consequently corresponded to the heterozygous genotypes aA_3 and aA_1. Similar results were obtained in matings with sows of phenotype 50 (genotype aA_2) and the same father. These experiments supported the hypothesis that four allelic genes produced the various phenotypes.

In order to obtain further evidence for the hypothesis, the progeny of a great variety of types of mating was studied. In all matings where both parents were of phenotype 0, the offspring were always of this same phenotype. When two sows of the same phenotype 100 were crossed with the same boar of phenotype 0 (genotype aa), the offspring in the two matings differed. There were two phenotypes (75 and 25) in one litter and only one (50) in the other. This means that the first sow was heterozygous for the genes A_3 and A_1, and the other sow homozygous for A_2. When both parents had the same plasma arylesterase activity (75), three phenotypes were obtained in the offspring in accordance with Mendelian inheritance. It was easily concluded that the genotype of both parents was aA_3 and the three phenotypes of the offspring corresponded to three kinds of genotypes, A_3A_3, aA_3 and aa. The offspring of a boar of phenotype 25 crossed with a sow of phenotype 125 segregated into three phenotypes, one of which (75) could correspond to two genotypes, aA_3 or A_1A_2. The existence of a series of multiple allelic genes was also supported by the observation of four phenotypes in the progeny of mating a boar of phenotype 125 and a sow of phenotype 100, the genotypes of which were A_2A_3 and A_1A_3, respectively. A similar segregation was obtained in the following mating:



In the series of mating performed, three various genotypes, A_1A_3, A_2A_2 and aA_4, were observed producing the same phenotype 100. These and a number of similar results strongly support the hypothesis that the biosynthesis of plasma arylesterase in adult pigs is genetically determined, and that the activity of this enzyme is the manifestation of additive effects of allelic genes.

The biochemical reactions determining this genetically controlled esterase activity are unknown. It has been demonstrated that the variation in activity is not due to the presence of activators or inhibitors. The various activities observed may be due to the same enzyme protein, the concentration of which varies or the specific activity of which is different in various phenotypes. The first explanation is the more likely, since it would be difficult otherwise to explain the rise in activity for certain groups in a litter during the course of lactation and also the various activity-levels observed. A third possibility is that the various activity-levels are due to the presence of different enzyme molecules of various turnover numbers, but this explanation seems unlikely for the same reasons. No differences in properties of the activity of various phenotypes have been observed. We therefore conclude that the various activity-levels found experimentally actually reflect various concentrations of the same enzyme protein, the synthesis of which is genetically determined by a series of multiple allelic genes. This synthesis is probably enzymatically controlled, and the activity of the enzyme(s) involved is (are) directly influenced by gene action.

We have no explanation so far as to the mechanism underlying the formation of the series of allelic genes. The existence of multiple activity-levels makes likely the occurrence of duplicate, triplicate and quadruplicate genes, corresponding to the allelic genes A_2, A_3 and A_4. This means that these alleles are to be regarded as the result of duplication, etc., of gene A_1 at the same locus in the chromosome.

This investigation has been supported by grants from the Swedish Medical Research Council. We are grateful to Prof. A. Hansson and Dr. S. Skårman, Animal Breeding Institute, Wiad, Sweden, for permission to use the livestock of that Institute.

---

[1] Augustinsson, K.-B., *Nature*, 181, 1786 (1958); *Acta Chem. Scand.*, 13, 571 (1959).

[2] Augustinsson, K.-B., and Olsson, B., *Biochem. J.*, 71, 477 (1959).

[3] Augustinsson, K.-B., and Olsson, B., *Biochem. J.*, 71, 484 (1959).

LETTERS TO THE EDITORS

ASTROPHYSICS

The Solar Flare of June 1, 1960

A SOLAR flare in the 3^+ category of importance and of exceptionally large extension was observed on June 1 at the Royal Greenwich Observatory, Herstmonceux, and at a number of other solar stations in Europe. We have recently been analysing the film in *Hα* light taken with the Lyot heliograph at the Royal Observatory, Cape of Good Hope, which gives a complete record of the flare at 1-min. intervals under cloudless conditions.

The spot group over which the flare occurred was of complex *E*-type containing 24 spots and had extended rapidly in area since its first appearance on the east limb on May 29. The flare began at 0823 U.T. and developed rather slowly until about 0837 when the 'flash' phase occurred with a rapid increase in area and intensity at the main centre (N., 30° lat.; E., 50° long.). The greatest extent of the emission filaments was recorded at about 0900 (Fig. 1) when the measured area was 27 (unit = 1 sq. degree heliographic at the centre of the solar disk). If we correct for foreshortening, the heliocentric angle (*h*) being 54°, we obtain a corrected area of 46 square degrees, or 2,230 millionths of the hemisphere, which makes this flare one of the largest observed in recent years and comparable in area with that of July 25, 1946.

From the measured co-ordinates we have replotted the shape of the flare as it would have appeared had it been seen on the Sun's central meridian. The emission filaments in this way can be seen to extend across the spot group in a north-east – south-west direction for a distance of 290,000 km., and some of the isolated outlying bright regions were located 200,000 km. to the south of the main centre.

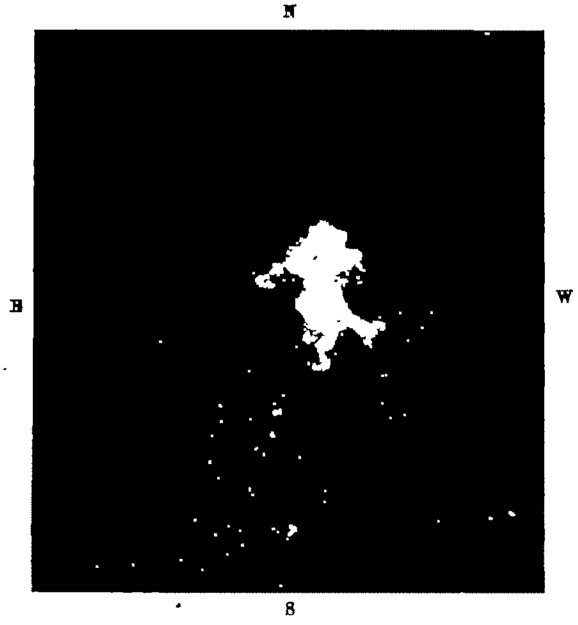


Fig. 1. Class 3^+ flare of June 1, 1960 (0900 U.T.), recorded with the Lyot *Hα* heliograph at the Royal Observatory, Cape of Good Hope

The Tatsfield Receiving Station of the B.B.C. (engineer-in-charge, H. V. Griffiths) reported a very severe sudden ionospheric disturbance occurring from 0837 until 1200, absorption remaining greater than normal until about 1400. In the peak period about 0900 all communications at high frequency were affected.

In the geomagnetic field a sudden commencement was recorded at 1800 on June 3, and this was followed by a minor storm (K_p max. = 7) lasting for two days. However, the distance of the flare from the Sun's central meridian reduced the probability that a magnetic storm would follow, and the long time interval between the flare and the sudden commencement, s.c. (57 hr.), suggests that this particular storm was caused by particles emitted from a subsequent flare.

A fuller account of the flare will be published elsewhere with accompanying light-curves. We wish to express our thanks to the staff at the Royal Observatory, Cape of Good Hope (under Prof. R. H. Stoy), for the fine film record; J. Churms, in charge of the Lyot heliograph, assisted by Mrs. E. Fiamingo, J. D. Laing, R. Lake and D. S. Malan.

M. A. ELLISON
SUSAN M. P. MCKENNA
J. H. REID

Dublin Institute for Advanced Studies,
School of Cosmic Physics,
Dunsink Observatory.

Effect of Upper Atmosphere Wind on the Rotation of Satellite $1958\delta 1$

CHANGES in the rotation of $1958\delta 1$ (*Sputnik* 3 rocket) can apparently be explained by, and give additional evidence of, strong westerly wind in the upper atmosphere. According to Merson, King-Hele and Plimmer[1] such air-flow, accompanying the Earth's rotation, accounts for observed effects in the movement of the orbital planes of satellites.

The rotation period of $1958\delta 1$, estimated from its regular fluctuations of brightness, increased at a decreasing rate, from just over 8 sec. in June 1958, to about 9·5 sec. in mid-November. It then decreased by at least 0·3 sec. during the last few days of flight, as noted, for example, by Carr, Stewart and Senne[2]. Late in July 1958, the rate of increase decreased significantly. This effect is mentioned by Esipova and Zverev[3]. It coincided with entry of the perigee into denser tropical atmosphere; King-Hele and Walker[4] found a change in the rate of decay of the orbital period at this point.

Air resistance at perigee alone would be expected to exert a progressively increasing deceleration of spin. The observed behaviour reveals an opposing acceleration, which increased with the air density at perigee, and in the end became dominant.

Esipova and Zverev determined from visual observations that the rotation axis was transverse to the rocket axis, giving end-over-end tumbling. Since the observed 'flash period' always increased slightly with increasing flight range of observation, the rotation was retrograde with respect to the west-to-east transits observed and, therefore, clockwise as viewed from the north.

Such rotation would be most sensitive to accelerating 'windmill' behaviour, generated by the cross-wind, when the satellite passed northwards through perigee in the relatively dense and fast circulating tropical atmosphere. This condition would apply from late July 1958 onwards, and the effect is likely to have increased considerably when the altitude decreased shortly before fall-in.

Each feature of the rotation thus appears to be accounted for, perhaps more convincingly than in terms of meteorite impact, material ablation or even forces of electrical or magnetic origin. It may be that only very long, light-weight objects such as cylindrical balloons and empty rocket cases will show this type of response.

C. R. FAULKNER

7 Womma Road,
Elizabeth North,
South Australia.

[1] Merson, R. H., King-Hele, D. G., and Plimmer, R. N. A., *Nature*, 183, 239 (1959).

[2] Carr, P. H., Stewart, R. M., and Senne, J. H., *Amer. J. Phys.*, 28 (1), 64 (1960).

[3] Halpova, M. L., and Zverev, M. S., *Astr. Sovet an SSSR.*, B, 4, 12 (1959). (R.A.E. Farnborough Lib. Trans. 842.)

[4] King-Hele, D. G., and Walker, D. M. C., *Nature*, 182, 860 (1958).

RADIOPHYSICS

Possibility of detecting Ionospheric Drifts from the Occurrence of Spread *F* Echoes at Low Latitudes

DURING the course of an investigation concerning the geographical extent of the scattered and diffuse echoes frequently observed during the night hours at high and low magnetic latitudes (spread *F*) an interesting phenomenon was observed. Times of occurrence of spread *F* echoes on ionospheric soundings taken every 15 min. during September and October 1957 at four stations in Peru (Talara, Chiclayo, Chimbote and Huancayo—average separation about 350 km., magnetic dip from 2° to 13°) strongly suggested that the patches of irregularities thought to be producing the spread *F* were often observed successively at each of the four stations. For example, an occurrence of spread *F* might be observed to begin at, say, 0015 hr. at Talara, the north-westernmost station, at 0045 at Chiclayo, at 0100 at Chimbote and at 0145 at Huancayo, the south-easternmost station. This tendency was particularly marked for the relatively short occurrences (less than about 2 hr. in duration) that were commonly observed during the latter half of the night. As the stations were located approximately along a straight line, it is not possible to deduce unambiguously the magnitude and direction of the suggested drift. It has been shown, however, that the geographic north–south component of the night *F* region drift is usually small at these latitudes[1]. Therefore, on the assumption that the drift was wholly in the magnetic east–west direction, magnitudes of the geographic east–west component of the apparent drifts indicated by the spread *F* occurrences during September and October have been estimated. A mean apparent drift velocity of 135 m./s. towards the east was obtained for period 0000–0400 hr. Skinner, Hope and Wright, using the Mitra technique at another equatorial location (Ibadan) during the same period, observed a mean east–west component of *F* region drift of about 110 m./s. towards the east[2]. The degree of agreement suggests that drifts, either of the patches of irregularities giving rise to the spread *F* echoes or of the disturbance producing the irregularities, may play an important part in the occurrence of spread *F* at low latitudes.

A more comprehensive study of spread *F* occurrences along the Peruvian chain of stations during the International Geophysical Year period, including a full interstation correlation analysis, is now being completed and will be published elsewhere.

R. W. KNECHT*

National Bureau of Standards,
Boulder, Colorado.
Aug. 3.

* On leave at the Cavendish Laboratory, Cambridge, England.

[1] Purslow, B. W., *Nature*, 181, 35 (1958).

[2] Skinner, N. J., Hope, J., and Wright, R. W., *Nature*, 182, 1363 (1958).

PHYSICS

Thermal Expansion at Low Temperatures

CONSIDERABLE experimental data have been published[1] on the heat capacity C of solids, extending to temperatures which are very low in relation to their characteristic temperature θ; data are available in the temperature region $T \sim \theta/100$, where the Debye continuum model may be expected to apply and where for metals the electronic contribution is important. Complementary information regarding the thermal expansion coefficient, α, is desirable as it would throw additional light on the lattice dynamics of solids, particularly the anharmonic nature[2] of the interatomic forces as evidenced by the Gruneisen parameter $\gamma = 3\alpha\chi V/C$ (χ = incompressibility, V = volume). Also any data obtained about an electronic expansion coefficient, α_e, in metals should provide useful information about their band structures.

Unfortunately, most methods of measuring the expansion, whether by X-rays[3], interferometry[4] or capacitance[5], have not been sufficiently sensitive to trace its variation much below $\theta/10$. However, there are now available techniques for the accurate comparison of small capacitances which allow movements as small as 10^{-9} cm. to be detected, and these may be used to determine expansion coefficients down to $T \sim \theta/100$. Such techniques depend on the use of three-terminal capacitors in which the capacity to be measured is a mechanically well-defined gap between two of the terminals (or conducting surfaces) and the third terminal is a conductor which acts both as a guard ring and as a shield surrounding the other two. This unknown capacitance is then compared with a reference capacitance in a four-arm bridge of which the two other arms are tightly coupled inductive arms; ground-lead capacitances do not appear in the balance equations but merely affect the bridge sensitivity. Some recent developments in precise capacitance measurement have been described by Thompson[6] and their application to measuring thermal expansion will be described elsewhere[7]. The measurements described here on the thermal expansion of copper and iron were made with a capacitance-bridge kindly loaned by Mr. A. M. Thompson, of the Commonwealth Scientific and Industrial Research Organization Division of Electrotechnology.

An expansion 'cell' was made from O.F.H.C. copper (plus brass screws and mica insulating washers) which is a cylinder about 6 cm. long and 5 cm. diameter; in it is mounted a bobbin-shaped specimen of 5-cm. length with parallel lapped faces of 2-cm. diameter at each end. One end is fixed and the other (free) end-face forms a parallel-plate condenser with a 1·3-cm. diameter copper plate distant about 0·02 cm. Variations in the relative length of specimen and copper cell alter this 0·02-cm. gap and hence alter its capacitance. With our present bridge sensitivity of 10^{-6} *pF*, the 5 *pF* capacitance formed by this gap may be measured to 1 in 5×10^6, corresponding to $0{\cdot}5 \times 10^{-8}$ cm.; this amounts to about 1 part in 10^9 for a system of length 5 cm.

The expansion cell is mounted in a conventional cryostat[3] so that its temperature may be varied from 1·2° to 300° K. Thus far, most measurements have been confined to the region below 25° K. on specimens of (A) annealed O.F.H.C. copper, (B) sintered beryllium, kindly supplied by the Australian Atomic Energy Commission through Mr. G. L. Hanna, of its Metallurgy Section, (C) annealed 99·96 per cent iron, kindly supplied by the British Iron and Steel Research Association. Hence data have been obtained on the relative changes in length of (A) copper versus copper, (B) copper versus beryllium, (C) copper versus iron.

For system (A) the variation of gap with temperature is very small, confirming that the cell is mechanically stable.

For system (B) the relative measurements on copper–beryllium give values of the expansivity of copper if α(beryllium) $\ll$ α(copper). At low temperatures ($T < \theta/10$) we expect this to be true, at least for the lattice vibrational contribution, α_g, since to a first approximation:

$$\alpha_g(\text{beryllium})/\alpha_g(\text{copper}) \simeq C_g(\text{beryllium})/C_g(\text{copper}) \simeq [\theta(\text{copper})/\theta(\text{beryllium})]^3$$

and θ(copper) is more than three times smaller than θ(beryllium); here C_g is the lattice component of the specific heat. It appears partially confirmed by our data which then yields $\alpha = 0{\cdot}59_5 \times 10^{-6}$ per deg. C. as compared with a value $\alpha = (0{\cdot}58 \pm 0{\cdot}04) \times 10^{-6}$ per deg. C. obtained by Rubin *et al.*[4] at 25° K., their lowest temperature. However, this does not preclude beryllium from exhibiting a small electronic coefficient α_e, proportional to temperature (rather than T^3 as for α_g), which may be important in the evaluation of our results below 5 or 10° K. Concerning α_e, Visvanathan[5] has deduced theoretically that the electron gas should be responsible for a thermal expansion coefficient given by $3\alpha_e = aC_e/\chi V$, where C_e is the electronic heat capacity. The numerical constant a (sometimes denoted γ_e) should be 2/3 for a free electron gas, and for copper this leads to $\alpha_e \simeq 1{\cdot}5 \times 10^{-10}\,T$ per deg. C.; for beryllium it would lead to about half this value for α_e if the assumption $a = 2/3$ were true.

Assuming the expansivity of beryllium to be negligible, the data on system (B) give the following results for copper:

(1) No evidence of change in length greater than about 1 Å. could be detected between 1 and 4° K. If we assume that $\alpha = \alpha_e + \alpha_g = AT + BT^3$, then this limits the term $\alpha_e = AT$ to be not greater than $2 \times 10^{-10}\,T$ and the second term to $3 \times 10^{-11}\,T^3$. Theoretically α_e should be slightly less than this limiting value and may be partially masked by a similar term in beryllium.

(2) Analysis of the changes in length observed in the region from 4 to about 9 or 10° K. indicated that $\alpha \simeq (3{\cdot}0 \pm 0{\cdot}3) \times 10^{-11}\,T^3$ per deg. C.

(3) Two sets of values for the Grüneisen parameter were calculated as follows: a value γ_T(total) $= 3\alpha\chi V/C$, where $C = C_e + C_g$ and a value γ_g(lattice) $= 3\alpha_g\chi V/C_g$. Values of γ_T were sensibly constant at $1{\cdot}85 \pm 0{\cdot}05$ down to about 12° K. but fell rapidly below that, reflecting the apparent absence of any linear term in α to counterbalance the linear term in C. However, γ_g remains fairly constant to the lowest temperatures. Below 10° K., values $\gamma_g = 1{\cdot}9 \pm 0{\cdot}2$ follow from the relation $\alpha = (3{\cdot}0 \pm 0{\cdot}3) \times 10^{-11}\,T^3 = \alpha_g$ and the established data that $C_g = 1946\,(T/345)^3$ j/g mole deg.

For the system (C) of iron versus copper, changes in length were observable down to 1·5° K. These were approximately proportional to T^2 at the lowest temperatures, corresponding to an expansion coefficient varying as T. Above 4° K. they were corrected for the expansion of copper using data obtained on system (B). Results may be summarized for iron as follows:

(1) Below 8° K., $\alpha \simeq (0{\cdot}26 \pm 0{\cdot}04) \times 10^{-8}\,T$ per deg. C.; assuming that this linear term is the electronic coefficient α_e, then we find that $a = \gamma_e = \alpha_e\chi V/C_e \simeq 1{\cdot}7$.

(2) Between 8° and 15° K., results can be represented by $\alpha = 0{\cdot}26 \times 10^{-8}\,T + (1{\cdot}05 \pm 0{\cdot}1) \times 10^{-11}\,T^3$; if the second term is identified with α_g, then $\gamma_g \simeq 2{\cdot}0 \pm 0{\cdot}2$. Much of the uncertainty in the expansion coefficient above 8° K. arises because the correction for copper is substantial.

(3) Data obtained in the region 55–90° K. give values of γ_T ranging from 1·62 to 1·68 and measurements between 20 and 15° K. give $\gamma_T = 1{\cdot}8 \pm 0{\cdot}1$. These may be compared with a room temperature value of about 1·7.

Apart from taking further measurements on the system (C) between 10° and 50° K., it is hoped to: (a) obtain absolute values of α for copper using a different form of expansion 'cell' in which the specimen may be raised in temperature while the 'cell' is fixed at the temperature of a liquid bath. Such a cell has been completed and seems to work satisfactorily; (b) data for sapphire relative to copper in the existing 'cell' should also yield α values for copper since α for sapphire should be negligible at the lowest temperatures; (c) data on the electronic expansion coefficient for chromium and for palladium, (d) data for lead relative to copper between 1° and 10° K. where we should expect $\alpha_g(\text{lead}) \gg \alpha_g(\text{copper})$, and ($e$) data on the electronic expansion coefficient for the superconductors aluminium and niobium would be of great interest. Earlier measurements[10] of the change in dimensions of aluminium when superconductivity is destroyed by a magnetic field suggest that α_e should be surprisingly large; for niobium the large electronic heat capacity in the normal state and its high transition temperature make it an interesting study.

In conclusion, it appears from these measurements that iron exhibits a component of thermal expansion arising from the free electrons. In copper no such component has been found as yet although values for the Grüneisen parameter have been established down to below 10° K.

I am most grateful to my colleagues Messrs. A. F. A. Harper, W. R. G. Kemp and A. M. Thompson for their interest and advice.

GUY K. WHITE

Division of Physics,
Commonwealth Scientific and
Industrial Research Organization,
Sydney.
July 14.

---

[1] Review by Keesom, P. H., and Pearlman, N., "Handb. der Physik", 14, 282 (1956).

[2] Barron, T. H. K., *Phil. Mag.*, 46, 720 (1955).

[3] Simmons, R. O., and Balluffi, R. W., *Phys. Rev.* 108, 278 (1957).

[4] Rubin, T., Altman, H. W., and Johnston, H. L., *J. Amer. Chem. Soc.*, 76, 5289 (1954).

[5] Bijl, D., and Pullan, H., *Physica*, 21, 285 (1955).

[6] Thompson, A. M., *Inst. Rad. Eng. Trans. Instrumentation*, I-7, 245 (1958).

[7] White, G. K., to be submitted to *Cryogenics* (Heywood, London).

[8] White, G. K., "Experimental Techniques in Low-Temperature Physics", 158 (Oxford University Press, 1959).

[9] Visvanathan, S., *Phys. Rev.*, 81, 626 (1951).

[10] Olsen, J. L., and Rohrer, H., *Helv. Phys. Acta*, 30, 49 (1957).

Effect of Temperature on the Expansion on Setting of Gypsum Plaster

IT has been shown by Ridge[1] that setting-temperature exerts a profound effect on the structure of set gypsum plaster. He postulated that this change in structure would be accompanied by changes in other properties such as the expansion on setting. Experimental evidence showing the expansion of plaster on setting at different temperatures has recently been obtained. The observations were made incidental to the preparation of plaster samples of different pore sizes that were to be used as standard porous bodies.

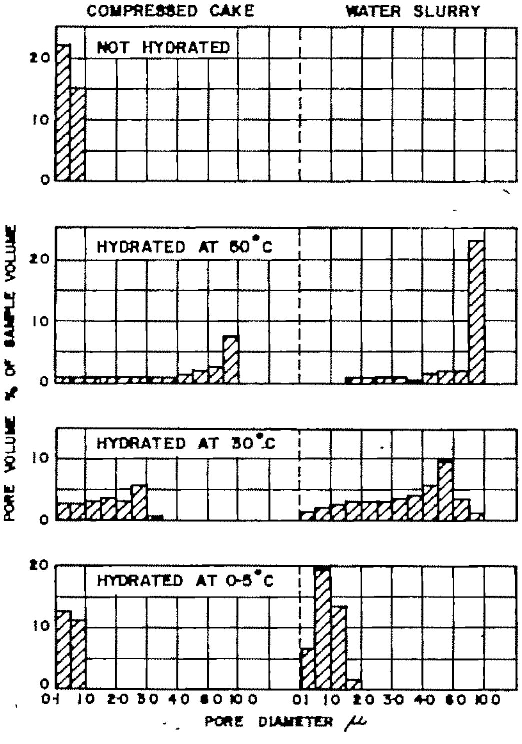


Fig. 1. Histograms for the pore-size distribution of plaster samples hydrated at different temperatures

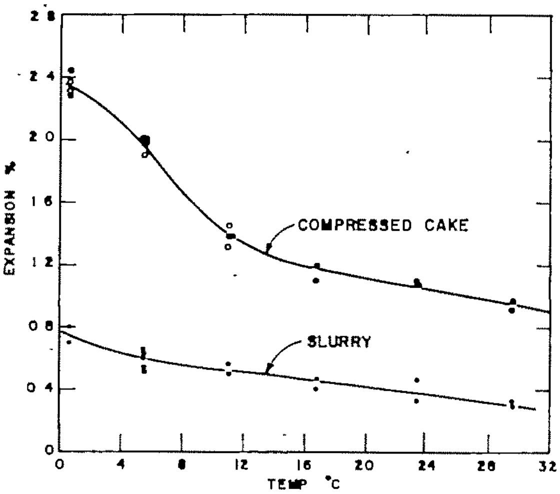


Fig. 2. Expansion on setting of plaster at different temperatures

A method was developed for compressing plaster of paris at a pressure of 5,000 p.s.i. into a cake which could then be hydrated at a desired temperature. The average pore size decreased as the temperature of set was decreased. This result confirms the observations made by Ridge[1] that crystal sizes decrease as the temperature of set is decreased.

Thus it has been found that by varying the temperature of set of plaster samples it was possible to vary their pore sizes over a wide range, as was also found by Ridge and Crook[2]. This was true whether the samples were made from a cake or water slurry of plaster of paris. Histograms for the pore-size distribution as obtained by a mercury porosimeter are given in Fig. 1. These results are for samples made from commercial unretarded plaster of paris. This plaster did not give reproducible results for expansion on setting.

Samples of pottery plaster compressed into cakes as well as mixed as water slurries in the ratio of 2 : 1 (plaster to water) were allowed to set at various temperatures. The expansion due to setting was measured with the aid of a travelling microscope. This expansion increased as the temperature of set was decreased. The results are shown in Fig. 2. The cake expanded about three times as much as the slurry for the same temperature of set.

The expansion on setting of plaster from a slurry was explained by Lea and Nurse[3] and Hill and Ridge[4] as being caused by the growth of crystals in contact. On this basis, when the conditions of setting are such as to lead to smaller crystals the chance of encounter with other crystals is greater, and expansion should be greater. It follows also that if the crystals are brought closer together initially the final expansion will be even greater for the same final size and shape of crystals. The greater expansion of the cake, which was about three times as much as that of plaster set from a water slurry at the same temperature, appears to confirm this. In the compressed cake the particles of hemihydrate are in actual contact, and expansion must begin as soon as hydration begins. In the case of the slurry, particles of hemihydrate are separated by water, and hydration can proceed for some time before encounter of the crystals occurs. In fact, a contraction is first observed when plaster begins to hydrate from a slurry.

The above results have practical significance in so far as they indicate the factors which control the expansion and pore-size distribution of setting gypsum plaster. Such information should be useful where control of these properties is essential.

I gratefully acknowledge the assistance of S. E. Dods, who carried out the laboratory experiment, and I also wish to thank B. M. O'Kelly for his helpful criticism.

P. J. SEREDA

Building Materials Section,
Division of Building Research,
National Research Council,
Ottawa.

[1] Ridge, M. J., *Nature*, 182, 1224 (1958).

[2] Ridge, M. J., and Crook, D. N., *Aust. J. App. Sci.*, 10, 497 (1959).

[3] Lea, F. M., and Nurse, R. W., *Disc. Farad. Soc.*, 5, 350 (1949).

[4] Hill, R. D., and Ridge, M. J., *Aust. J. App. Sci.*, 10, 232 (1959).

Packing of Mixtures of Hard Spheres

We were pleased to see the recent communication[1] by E. B. Smith and K. R. Lea on their Monte Carlo calculation for mixtures of hard-sphere molecules. We are quite interested in this problem and have been trying to approach it experimentally by studying the random packing of mixtures of real macroscopic spheres.

When smooth spheres are poured into a container and lightly tamped, they assume a firmly packed disordered configuration. This corresponds, we believe, to the high-density limit of the disordered upper branch of the curve for the hard-sphere equation of state. In their machine computations on hard-sphere systems, Alder and Wainwright[2], and Wood and Jacobson[3], have found that an apparent phase transition to an ordered configuration usually occurs before the disordered configuration is tightly packed. By suppressing this transition, however, Jacobson and Wood were able to extend some of their Monte Carlo studies to disordered systems at the high-density limit[4]. We hope that Smith and Lea will also have an opportunity of investigating this limit in their calculations. We think it would be well worth while to check, whenever possible, how closely a few spheres with periodic boundary conditions actually behave like many spheres.

We have so far tested each of three different binary systems of 'Lucite' spheres at eleven different mixture ratios. We measure the piston displacements produced by successive pre-mixed 500-ball aliquots in each of five cylinders of various diameters. By extrapolating the average displacement volume to infinite cylinder diameter we eliminate surface effects. The results reported here have been digested from some 2,000 separate measurements.

In the three systems tested the contraction, or negative excess volume, was found to be approximately symmetrical:

$$V^{xs} \simeq -2A\,(V_1 + V_2)X_1X_2$$

where A is a dimensionless contraction factor dependent on the volume disparity, and X_1 and X_2 are 'mole' fractions. Even with our largest disparity, corresponding to a radius ratio of 1·6 : 1, there was no apparent asymmetry. By contrast, the calculations of McLellan and Alder[5] indicate a pronounced asymmetry at this radius ratio in low-density mixtures. The comparison is ambiguous, however, since their results also show that the asymmetry tends to vanish when the volume contractions are as small as those we have found.

Table 1

V_1 (c.c./ball)	V_2 (c.c./ball)	V^{xs} ($x = 0·5$, c.c./ball)	A
0·642	0·406	−0·003 ± 0·001	0·006 ± 0·002
0·646	0·266	−0·004 ± 0·001	0·009* ± 0·002
0·647	0·160	−0·012 ± 0·001	0·030 ± 0·002

The actual volumes of the spheres themselves were 0·408 c.c. for the larger component and 0·260 c.c., 0·1705 c.c. and 0·1032 c.c., respectively, for the smaller components. The packing volumes for the disordered pure components, as shown in Table 1, exceed the calculated close-packed volumes by 17·0, 16·0, 15·3 and 14·8 per cent, respectively, in very good agreement with the figure of 15(±3) per cent reported by O. K. Rice[6].

The apparent variation in volume of the larger component, V_1, is an artefact of the statistical analysis. If, as we suppose, it is due to a slight unacknowledged asymmetry in V^{xs}, it should be approximately linear in the volume disparity, δ (defined below), and should affect the volumes of the smaller components in an equal but opposite manner. Our values of A should not be affected at all by such an asymmetry.

We summarize our results by:

$$A \simeq 0{\cdot}019_5\,\delta^2$$

where $\delta = 2(V_2 - V_1)/(V_2 + V_1)$ is the dimensionless volume disparity. Since A must be an even function of δ which goes to zero at $\delta = \pm 2$, as well as at $\delta = 0$, our expression gives only the limiting behaviour at small differences of radii. We find no indication of a positive V^{xs} at small δ.

For larger differences of radii there are similar results reported by C. C. Furnas on mixtures of lead shot and other systems[7]. It would be interesting to see if Furnas's estimated shrinkages for arbitrary fractional void contents in static systems are anything like the results one calculates for dynamic systems with the same voidages.

PAUL C. MANGELSDORF, JUN.
ELMER L. WASHINGTON

Institute for the Study of Metals,
University of Chicago,
Chicago 37, Illinois.

June 27.

[1] Smith, E. B., and Lea, K. R., *Nature*, 186, 714 (1960).

[2] Alder, B. J., and Wainwright, T. E., *J. Chem. Phys.*, 27, 1208 (1957).

[3] Wood, W. W., and Jacobson, J. D., *J. Chem. Phys.*, 27, 1207 (1957).

[4] Jacobson, J. D., and Wood, W. W., Progress Report GMX-10-22, Los Alamos Scientific Laboratory (1958).

[5] McLellan, A. G., and Alder, B. J., *J. Chem. Phys.*, 24, 115 (1956).

[6] Rice, O. K., *J. Chem. Phys.*, 12, 1 (1944).

[7] Furnas, C. C., *U.S. Bur. Mines Bull.*, 307, 74 (1929); also *Indust. and Eng. Chem.*, 23, 1052 (1931).

Radioactive Labelling of Membrane Filters for the Assay of Air-borne Material

The quantitative assessment of air-borne material with membrane filters is being widely employed, mainly because of their high collection efficiency, non-hydroscopic properties and more uniform particle deposition than on other filter materials[1]. Since most of the particles deposited are held at the surface[2], the classical methods of assessment of deposits can be replaced or augmented by indirect methods. The latter consist, for example, in estimating the amount of deposit material by comparing stains[3] with suitable

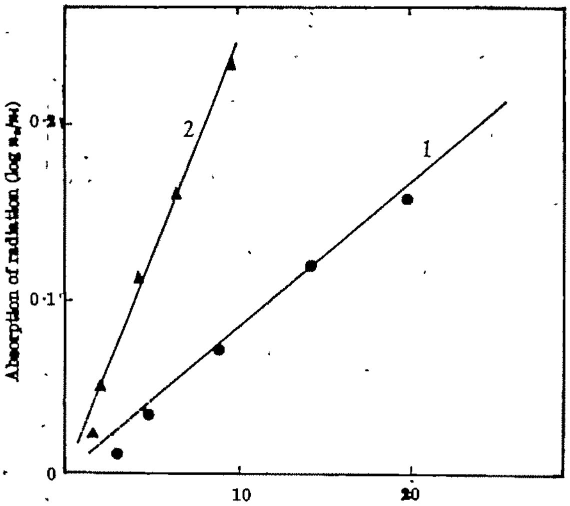


Fig. 1. Relation between β-ray absorption and thickness of dust layer. Curve 1, filters labelled with thallium-204; curve 2, filters labelled with nickel-63

standards or by objective measurement as, for example, reflectance photometry[4]. Chemical reaction between suitably impregnated or wetted filters and aerosol droplets may also be employed with quantitative estimation of the resulting colour effects[5].

It is known that various substances may be incorporated into the filter mass by adding suitable reagents to the stock solutions used for filter preparation[6]; thus it is possible to obtain filters containing chemical reagents in the form of very fine and homogeneous dispersion throughout the filter. Such reagents may react with aerosol droplets or with the surface layer of solid particles.

The application of radioactive thickness gauging for the estimation of deposit mass in filters has already been reported[7]. The present communication deals with the application of special features of membrane filters by converting the filters themselves into the radiation source used for thickness gauging, thereby eliminating the effect of filter thickness from measurement.

Although the incorporation of radioactive material into the filter mass is an evident procedure and will be reported in due course, initial work was performed by adsorbing radioactive nickel or thallium salts from solution upon the filter surface. The filters used had a mean pore size of $2r = 0·9\mu$ and a thickness of 130μ. The diameters of the filter disks were 36 mm. Initial total filter activities were 0·1–0·2 μc. and 1–5 μc. for thallium and nickel filters, respectively.

Filters of this kind were used for the estimation of the concentration of solid aerosols and industrial dust of constant composition. Prior to air filtration, initial filter activity was measured with a Geiger–Müller window counter (3·7 mgm./cm.^{2}) (activity n_0). Thereafter air was drawn through the filter, and as soon as a visible layer had formed on the filter, filtration was interrupted, residual activity measured and the mass of the deposit determined by weighing. This procedure was repeated several times and the expressions log n_0/n_i, where n_i are the residual activities, calculated. These values were correlated with the amounts of deposit per unit filter area.

Fig. 1 illustrates a typical example with flue dust of mean particle size $1·7\mu$, the chief chemical components of which were alumina, ferric oxide, silica and traces of other components. Experiments summarized in Fig. 1 were performed with filters labelled with nickel and thallium.

Results indicate that the preparation of homogeneously labelled filters and measurement therewith are possible. Such filters may be used for the rapid assessment of air-borne material. The lower limit of sensitivity is at present found to be 1·6 mgm./cm.^{2} and 6·0 mgm./cm.^{2} for filters labelled with nickel and thallium, respectively. Because of their weak radiation and long half-lives, nickel filters seem to be the more suitable ones. With an effective filter area of 1 cm.^{2}, absolute air volumes of 10–300 litres are sufficient to obtain deposits suitable for the assessment of high and medium dust concentrations.

It is evident that the present procedure provides mass-proportional values of dust concentration. More detailed investigation indicates that the sensitivity of measurement by the method outlined depends not only on the chemical composition of the assayed dust but also on its particle size distribution.

A more detailed account of this work will appear elsewhere.

G. Kubie

Mining Institute,
Czechoslovak Academy of Sciences,
Prague, 8.

K. Spurný

Institute of Physical Chemistry,
Czechoslovak Academy of Sciences,
Prague, 12.

[1] Spurný, K., and Vondráček, V., *Chem. Listy*, 50, 1331 (1956).

[2] Kubie, G., Jech, C., and Spurný, K., *Coll. Czechoslov. Chem. Comm.* (in the press).

[3] Spurný, K., *Prac. Lékařství*, 11, 197 (1959).

[4] Paulus, H. J., Talvitie, N. A., Fraser, D. A., and Keenan, R. G., *Indust. Hyg. Quart.*, 18, 267 (1957).

[5] Lodge, J. P., and Tufts, B. J., *Tellus*, 7, 2 (1956).

[6] Spurný, K., *Chem. Listy* (in the press).

[7] Stephan, D. G., Bohnslav, P. T., Herrick, R. A., Walsh, G. W., and Rose, jun., A. H., *Amer. Indust. Hyg. Assoc. J.*, 19, 276 (1958).

RADIATION CHEMISTRY

Changes in Conductivity of Pure Water caused by X-Irradiation

Most of our present knowledge about the physicochemical processes occurring in the radiolysis of water has been obtained by purely chemical methods[1]. I have now tried to obtain some additional data by using a physical method. In the course of the primary and secondary processes which occur when water is irradiated with ionizing radiation, it is possible that charged particles will be formed which cause an increase in conductivity during irradiation. I therefore studied the variation with time of the conductivity of pure, non-degassed water when it was submitted to pulsed X-irradiation, in order to obtain information about the eventual concentration and life-time of such charged particles[2].

In a preliminary investigation, water, prepared by distilling three times—twice in a quartz still—with access of air, was irradiated in a conductivity cell made of 'Plexiglas' and with silver electrodes, with X-ray pulses (60 kVp., average dose-rate about 5 kr./min.) obtained by a rotating sectored disk.

A d.c. voltage was applied to the cell through a resistor, so that a periodical change in conductivity synchronous with the X-ray pulses would give rise

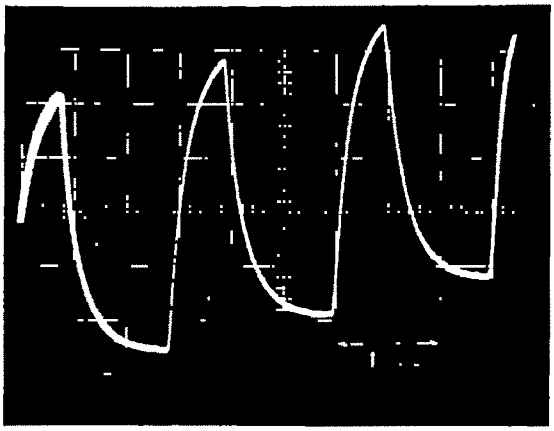


Fig. 1. Photograph of an oscilloscope picture showing the variation of conductance when water is irradiated with square wave X-ray pulses (light to dark period 1 : 2)

to an a.c. voltage with the same frequency. This voltage was measured by means of a synchronized amplifier. The synchronization was effected by interrupting the light beam falling on a photoelectric cell by the same sectored disk.

The experiment showed that there was in fact a periodical change in conductivity, the amplitude of which was inversely proportional to pulse frequency in the range from 10 to 3,000 c.p.s. covered in this investigation. It could therefore be concluded that during irradiation ions were formed with a life-time greater than 0·1 sec.

Based on these results, I constructed an apparatus with which I could display on an oscilloscope screen the variation with time of the conductivity of water irradiated with slow X-ray pulses (0·2–20 c.p.s.).

The water used in this experiment was pre-distilled first from alkaline permanganate and then from acid dichromate solution before being further purified in the quartz still, in order to be certain that no organic impurities were present. Between the two quartz distillation stages the vapour was heated to about 800° C. The conductivity cell, this time made of quartz and with platinum electrodes, was connected to an a.c. bridge operating at 2 kc.p.s. The diagonal voltage, which was proportional to the variation of conductance, was amplified, rectified, and fed to a d.c.-oscilloscope ('Tektronix').

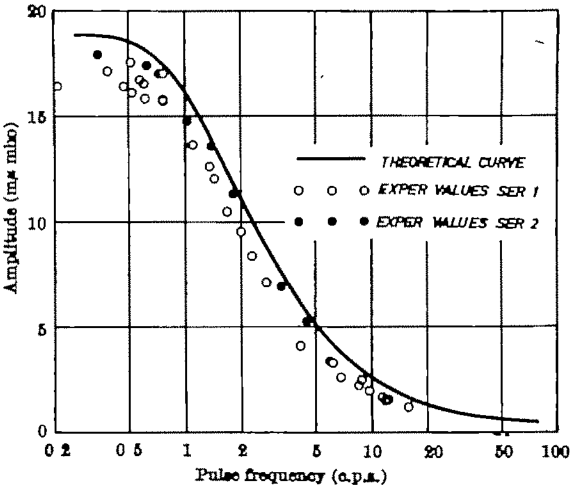


Fig. 2. Amplitude of the periodic variation of conductance as a function of pulse frequency. The theoretical curve is calculated from the experimentally obtained dose-rate dependence and life-time. Maximum dose-rate, 11·9 krads/min.

Fig. 1 shows a photograph of the oscilloscope picture showing the variation of conductance caused by irradiation with square wave-pulses (light to dark period = 1 : 2). In Fig. 2 the amplitude of the periodical conductance changes is plotted against pulse frequency. Two effects seem to be superimposed: (1) A reversible increase in conductivity during irradiation which returns to zero after the end of irradiation; (2) an irreversible rise in conductivity which starts practically instantaneously with irradiation and continues until the end of irradiation.

An analysis of the variation of conductivity as a function of pulse-frequency and dose-rate leads to the conclusion that the reversible effect may be due to the formation of ions the concentration of which varies according to the differential equation:

$$\frac{d[X]}{dt} = G_x \frac{\delta}{N_a} - k'[X][S] - 2k[X]^2$$

where $[X]$ is the concentration of the ions in question, $[S]$ that of a scavenger substance with which these ions can react monomolecularly, N_a the Avogadro number, δ the dose-rate, k and k' reaction constants, and G_x the yield of the ions formed.

A comparison of the properties of the observed ions with radiation-chemical data from the literature suggests that the ion X may be identical with the radical-ion $\cdot O_2^-$, that is, the anion of the radical $HO_2\cdot$ (ref. 3). If this is assumed and if the radical $HO_2\cdot$ is completely dissociated at the pH of the water investigated (5·5): $G_x = 4{\cdot}3$ radicals/100 eV., $k'[S] = 2{\cdot}9$ sec.$^{-1}$, and $k = 1{\cdot}45 \times 10^7$ litres/mole × sec. The radical-ion $\cdot O_2^-$ is, according to Hajssinsky[4], formed directly by the reaction of H-radicals with the dissolved oxygen:

$$H\cdot + O_2 \rightarrow H^+ + \cdot O_2^-$$

A more detailed discussion of a chemical reaction mechanism suggested leads to the equation: $G_x = G_H + G_{OH} + G_{HO_2} - 0{\cdot}4 = 4{\cdot}6$ radicals/100 eV. (with radical yields according to Allen and Schwarz[5]). Dainton and Rowbottom[6] have determined the recombination constant of the radical $HO_2\cdot$ as 3×10^6 litres/mole × sec. The difference between this value and mine (for $\cdot O_2^-$) might be explained by a difference in pH.

The irreversible effect observed in my experiment is probably due to the formation of percarbonic acid from the carbon dioxide dissolved in the water[7]. According to my experiment the yield of this reaction would be $G(H_2CO_4) = 0{\cdot}2$ molecule/100 eV. The term 0·4 in the equation for G_x mentioned above is twice this value.

A full account of this investigation will be published elsewhere.

K. Schmidt

Max Planck-Institut für Biophysik,
Forsthausstr. 70,
Frankfurt a. M.

---

[1] Dainton, F. S., *Brit. J. Radiol.*, 31, 645 (1958).

[2] Lotz, A. P., and Schmidt, K., *Strahlentherapie*, 110, 223 (1959).

[3] Weiss, J., *Trans. Farad. Soc.*, 31, 668 (1935).

[4] Hajssinsky, M., *J. chim. phys.*, 53, 542 (1956).

[5] Allen, A. O., and Schwarz, H. A., Proc. Internat. Conf. Geneva (1958).

[6] Dainton, F. S., and Rowbottom, J., *Trans. Farad. Soc.*, 49, 1160 (1953).

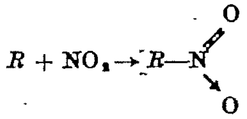
[7] Günther, P., and Holzapfel, L., *Z. Phys. Chem.*, 49, 303 (1941).

Radiation-induced Nitration of Aliphatic Hydrocarbons

THE behaviour of fission product iodine in a tributyl phosphate–kerosene system for reprocessing pile-irradiated uranium fuels has recently been studied in this laboratory. It was found that the principal mode of fixation of iodine in the hydrocarbon diluent was scavenging by hydrocarbon radicals produced by the action of the fission product radiation. However, it was observed that the G-value for fixation under process conditions was only about 0·1. This is very much lower than the values of about 7·0 reported for air-free n-heptane[1] and 5·6 for air-free *cyclo*hexane[2], which are generally accepted as giving some indication of the total yield of radicals in irradiated aliphatic hydrocarbons.

It was considered that other radical scavengers must be present in the process solutions in addition to the iodine. Atmospheric oxygen will certainly be at least partly responsible for the low uptake of iodine; but it was surmised that the nitrogen oxides, always present in radioactive nitrate solutions, may be more important in some cases. The oxides NO and NO_2 both have an 'odd electron' structure and are paramagnetic; they would therefore be expected to combine with alkyl radicals rapidly and with little activation energy requirement. To test this idea, n-dodecane containing 10 gm. NO_2/litre was irradiated using a 7·2-c. strontium-90 β-source. The mean radiation dose-rate was 2×10^{18} eV./ml. hr. and the duration of the irradiation was 114 hr. No special precautions were taken to exclude air. Infra-red spectral examination of the irradiated dodecane showed strong R—NO_2 (1,555 cm.$^{-1}$, 1,350 cm.$^{-1}$) and R—COOH (1,720 cm.$^{-1}$) bands. Slight absorption peaks at 1,680 cm.$^{-1}$ and 1,645 cm.$^{-1}$ were attributed to alkyl nitrite and alkyl nitrate, respectively. Comparison with standard substances showed that the G-value for R—NO_2, assumed to be nitrododecane, was 5·0. The yield of carboxylic acid, taken as dodecanoic acid, was about 1·0. No change could be detected in a dodecane solution of NO_2 which had been allowed to stand in the absence of radiation for a similar length of time. Carboxylic acid formation is presumably the end result of radical scavenging by atmospheric oxygen: in an earlier experiment, in which the dissolved NO_2 became exhausted, the yield of carboxylic acid was more than doubled.

These results are in good agreement with previous work on iodine scavenging in oxygen-free hydrocarbons[1,2] and suggest that one of the most important solvent degradation phenomena in highly active tributyl phosphate–hydrocarbon processes may be radiation-induced nitration. It is probable, in NO_2 solutions that are completely devoid of oxygen, that the only products arising from the alkyl radicals will be nitroalkanes together with small amounts of alkyl nitrites, the latter possibly arising from a reaction of alkyl radicals with excited NO_2 molecules:



$$R + NO_2 \rightarrow R\text{—}N\begin{smallmatrix} \nearrow\!\!\!\!= O \\ \searrow O \end{smallmatrix}$$

$$R + NO_2^* \rightarrow R\text{—}O\text{—}N{=}O$$

The radiation chemistry of aliphatic hydrocarbon–nitrogen oxide systems seems to be worthy of further study since information thus obtained should be of considerable value in elucidating organic radiation chemical mechanisms in general, and would provide a unique opportunity of obtaining unequivocal evidence regarding some of the fundamental processes proposed in contemporary theories of aliphatic nitration such as, for example, those reviewed by A. V. Topchiev[3].

I am indebted to Mr. E. Hughes, of the Chemical Services Department, Windscale, for the infra-red analysis involved in this work.

This communication is published by permission of Sir William Cook, managing director, and Dr. H. Kronberger, director of research and development, of the Development and Engineering Group of the United Kingdom Atomic Energy Authority.

TYSON RIGG*

U.K. Atomic Energy Authority,
Development and Engineering Group,
Windscale Works,
Sellafield,
Seascale,
Cumberland.

---

* Present address: Research Council of Alberta, Edmonton, Alberta.

[1] Forsyth, P. F., Weber, E. N., and Schuler, R. H., *J. Chem. Phys.*, 22, 66 (1954).

[2] Fessenden, R. W., and Schuler, R. H., *J. Amer. Chem. Soc.*, 79, 273 (1957).

[3] Topchiev, A. V., "Nitration of Hydrocarbons" (Pergamon Press, London, 1959).

Role of Oxygen in the Cross-linking and Degradation of Deoxyribonucleic Acid by Ionizing Radiations

WHEN deoxyribonucleic acid in dilute aqueous solutions is irradiated with X-rays, the attack by the free radicals produced in water leads to main-chain scission, and this reaction is essentially the same in the presence as in the absence of oxygen[1]. Irradiation of nucleic acid in the solid state and containing less than 25 per cent of water leads to a complex series of reactions which, judged by physico-chemical measurements, were largely unaffected by oxygen. With nucleic acid gels having a water content between these two extremes, oxygen was found to exert a pronounced influence on the changes produced by irradiation with 1-MeV. electrons. Since deoxyribonucleic acid is present in the cells in the form of a relatively concentrated gel, the response to radiation in this form is more likely to be of biological significance than the behaviour of dilute solutions or nearly dry solid.

The nucleic acid used in these gel experiments was obtained from salmon sperm, contained little salt (less than 3 per cent sodium acetate) and was free from protein (less than 0·02 per cent). Its molecular weight was 10^7 and its physico-chemical properties have been described in detail (see ref. 2). The molecular weight (determined by light-scattering) of nucleic acid in the dry or nearly dry state initially falls on exposure to 1-MeV. electrons to about two-thirds of its starting value and then increases again, while the intrinsic viscosity falls continually with dose. From these and other data, Alexander, Lett, Moroson and Stacey[3] concluded that irradiation produced branching and main-chain scission simultaneously, to approximately the same extent, so that the molecule becomes less asymmetric (that is, resulting in a fall of viscosity) without there being a substantial change in the average molecular weight.

By equilibrating the nucleic acid with air or nitrogen at different relative humidities, the water content (gm. of water per 100 gm. of polymer) was varied from < 0·5 per cent to 200 per cent. As the water content is increased above 25 per cent, main-chain scission with reduction in molecular weight becomes the predominant reaction of irradiation in air (see Fig. 1). When the gels are irradiated in the absence of oxygen, the molecular weight increases (see Fig. 1) until some of the nucleic acid has become so highly cross-linked that it no longer dissolves in dilute salt solution, but only swells. Fig. 2 shows that the formation of this insoluble network has a threshold, and the behaviour of 'wet' nucleic acid irradiated in the absence of air is typical of a cross-linking system such as polythene[4]. Once cross-linked gel begins to be formed, the molecular weight (because of polydispersity, it is probable that the molecular weights of the highly cross-linked samples are underestimated) of the soluble fraction falls because the largest units are preferentially linked into the insoluble fraction. This again is in accord with polymer theory[4]. The quantitative recovery of the insoluble nucleic acid is difficult, since after suspension in dilute salt solution much of it is present in a highly swollen form which can only be removed by high-speed centrifugation and the values obtained vary somewhat from experiment to experiment.

We interpret these results, which will be published in full elsewhere, by assuming that sparsely ionizing radiations produce reactive centres in the nucleic acid molecules which can combine with one another to give cross-links, or react with oxygen to give a product which can no longer develop cross-links (cf. ref. 5). The increase in the number of cross-links formed in the absence of oxygen by a given dose with increasing water content of the nucleic acid specimen we attribute to the greater mobility in wet samples of the polymer chains, and this promotes interaction between the active points. In nucleic acid, with less than 25 per cent of water, inability of active centres to meet hinders cross-linking.

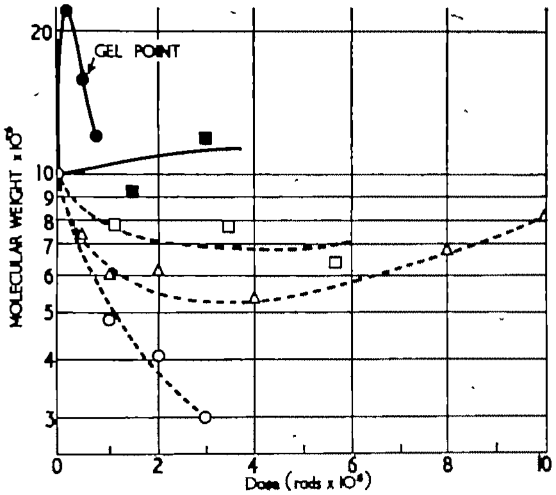


Fig. 1. Change in average molecular weight (measured by light scattering) of deoxyribonucleic acid fibres with different moisture contents after irradiation with 1-MeV. electrons under air and nitrogen

○, 100 per cent water content irradiated in air
●, 100 ,, ,, ,, ,, ,, ,, nitrogen (or vacuum)
△, 20 ,, ,, ,, ,, ,, ,, air
□, 0 ,, ,, ,, ,, ,, ,, air
■, 0 ,, ,, ,, ,, ,, ,, nitrogen (or vacuum)

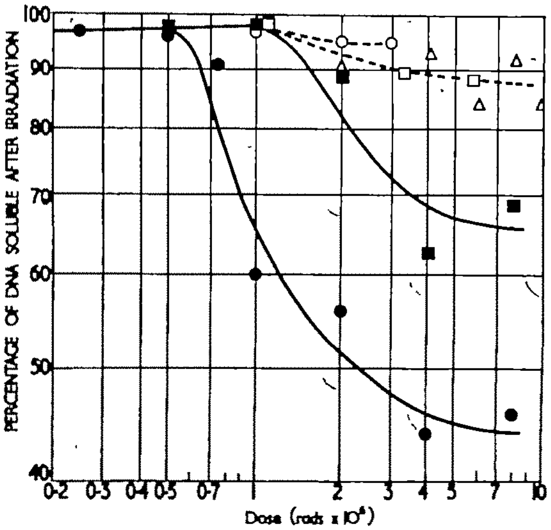


Fig. 2. Fraction of deoxyribonucleic acid rendered insoluble in M/100 sodium chloride (that is, removed by 6 hr. centrifugation at 20,000g). Symbols as in Fig. 1

In the presence of air, few cross-links are formed by direct action, and the degradation observed on irradiation of the samples containing an equal weight of water is due to direct action plus the attack by the radicals formed in the water. In the absence of oxygen, the active centres produced by direct action give rise to cross-links which exceed the number of main-chain scissions from the combination of direct and indirect actions, and therefore the net effect is an increase in molecular weight and gelation. Because the indirect effect produces only scission, there must, at a given dose under nitrogen, be a water content at which the amounts of scission and cross-linking are equal and above which gel is not formed. For a dose of 10^{6} rads this occurs at 300 per cent of water.

We wish to thank Mr. D. Moore of the Medical Research Council Experimental Radiopathology Unit for radiation facilities.

This investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the Medical Research Council, the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

PETER ALEXANDER
J. T. LETT

Chester Beatty Research Institute,
Institute of Cancer Research,
Fulham Road,
London, S.W.3.

[1] Smith, D. B., and Butler, G. C., *J. Amer. Chem. Soc.*, 73, 258 (1951). Conway, B. E., *Brit. J. Radiol.*, N.S., 27, 42 (1954).

[2] Lett, J. T., and Stacey, K. A., *Makromol. Chem.*, 38, 204 (1960).

[3] Alexander, P., Lett, J. T., Moroson, H., and Stacey, K. A., *Int. J. Radiation Biology*, Supp. 1, 47 (1959).

[4] Charlesby, A., *Proc. Roy. Soc.*, A, 222, 60 (1954).

[5] Alexander, P., and Charlesby, A., *J. Pol. Sci.*, 23, 355 (1957).

CHEMISTRY

Possible Discovery of Ion-Pairs by Interferometry

In the course of an investigation on electrodeposition to determine the cause of what Ibl and Muller[1] called an "anomalous maximum" near the cathode, and which O'Brien and Axon[2] independently noted and named the "second wave" in a complete, electrode-to-electrode interference pattern, it was found that this second wave does not develop in electrolyte solutions in which ion-pairs do not form. Such a solution is nickel sulphate[3], in which it has been shown that, presumably because of the strength of the bonds and lack of lability in the octahedral nickel aquo-complex, the closest approach of the sulphate ion cannot be less than the diameter of one water molecule (see Figs. 1 and 2). Electrolysis of a silver perchlorate solution gave the faintest traces of a second wave, which may be considered to be additional supporting evidence. Since Fajans and Luhdemann[4] have shown that free ions in solution may be expected to give higher refractive indices than ion pairs, and indeed a plot of concentrations versus refractive index of values taken from Landolt–Bornstein shows no deviation from linearity for nickel sulphate (which deviation is usually attributed to ion-pairs) until concentrations in the neighbourhood of 1 *M*, it follows that the cathode maximum may be explained by the dissociation of ion-pairs.

It was considered that the formation of ion-pairs was probably not an instantaneous process and that the electrodeposition cell being used was suited to a study of the kinetics of this process. The cell contains about 0·15 ml. of solution when the depth of the electrodes is 2 mm. and their separation 3 mm.

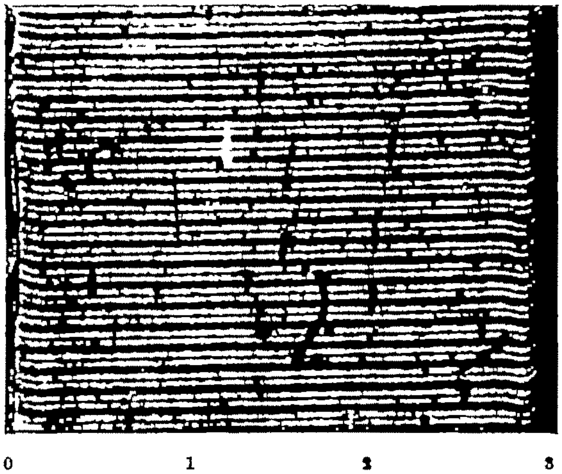


Fig. 1. 30 gm./l. copper sulphate, 3 mm. electrode separation, 2 m.amp./cm.^{2}, 10·8° C., 0 19700 V.

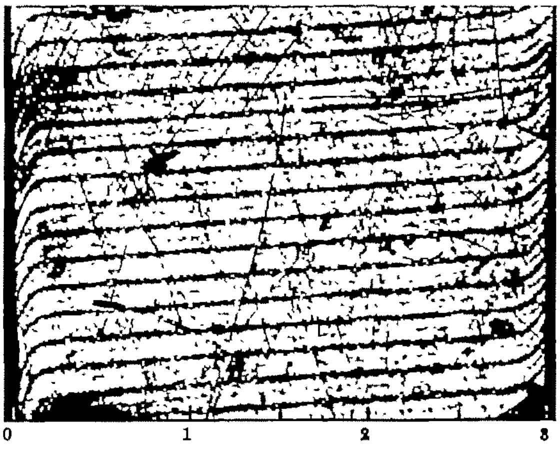


Fig. 2. 33 gm./l. nickel sulphate, 3 mm. electrode separation, 3 m.amp./cm.^{2}, 25 0° C., 2 0 V.

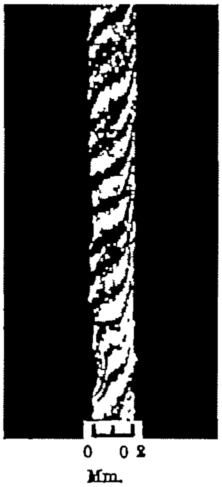


Fig. 3. 30 gm./l. copper sulphate, 0 2 mm. electrode separation, 2 m.amp./cm.^{2}, 9 8° C., 0 17221 V.

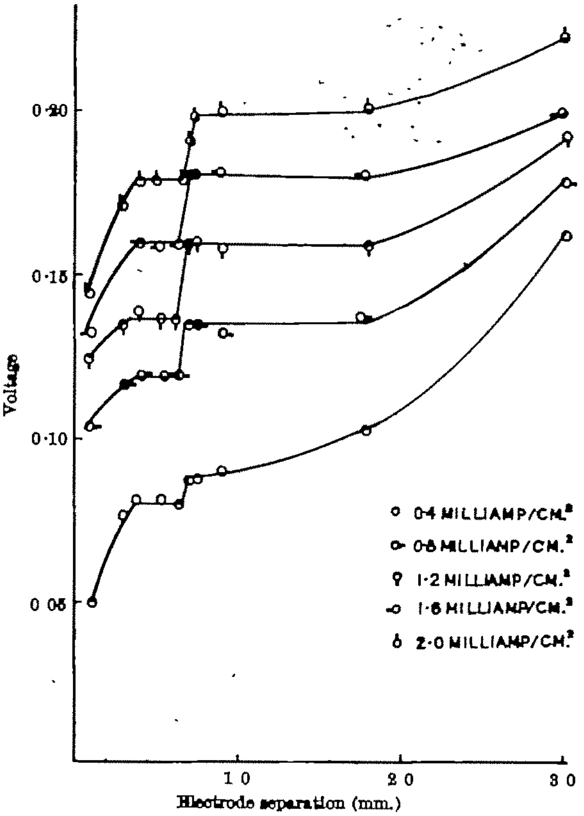


Fig. 4. Plot of voltage against electrode separation at several current densities

It can be calculated from the mobility of the ion (only Cu^{2+} need be considered as the cell is $Cu|CuSO_4|Cu$), which is about $1{\cdot}12 \times 10^{-3}$ cm./sec., that at 0·33 V. the time to traverse the 3 mm. of the cell is about 300 sec. The maximum of the second wave occurs at about 0·1 mm. from the electrode at both electrodes, and its amplitude has been found to vary directly as the current density[2], and the 'time of migration' to this distance should be 9 sec. Hence when the electrodes are placed so that the anode and cathode second waves overlap (Fig. 3), no second wave should form, and this was found to be so. But since there is the possibility that the effective dielectric constant of the solution is low and a change in field gradient might be expected, we do not place any special significance on the time of 9 sec.

When the electrodes were moved together at constant current density, a family of curves (Fig. 4) was found. The curves have the same features occurring at the same distance. A plateau where there is no apparent increase in total resistance with distance begins at about 0·37 mm. and ends at about 0·7 mm. in an abrupt, nearly vertical step.

It was expected that the distance at which the first plateau was found would vary with the voltage applied, since conventionally the speed of the ions has been considered to depend on this. This effect has not been found. The step height varies around about 0·02 V. while the expected height by Nernst's equation and thermodynamics from the dissociation constant of copper sulphate is 0·06 V.

Explanation of these and other aspects is being actively investigated, and greater precision of measurement is being sought.

R. N. O'Brien
C. Rosenfield

Department of Chemistry,
University of Alberta,
Edmonton.

---

[1] Ibl, N., and Muller, R. H., *Z. Elektrochem.*, **59**, 671 (1955).

[2] O'Brien, R. N., and Axon, H. J., *Trans. Inst. Met. Finishing*, **34**, 4 (1957).

[3] Duncan, J. F., and Keppert, D. L., in "The Structure of Electrolyte Solutions", edit. by Hamer, 398 (John Wiley and Sons, New York, 1959).

[4] Fajans, K., and Lühdemann, R., *Z. phys. Chem.*, B, **29**, 150 (1935).

Solid-Solid Interactions on Active Adsorbents

In recent years the diffuse spectral reflectance properties of various solid systems have been investigated[1,2], and several analytical applications have been developed[3-5]. Often it has been reported advantageous to mix the optically absorbing substance with an inactive powdered diluent such as sodium or potassium fluoride. When this is done the reflectance spectrum of the absorbing substance is sharpened and clarified in many cases. More pronounced effects have been obtained when a so-called active adsorbent powder such as chromatographic alumina or silica gel is substituted for the inactive diluent. In an attempt to study the nature of the changes brought about by active adsorbents in the solid state, pilot experiments have been carried out using Michler's ketone (4,4'-*bis*dimethylaminobenzophenone) mixed with active alumina. Michler's ketone has a well-defined absorption spectrum in transmittance in solution and reflectance from the solid, and is quantitatively removed from solution in a non-polar solvent by alumina. In a typical experiment 1 and 2 mgm. of the powdered ketone were mixed with 3 gm. of acidic and basic alumina (Woelm) and the solid mixtures allowed to stand for several days at room temperature in sealed containers. Visual changes slowly occurred in these systems until in appearance they were virtually identical with alumina on which the ketone had been adsorbed from a solution as in ordinary column chromatography. It is suggested that the two phenomena involve essentially the same adsorption process, differing only in rate.

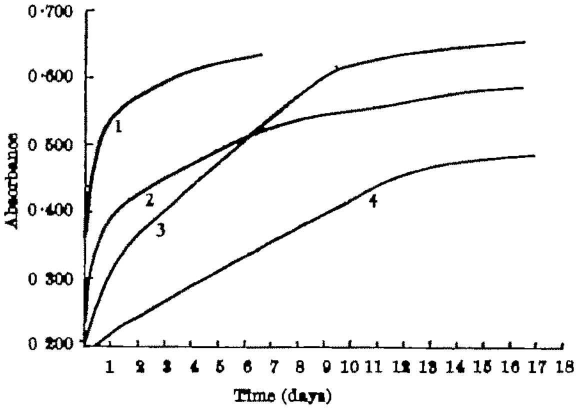


Fig. 1. Changes with time in the absorbance at the wave-length of the maxima of various mixtures of Michler's ketone and chromatographic alumina as measured by reflectance. 1, 2 mgm. ketone and 3 gm. acidic alumina; 2, 1 mgm. ketone and 3 gm. acidic alumina; 3, 2 mgm. ketone and 3 gm. basic alumina; 4, 1 mgm. ketone and 3 gm. basic alumina

The diffuse reflectance spectra of the Michler's ketone–alumina mixtures were measured at intervals as the solid–solid interactions were taking place. The instrument used was a Beckman model *DU* spectrophotometer with a standard reflectance attachment. Regular changes with time, both in the total absorbance (log base 10 of the reciprocal reflectance) and in the wave-length of the absorbance maxima (Figs. 1 and 2), were observed. Throughout, the gross form of the spectra remained characteristically

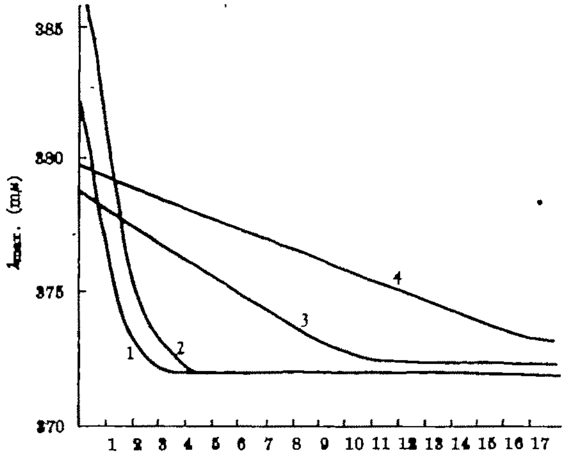


Fig. 2. Changes with time in the wave-length of the absorbance maxima of various mixtures of Michler's ketone and chromatographic alumina as measured by reflectance. 1, 2 mgm. ketone and 3 gm. acidic alumina; 2, 1 mgm. ketone and 3 gm. acidic alumina; 3, 2 mgm. ketone and 3 gm. basic alumina, 4, 1 mgm. ketone and 3 mgm. basic alumina

that of the ketone. The displacement of the absorbance maxima should be related to distortions in the electronic energy-levels of the ketone molecules due to interactions with the alumina on adsorption. The changes in absorbance at the wave-length of the maxima for the adsorbed species should be an index of the relative amount of the adsorbed species present at a given time. Further, the rates at which adsorption takes place on the different grades of alumina provide a measure of the relative activities of such adsorbents. When the solid–solid adsorption processes were essentially complete, the absorbance maxima were virtually identical with those of the ketone adsorbed on the same types of alumina from solutions. This confirms the visual impression as to the similarity of at least the end-result of these two processes. The adsorption from solution, of course, occurs far too rapidly to be studied kinetically, while the solid–solid process proceeds at a vastly retarded but measurable rate. It is hoped that the data being accumulated by reflectance will contribute to the knowledge of solid adsorptions and perhaps submit to a kinetic analysis which could help suggest the mechanism involved. A detailed account of this work will be published separately.

The financial support received from a Frederick Gardner Cottrell grant of the Research Corporation of New York is gratefully acknowledged.

PHILIP ANTHONY
HARRY ZEITLIN

Chemistry Department,
University of Hawaii,
Honolulu 14, Hawaii.

---

[1] Griffiths, T. R., Lott, K. A. H., and Symons, M. C. R., *Anal. Chem.* 31, 1538 (1959).

[2] Zeitlin, H., and Niimoto, A., *Anal. Chem.*, 31, 1167 (1959).

[3] Naughton, J. J., Frodyma, M. M., and Zeitlin, H., *Science*, 125, 121 (1957).

[4] Naughton, J. J., Zeitlin, H., and Frodyma, M. M., *J. Agric. Food Chem.*, 6, 933 (1958).

[5] Shibata, K., *J. Biochem.* (Japan), 45, 599 (1958).

Hydrocracking of Neopentane and Neohexane over Evaporated Metal Films

FOR the cracking of ethane in the presence of hydrogen over iron[1] and over nickel[2], it has been supposed that the molecule is adsorbed at adjacent carbon atoms (1–2 diadsorbed) prior to cracking. However, since work in this laboratory on the hydrocracking of higher hydrocarbons has given results which cannot readily be explained by 1–2 diadsorbed intermediates, the behaviour of neopentane and neohexane was investigated in order to establish the possibility of alternative mechanisms. In the case of the former, 1–2 diadsorption is impossible while in the latter it must be limited to the ethyl group attached to the quaternary carbon atom.

Table 1 shows results of reactions over evaporated films of nickel, tungsten, platinum and rhodium, using initial pressures of hydrogen of 45 mm. mercury and of hydrocarbon 3·7 mm. mercury. The metal films were prepared from spectroscopically standardized metals. Analyses were made after 5–25 per cent of the hydrocarbon had reacted, using liquid-modified gas adsorption chromatography[3]. The column, 60 ft. in length, with a squalane-on-'Pelletex' (a pelleted carbon black) packing, operating at 35° C., was capable of separating all saturated hydrocarbons from C_1 to C_6. The limit of detection was about 10^{-8} mole, equivalent to a pressure of 3×10^{-3} mm. mercury in the reaction vessel.

The results in Table 1 show that hydrocracking of neopentane and of propane occurred over nickel, tungsten and platinum with comparable ease, whereas neohexane reacted at temperatures up to 50 deg. C. below those for neopentane. Over nickel, hydrocracking of ethane required a temperature about 40 deg. C. above that for propane, and the overall activation energies for hydrocracking are 35 ± 5 kcal. mole^{-1} for both neopentane and propane and 69 kcal. mole^{-1} for ethane. These values may be compared with 34 and 54 kcal. mole^{-1} for propane[4] and ethane[2] respectively, obtained on nickel–kieselguhr catalysts using rather lower hydrogen-to-hydrocarbon ratios and lower temperatures. The order of catalyst reactivity for hydrocracking at the quaternary carbon atom is rhodium > tungsten > nickel > platinum, the same order as for propane. This order is quite different from that for the breaking of the C—N bond in methylamine and ethylamine, which is rhodium ≃ platinum > nickel > tungsten[5]. The reaction of neopentane on platinum is remarkable since the presence of 17 per cent *n*-butane in the product indicates substantial isomerization as well as cracking.

In the reactions of neohexane, cracking at the quaternary carbon atom to give isobutane and ethane as primary products predominated strongly on platinum and decreased in importance in the order platinum > tungsten ≫ nickel > rhodium, so that for rhodium the dominant initial cracking mode was in the ethyl group to yield methane and neopentane.

Table 1

Catalyst	Hydrocarbon	Temp. (° C)	Rate (mm. per hr. per 10 mgm. of catalyst)	Extent of reaction (per cent)	Distribution of product (per cent)*						
					M	*E*	*P*	*iso-B*	*n-B*	*neo-P*	*iso-P*
Nickel	Neopentane	230	0·3	8	95	4	1				
	Neohexane	188	0·4	10	46	9	5	13		27	
	Ethane	272	0·2	8	100						
	Propane	230	0·7	10	89	11					
Tungsten	Neopentane	202	0·07	2	57	17	11	15			
	Neohexane	161	0·2	7	33	19	6	36		6	
	Propane	188	0·7	25	65	35					
Rhodium	Neopentane	157	0·9	24	73	18	4	5			
	Neohexane	105	0·8	13	46	1	1	4		27	11
Platinum	Neopentane	296	0·4	11	25	14	17	27	17		
	Neohexane	285	0·4	10	5	41	5	44		5	
	Propane	295	0·5	10	40	60					

* *M*, methane; *E*, ethane; *P*, propane; *iso-B*, isobutane; *n-B*, *n*-butane; *neo-P*, neopentane; *iso-P*, isopentane.

These results show that the claim of Haensel and Ipatieff[6] that, over a nickel/kieselguhr catalyst, bonds to a quaternary carbon atom are least susceptible to attack, is not of general validity for other catalysts. Furthermore, in the hydrogenation of 1–1 dimethyl-*cyclo*propane on nickel–kieselguhr at 150° C. (ref. 7), the sole product, *iso*pentane, indicates exclusive rupture of a bond to the quaternary carbon atom. In this case, however, the highly strained *cyclo*propane ring may invalidate direct comparison with the saturated hydrocarbons.

Although these results show that hydrocracking of a C—C bond can occur without 1–2 diadsorption, it does not follow that the adsorbed intermediate is attached to the catalyst at only one carbon atom. There is evidence for 1–3 diadsorption of neopentane in catalytic exchange with deuterium[8]. In the diadsorbed intermediates responsible for multiple exchange between deuterium and saturated hydrocarbons (cf. Anderson[9]), each carbon atom is normally linked to the surface by a single bond, and the 1–2 diadsorbed intermediate previously postulated for the cracking of ethane[1,3] is identical with that established for multiple exchange in ethane[10]. However, assuming a value of ΔH for adsorption by a single bond of -12 kcal. mole^{-1}, and using corresponding characteristic temperatures for exchange[8] and cracking, it follows that the average life-time of such a diadsorbed species will, at cracking temperatures, be only 10^{-3} to 10^{-4} of the life-time under exchange conditions. Furthermore, it is known that over both nickel and tungsten an increase in temperature favours the further loss of hydrogen atoms from the adsorbed hydrocarbon residue[11]: the reduced rate of exchange of neopentane[8] and ethane[10] over nickel at higher temperatures is probably due to the formation of strongly adsorbed species, multiply bonded to the surface. It seems unlikely, therefore, that the same diadsorbed species is the principal intermediate in both exchange and hydrocracking. We suggest, at least in hydrocracking reactions where 1–2 diadsorption is sterically impossible, that reaction proceeds via 1–3 diadsorbed species and that, in general, diadsorbed intermediates in hydrocracking reactions are comparatively strongly adsorbed on the catalyst surface by the loss of more than one hydrogen atom on at least one carbon atom.

We are grateful to the Shell Co. (Australia), Ltd., for a grant towards the cost of materials.

J. R. ANDERSON
B. G. BAKER

Department of Chemistry,
University of Melbourne.

---

[1] Cimino, A., Boudart, M., and Taylor, H. S., *J. Phys. Chem.*, **58**, 796 (1954).

[2] Kemball, C., and Taylor, H. S., *J. Amer. Chem. Soc.*, **70**, 345 (1948).

[3] Eggertsen, F. T., Knight, H. S., and Groennings, S., *Anal. Chem.*, **28**, 303 (1956).

[4] Morikawa, K., Trenner, N., and Taylor, H. S., *J. Amer. Chem. Soc.*, **59**, 1103 (1937).

[5] Kemball, C., and Moss, R. L., *Proc. Roy. Soc.*, A, **244**, 398 (1958).

[6] Haensel, V., and Ipatieff, V. N., *Indust. Eng. Chem.*, **39**, 853 (1947).

[7] Slobodin, Ia. M., Grigor'eva, V. L., and Shmulliakovskii, Ia. E., *J. Gen. Chem.* (*U.S.S.R.*), **23**, 1480 (1953).

[8] Kemball, C., *Trans. Farad. Soc.*, **50**, 1344 (1954).

[9] Anderson, J. R., "Reviews of Pure and App. Chem.", 7, 165 (1957).

[10] Anderson, J. R., and Kemball, C., *Proc. Roy. Soc.*, A, **223**, 361 (1954).

[11] Wright, P. G., Ashmore, P. G., and Kemball, C., *Trans. Farad. Soc.*, **54**, 1692 (1958). Galwey, A. K., and Kemball, C., *ibid.*, **55**, 1959 (1959).

BIOCHEMISTRY

Assay of Corticosteroids in the Chick Embryo

FOR some time we have been studying various manifestations of the reaction induced in chick embryos by the inoculation of leucocytes from normal fowls (the Simonsen phenomenon) with special interest in the production of macroscopic foci on the chorioallantois[1]. In the course of this work it was observed that if hydrocortisone was added to the inoculum the number of foci was diminished and the embryo showed obviously retarded development.

Several studies of the effect of cortisone on the developing chick embryo have been reported[2–4]. They showed a moderate inhibition of growth with doses of the order of 0·3–0·5 mgm. per embryo. We have not found any reports of such studies with the newer types of anti-inflammatory corticosteroids.

Through the co-operation of Dr. T. F. McCrae of Glaxo Laboratories we have been able to test the following: cortisone alcohol, hydrocortisone alcohol, prednisone alcohol, prednisolone disodium phosphate and dexamethazone. All were used as suspensions in normal saline with the exception of prednisolone disodium phosphate which is freely soluble in water. In order to prevent any damage to the area used for inoculation of leucocytes, the suspensions were inoculated in 0·1 ml. vol. into the air space of twelve-day embryos and the eggs held vertically in the incubator for 1–2 hr. before being inoculated on the dropped chorioallantois with 2–5 × 10^6 fowl leucocytes in a volume of 0·1 ml. After four days further incubation at 38° C. the embryos were removed and weighed and the foci on the chorioallantoic membranes counted.

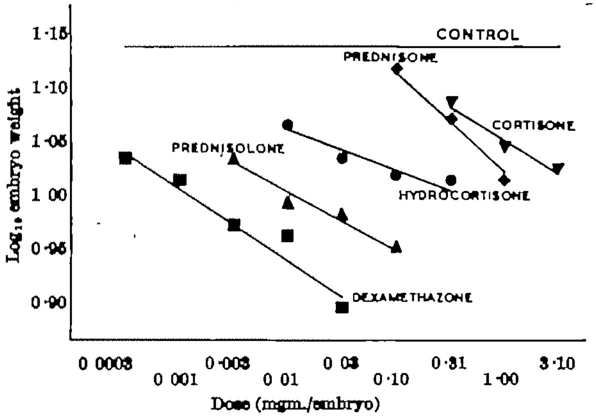


Fig. 1. Action of corticosteroids on embryo weights. Doses are shown in mgm./embryo, logarithmic intervals being used. The values have been adjusted to a uniform control weight of 13·8 gm.

The results for the significant range of doses of the five compounds used are shown in Fig. 1. Each point is the mean of a group of 8–16 embryos except for the highest doses of prednisolone and dexamethazone where some embryos died before the fourth day. The survivors from the larger doses of the 11-hydroxysteroids usually showed, in addition to retarded growth, definite pathological changes in the form of oedema, liver damage and abnormalities of feather growth. This was not seen with prednisone, where the effect seemed to be a simple retardation of growth.

The effect on focal counts from a standard inoculum of adult fowl leucocytes followed a similar trend. In

Table 1. ACTION OF CORTICOSTEROIDS IN REDUCING FOCAL COUNT ON CHORIOALLANTOIC MEMBRANE

Dose mgm. embryo	Prednisone per cent	Prednisone P	Hydro-cortisone per cent	Hydro-cortisone P	Pred-nisolone per cent	Pred-nisolone P	Dexa-methazone per cent	Dexa-methazone P
0·0003	—		—		—		40	0·02
0·001	—		—		—		10	<0·01
0·003	—		—		90	0·35	7	<0·01
0·01	—		35	0·05	30	0·01	5	<0·01
0·03	70	0·10	30	0·02	5	<0·01	0	<0·01
0·10	50	0·01	20	<0·01	2	<0·01	—	
0·31	50	0·01	5	<0·01	—		—	
1·00	30	<0·01	—		—		—	

All values are based on the median of the focal counts and indicate percentage of the corresponding control counts.

all experiments on randomly bred embryos there is a wide range of counts and the median has been taken as the most useful index of comparison. In Table 1 the medians have been adjusted as percentages of the corresponding control values and the statistical significance of their difference from the control shown by the value p as calculated from Student's test. When cortisone or prednisone was given by the air space no effect on focal count was observed and the values shown are from an experiment in which prednisone was mixed with the leucocytes just prior to their inoculation.

It will be seen that by both criteria the activities of the corticosteroids are in the same order:

$$\text{dexamethazone} > \text{prednisolone} > \text{hydrocortisone} > \text{prednisone, cortisone}$$

The striking difference between prednisone and prednisolone, which by the conventional tests in laboratory mammals are of approximately equal activity, is noteworthy and may reflect the absence of some enzymic capacity in the embryos.

These experiments are being extended to other corticosteroids, and exploratory work on the nature of the action of prednisolone on the focal count is in progress.

F. M. BURNET
N. L. WARNER

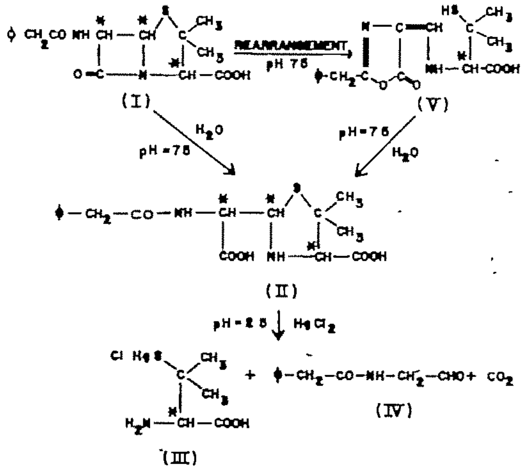
The Walter and Eliza Hall
Institute of Medical Research,
Melbourne.
June 23.

---

[1] Boyer, G., *Nature*, 185, 327 (1960).
[2] Karnofsky, Ridgway and Patterson, P., *Endocrinol.*, 48, 596 (1951).
[3] Sames and Leatham, J., *Proc. Soc. Exp. Biol. Med.*, 78, 231 (1951).
[4] Evans, H., *Proc. Soc. Exp. Biol. Med.*, 83, 36 (1953).

Degradation of Benzylpenicillin at pH 7·5 to D-Benzylpenicilloic Acid

IN acid aqueous solution, benzylpenicillin (I) becomes rearranged to D-benzylpenicillic acid[1a], and in alkaline aqueous solution, it is hydrolysed to the α-diastereomer of D-benzylpenicilloic acid[1b] (II). The product of degradation of benzylpenicillin in aqueous solution at pH 7·5 has not been identified. During work on the mechanism of antigenicity of penicillin, it was necessary to investigate the degradation pathway of benzylpenicillin under physiological conditions. It was found that in aqueous solution at pH 7·5, benzylpenicillin is degraded to D-benzylpenicilloic acid, which appeared to be present as a mixture of its diastereomers.



A solution of 714 mgm. (2·0 millimols) of sodium benzylpenicillin in 100 ml. of 0·2 M phosphate buffer was kept at 37° C. for 120 hr. During this time, the optical rotation fell from $\alpha(D,29) = +4\cdot1°$ for the fresh penicillin solution to $\alpha(D,29) = +0\cdot85°$. (Optical rotations were measured in a Schmidt and Haensch polarimeter with a 2-decimetre cell.) Ultra-violet spectrophotometry showed only the formation of an absorption peak at λ322 mμ and a decrease in ultra-violet end absorption. The peak at λ322 mμ has been demonstrated to be due to the formation of a very small quantity of D-benzylpenicillenic acid (V) by re-arrangement of benzylpenicillin[2a]. The decrease in optical rotation and in ultra-violet end absorption is consistent with the formation of D-benzylpenicilloic acid[1c,2b]. Also consistent with the formation of D-benzylpenicilloic acid is the observation that degradation of benzylpenicillin aqueous solution at pH 7·5 caused the liberation of a new acid group. This was indicated by the fact that additions of alkali throughout the course of the degradation were necessary in order to maintain the pH at 7·5.

Treatment of the reaction solution with one molar equivalent of mercuric chloride at pH 2·5 caused the immediate precipitation of the mercuric mercaptide of D-penicillamine (III) and the liberation of a Schiff aldehyde-positive compound into the supernatant liquid. This aldehyde was isolated as its 2,4-dinitrophenylhydrazone derivative by Shriner and Fuson's method[3]; yield, 500 mgm. (70 per cent). After crystallization from 95 per cent ethanol, the yellow needles melted at 193–194° C. (dec.); the reported melting point for benzylpenilloaldehyde 2,4-dinitrophenylhydrazone is 194–195° C. (dec.)[2c]. A mixed melting point of this compound with synthetic benzylpenilloaldehyde 2,4-dinitrophenylhydrazone was 193–195° (dec.). (Benzylpenilloaldehyde was prepared by synthesis[2d] and converted to its 2,4-dinitrophenylhydrazone by Shriner and Fuson's method[3]; after crystallization from 95 per cent ethanol, the yellow needles melted at 194–195° C. (dec.).) These melting-point data indicate that the phenylhydrazone derivative isolated was indeed benzylpenilloaldehyde 2,4-dinitrophenylhydrazone.

Mercuric chloride in aqueous acid solution immediately degrades D-benzylpenicilloic acid to the mercuric mercaptide of D-penicillamine (III), benzylpenilloaldehyde (IV), and carbon dioxide[1d]. The isolation, by this means, of benzylpenilloaldehyde in 70 per cent yield indicates that benzylpenicillin was hydrolysed to D-benzylpenicilloic acid.

The hydrolysis of sodium benzylpenicillin in *p*H 7·5 buffer yielded a monosodium benzylpenicilloate solution with a considerably less positive optical rotation (α(*D*,29) = + 0·85°) than that of a freshly prepared equimolar buffer solution (*p*H 7·5) of monosodium D-α-benzylpenicilloate (α(*D*,29) = + 1·98°). (Monosodium D-α-benzylpenicilloate was prepared by alkaline hydrolysis of sodium benzylpenicillin[1a], and recrystallized twice from water–acetone; melting point, 154–155° C. (dec.).) On standing at 37° C., the α-diastereomer underwent mutarotation; the optical rotation of this D-α-benzylpenicilloate solution fell to α(*D*,29) = + 0·44° after 60 hr. These observations suggest that the D-benzylpenicilloic acid formed by hydrolysis at *p*H 7·5 of benzylpenicillin may be present as a mixture of its diastereomers[1e].

The hydrolysis of benzylpenicillin at *p*H 7·5 may proceed through two possible pathways: (1) the α-diastereomer of D-benzylpenicilloic acid may be formed primarily by direct hydrolysis of the β-lactam linkage of benzylpenicillin, followed by epimerization to yield a mixture of its diastereomers; (2) benzylpenicillin may become degraded by slow rearrangement to D-benzylpenicillenic acid (V), which is rapidly hydrolysed to yield a mixture of diastereomers of D-benzylpenicilloic acid directly. In support of the latter pathway are the following observations: a small quantity of D-benzylpenicillenic acid was detected in the degrading benzylpenicillin buffer solution (see above). In aqueous solution at *p*H 7·5 at 37° C., D-benzylpenicillenic acid is hydrolysed rapidly to D-benzylpenicilloic acid ($t_{1/2}$ = 6·5 min.) (unpublished work). It must be noted that the degradation at *p*H 7·5 of benzylpenicillin may proceed through both these pathways simultaneously. Further work on this problem is in progress.

I thank Drs. E. Perlman, S. S. Schneierson, and H. Sobotka of the Mount Sinai Hospital for their interest during the course of this work, and the Charles Pfizer Laboratories, Brooklyn, New York, for a generous supply of sodium benzylpenicillin.

BERNARD B. LEVINE*

Departments of Chemistry and Microbiology,
Mount Sinai Hospital,
New York, N.Y.

---

* Damon Foundation Research Fellow, 1958–59.

[1] Cited by: Florey, H. W., Chain, E., Heatley, N. G., Jennings, M. A., Sanders, A. G., Abraham, E. P., and Florey, M. E., "Antibiotics", 2 (Oxf. Univ. Press, London, 1949). (*a*) p. 839; (*b*) p. 840; (*c*) p. 803; (*d*) p. 839; (*e*) see p. 844 for a discussion of the stereochemistry of penicilloic acids.

[2] Cited in: "Chemistry of Penicillin", edit. by Clarke, H. T., Johnson J. R., and Robinson, R. (Princeton Univ. Press, Princeton, N.J., 1949): (*a*) pp. 162, 431; (*b*) p. 426; (*c*) p. 477; (*d*) p. 482; (*e*) p. 573.

[3] Shriner, R. L., and Fuson, R. C., "The Systematic Identification of Organic Compounds", 171 (John Wiley and Sons, Inc., New York, 1948).

Formation of D-Penicillamine-Cysteine Mixed Disulphide by Reaction of D-Benzylpenicilloic Acid with Cystine

As part of a study of skin sensitization to benzylpenicillin, I have investigated the behaviour of D-benzylpenicilloic acid (4-carboxy-5,5′-dimethyl-α-phenylacetamido-2-thiazolidine acetic acid). This compound was found to give allergic cross-reactions of the contact dermatitis type with both benzylpenicillin and D-penicillamine (unpublished work). The allergic activity of D-penicillamine is probable due to its ability to react with cystine disulphide linkages of epidermal proteins to form D-penicillamine cysteine mixed disulphide residues[1]; the allergic cross-reactions between D-benzylpenicilloic acid and D-penicillamine might be due to the ability of the former to react also with disulphide linkages of epidermal proteins to form D-penicillamine-cysteine residues. There are no reports in the literature on the reactivity of D-benzylpenicilloic acid with either thiols or disulphides; I report here the reaction between D-benzylpenicilloic acid and cystine in aqueous solution at *p*H 7·5.

Cystine (96 mgm.) was suspended in 0·1 *M* aqueous solution of monosodium D-α-benzylpenicilloate at *p*H 7·5. (Monosodium D-α-benzylpenicilloate was prepared by alkaline hydrolysis of benzylpenicillin[2] and recrystallized twice from water–acetone; melting point, 154–155° C. (dec.). The material was found to be free of D-penicillamine by a paper chromatographic method capable of detecting less than 0·1 (unpublished work).) This reaction mixture was stirred at 37° C. for 24 hr. A 0·1 *M* aqueous solution of monosodium D-α-benzylpenicilloate under the same conditions served as a control. Aliquots of the reaction mixture supernatant and the control solution were analysed by descending paper chromatography with phenol–water as solvent. Monosodium D-α-benzylpenicilloate, D-penicillamine, cystine, and D-penicillamine-cysteine were chromatographed simultaneously to serve as standards. (D-Penicillamine-cysteine was prepared by the method of Tabachnick *et al.*[1], melting point, 195° C. (dec.).) The results are shown in Fig. 1. The reaction mixture supernatant contained another ninhydrin-positive compound with R_F identical with that of D-penicillamine-cysteine (R_F 0·33). This compound was eluted from the chromatogram. It gave a positive nitroprusside reaction only after reduction with alkaline cyanide solution, and yielded cysteic acid

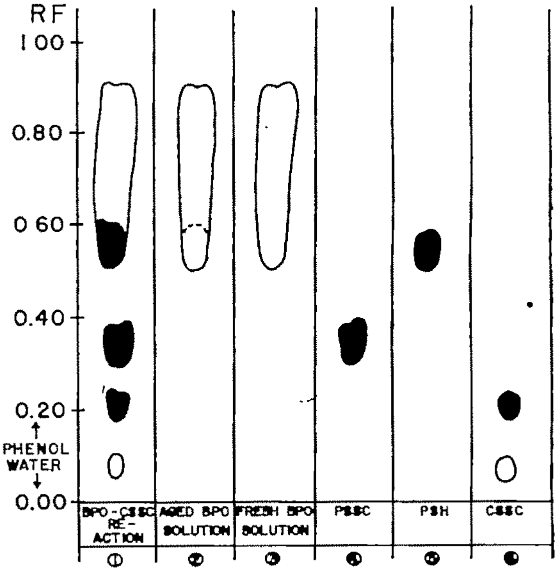


Fig. 1. Phenol–water paper chromatogram of: (1) the D-benzylpenicilloic acid (*BPO*)–cystine (*CSSC*) reaction solution; (2) the aged D-benzylpenicilloic acid (*BPO*) solution; (3) a freshly prepared D-benzylpenicilloic acid (*BPO*) solution; (4) D-penicillamine-cysteine (*PSSC*) standard; (5) D-penicillamine (*PSH*) standard; (6) cystine (*CSSC*) standard. Colour development was with ninhydrin

and penicillamine sulphonic acid after oxidation with aqueous bromine. These reactions have been described previously for D-penicillamine-cysteine[1]. These results indicate that D-penicillamine-cysteine mixed disulphide was formed by reaction of D-benzylpenicilloic acid with cystine.

The chromatogram of the reaction mixture supernatant also showed the presence of another spot superimposed on the D-benzylpenicilloic acid streak (Fig. 1). Its R_F was identical to that of D-penicillamine. Elution of this spot and oxidation with aqueous bromine yielded only penicillamine sulphonic acid. This spot appears to be due to the presence of D-penicillamine in the reaction mixture supernatant, probably formed by a secondary reaction between D-penicillamine-cysteine mixed disulphide and cysteine, the products of the D-benzylpenicilloic acid–cystine reaction. In aqueous solution at pH 7·5, D-penicillamine-cysteine was found to react with cysteine to yield D-penicillamine and cystine.

The formation of the mixed disulphide of D-penicillamine and glutathione was similarly observed when monosodium-D-α-benzylpenicilloate was treated with oxidized glutathione in aqueous solution at pH 7·5.

The mechanism of the D-benzylpenicilloic acid–cystine reaction is unknown. Early experiments suggest that the reactive form of D-benzylpenicilloic acid may be D-benzylpenamaldic acid (α-phenylacetamido - β - (α′ - amino - β′ - mercapto*iso*valeric acid) acrylic acid), traces of which appear to exist in tautometric equilibrium with D-benzylpenicilloic acid.

D-Benzylpenicilloic acid may react also with cystine disulphide linkages of epidermal proteins to form D-penicillamine-cysteine mixed disulphide residues. This chemical reaction might explain the allergic cross-reactivity between D-benzylpenicilloic acid and D-penicillamine; both of which may react with cystine disulphide linkages of epidermal proteins to form the D-penicillamine-cysteine antigenic-determinant group. Since benzylpenicillin is hydrolysed to D-benzylpenicilloic acid under physiological conditions[2], its allergic cross-reactivity with the latter and D-penicillamine (unpublished work) may be similarly explained.

I wish to thank Drs. E. Perlman, S. Schneierson and H. Sobotka of the Mount Sinai Hospital for their interest during the course of this work.

BERNARD B. LEVINE*
Departments of Chemistry and Microbiology,
Mount Sinai Hospital,
New York, N.Y.

* Dazian Foundation Research Fellow, 1958–59.

[1] Tabachnick, M., Eisen, H. N., and Levine, B. B., *Nature*, 174, 701 (1954).

[2] Cited in: "Chemistry of Penicillin", 573 (edit. by Clarke, G. T., Johnson, J. R., and Robinson, R. (Princeton Univ. Press, Princeton, N.J., 1948).

[3] Levine, B. B., *Nature*, see preceding communication.

New Inhibitor of Monoamine Oxidase

THE following is the initial report of a structurally unique monoamine oxidase inhibitor, N-benzyl-N-methyl-2-propynylamine hydrochloride (*A*19120). This work includes *in vitro* action of this inhibitor on rat liver mitochondria as well as *in vivo* inhibition of monoamine oxidase of mouse brain and the liver.

The mitochondria were isolated from homogenate of rat liver by the differential centrifugation method of Hogeboom *et al.*[1], and suspended in $M/15$ phosphate buffer, pH 7·2. Homogenates of whole brain and liver tissue from test or control male mice were prepared by adding 1 ml. of the phosphate buffer for each 0·2 gm. tissue and homogenizing with Potter–Elvehjem homogenizers.

The monoamine oxidase activity of mitochondria or tissue homogenates was measured by a Warburg manometric technique at 37° C. The flasks contained tissue or mitochondria equivalent to 0·2 gm. of original tissue, $M/15$ phosphate buffer pH 7·2, and (in specified experiments) inhibitor. Serotonin creatinine sulphate was added at zero time to give a final concentration of $M/100$ in the 2·0-ml. reaction mixture. During the pre-incubation–equilibration period reaction mixtures were oxygenated for 5–10 min. Calculations were based on the uptake of oxygen during the first 60 min. of reaction-time.

The *in vitro* activity of N-benzyl-N-methyl-2-propynylamine hydrochloride was compared with that of several known compounds. All were pre-incubated for 25 min. The concentration of drug which produces 50 per cent inhibition of mitochondrial monoamine oxidase was read off the straight-line graph obtained by plotting the log concentration of inhibitor against per cent inhibition. The results were: *A*19120, 9×10^{-7} M; nialamide, 9×10^{-7} M; harmaline, 1×10^{-6} M; β-phenyl*iso*propyl hydrazine, 4×10^{-6} M; and iproniazid, 7×10^{-6} M.

Table 1. EFFECT OF PRE-INCUBATION TIME ON INHIBITION OF MONOAMINE OXIDASE *A*19120, HARMALINE AND IPRONIAZID

Inhibitor	Concentration $M/1$	Per cent inhibition after pre-incubation time* 0 min.	8 min.	15 min.	30 min.
*A*19120	5×10^{-7}	12	19	19	40
	1×10^{-6}	15	27	37	61
	2×10^{-6}	21	41	56	83
Iproniazid	$7·5 \times 10^{-6}$	4	12	25	76
Harmaline	5×10^{-7}	29	—	37	40

* Values as per cent of controls.

Table 1 summarizes the effect of increasing the pre-incubation time at 37° C. with *A*19120, iproniazid, and harmaline. Both *A*19120 and iproniazid show progressive inhibition with increasing pre-incubation time whereas harmaline does not.

In another series of experiments substrate was added to the mitochondria and the uptake of oxygen followed for 30 min., then the inhibitor was added from a second side-arm at a concentration which would have given 50 per cent inhibition of monoamine oxidase with 25 min. pre-incubation. Compound *A*19120 depressed the rate of oxygen consumption 22 per cent over controls, harmaline 54 per cent and iproniazid had no effect. This indicates that *A*19120 and iproniazid may not be identical in their mechanism of inhibition of monoamine oxidase.

Determinations for ammonia production by the Conway microdiffusion technique[2] and serotonin disappearance, by the method of Udenfriend *et al.*[3], were carried out on samples from Warburg vessels 60 min. after the addition of substrate to mitochondria. The ratios of oxygen/ammonia, oxygen/serotonin and ammonia/serotonin were 0·8–1·3 for controls, for *A*19120 at 1×10^{-6} M, and for iproniazid at $1·25 \times 10^{-6}$ M. This agreement between the theoretical ratio of 1·0 and experimental values indicates that these inhibitors probably act directly on the monoamine oxidase–serotonin system.

The reversibility of the inhibition effect was studied by a procedure similar to that of Udenfriend *et al.*[4]

Table 2. DURATION OF ACTION OF INHIBITION OF MONOAMINE OXIDASE IN MICE BY *A*19120 OR IPRONIAZID. DOSE, 200 MGM./KGM.

Days	Per cent inhibition			
	*A*19120		Iproniazid	
	Brain	Liver	Brain	Liver
1/6	68	73		
1	73	93	78	85
2	78	74		
3	74	65		
4	69	59		
5	59	49	58	37
6	55	44		
7	44	34		
8	50	38		
9	48	33		
10	17	6	30	12
12	17	0		
14	17	7	21	9

except that the activity of monoamine oxidase was measured by the Warburg technique. The inhibition produced by *A*19120 at 3×10^{-4} *M*, or iproniazid at 1×10^{-5} *M* (30 min. pre-incubation), was not reversed with four washings, whereas inhibition by 3×10^{-6} *M* harmaline was decreased from 84 to 50 per cent.

In a single experiment the duration of inhibition of monoamine oxidase of mouse brain and liver produced by one oral dose of 200 mgm./kgm. of *A*19120 or the same dose of iproniazid was determined. The results are in Table 2. Significant inhibition of brain monoamine oxidase occurred for at least seven days after administration of *A*19120. Although liver inhibition is less than that of brain after the first day, there is probably no preferential inhibition of the brain monoamine oxidase by *A*19120 at this pharmacologically high dose. Preliminary data from our laboratories also indicate that *A*19120 causes maximal increase in brain norepinephrine. Pharmacological work is now in progress and will be reported in a separate publication.

The results obtained in this work show that *A*19120 is a potent inhibitor of monoamine oxidase of a new structural type, and thus the present concepts of inhibition of monoamine oxidase should be enlarged.

J. D. TAYLOR
A. A. WYKES
Y. C. GLADISH
W. B. MARTIN

Abbott Laboratories,
North Chicago, Illinois.

[1] Hogeboom, G. H., Schneider, W. C., and Palade, G. H., *J. Biol. Chem.*, 172, 619 (1948).

[2] Conway, E. J., "Microdiffusion Analysis and Volumetric Error" (Macmillan Co., N.Y., 1958).

[3] Udenfriend, S., Weissbach, H., and Clark, C. T., *J. Biol. Chem.*, 215, 337 (1955).

[4] Udenfriend, S., Witkop, B., Redfield, B. G., and Weissbach, H., *Biochem. Pharmacol.*, 1, 160 (1958).

Syntheses of Glucose, Cellobiose and Other Saccharides by *Acetobacter acetigenum* in a Lactate-buffered Glycerol Medium

WE have cultivated *Acetobacter acetigenum* N.C.I.B. 8132, a cellulose-forming micro-organism, in 10 litres of medium in 40 'Glaxo' flasks, which were shaken during incubation at 30° for twenty-one days. The medium contained (gm./l.): potassium dihydrogen phosphate, 2·0; crystalline magnesium sulphate, 1·0; crystalline ferrous sulphate, 0·01; ammonium hydrogen phosphate, 2·5; calcium D-pantothenate, 0·002; riboflavin, 0·002; biotin, 0·0001; glycerol, 30; lactic acid, 10·2; the *p*H value was adjusted with potassium hydroxide to 4·6. The metabolism solution was Seitz-filtered to remove cells and cellulose and concentrated to 500 ml. over barium carbonate, *in vacuo* at 35°. Activated charcoal, 'Ultrasorb *S.C.* 120/240' (British Carbo Norit Union) as used by Hughes and Whelan[1], was sieved through a British Standards 170 mesh and the material retained on the sieve was used to pack two 'Pyrex' glass columns (138 × 7·8 cm.) to a depth of 105 cm. In each column 1·9 kgm. of this charcoal rested on a pad of glass-wool overlayed with 100 gm. of 'Celite' added as a slurry in water. The columns were washed each with 5 litres of 50 per cent (v/v) aqueous ethanol and then each with 20 litres of distilled water. After removal of insoluble barium salts the metabolism concentrate was rediluted to 10 litres with distilled water and passed through the columns during 14 hr. Each column was eluted with 80 litres of distilled water followed by aqueous ethanol solutions (each of 50 litres) in which the respective ethanol percentages (v/v) were 0·5, 5, 10, 20, 35, and 50. Six aqueous ethanolic fractions, A_1–A_6, were collected and concentrated at 35°. Portions of each were de-ionized with 'Zeo-Karb 225' and 'Deacidite *E*' and chromatographed on paper against authentic sugars using (*a*) *n*-propanol/water/ethylacetate, 7:2:1 by volume; (*b*) pyridine/water/ethylacetate, 1:2:2 by volume; (*c*) ethyl acetate/acetic acid/water, 3:1:3 by volume. The chromatograms gave evidence of the presence of the following sugars: A_2, glucose, fructose, xylose, and ribulose; A_3, similar to A_2 together with a trace of cellobiose; A_4, mainly cellobiose; A_5, cellotriose and cellotetraose. Fraction A_2 was then de-ionized and submitted to column partition chromatography according to the procedure of Lemieux, Bishop and Pelletier[2], which involves the use of 'Celite No. 535' to hold the stationary phase. After irrigation with water-saturated *n*-butanol, the column was extruded and cut into zones as determined by an alkaline permanganate spray. A fraction was separated which, after several further passages through the 'Celite' and a final purification by band paper chromatography, yielded 45 mgm. of a substance which had the mobility of glucose when chromatographed in two different solvent systems. An acetate was prepared by heating with anhydrous sodium acetate and acetic anhydride, and after purification this had m.p. 131°, alone or mixed with authentic β-penta-acetyl glucose of m.p. 131°. The infra-red spectra of both acetates were compared and no significant differences could be observed. (Found: C, 49·3; H, 5·8 per cent. Calc. for $C_{16}H_{22}O_{11}$: C, 49·2; H, 5·7 per cent.)

The procedures by which glucose had been isolated were now applied to fraction A_4, yielding 52 mgm. of a substance which showed the mobility of cellobiose when run on paper chromatograms in different solvent systems. The substance was acetylated with pyridine and acetic anhydride and the purified derivative had m.p. 191°, unchanged by admixture with authentic β-cellobiose octa-acetate, m.p. 191°. (Found: C, 49·7; H, 5·7 per cent. Calc. for $C_{28}H_{38}O_{19}$: C, 49·6; H, 5·6 per cent.) The infra-red spectra of this octa-acetate and that of authentic β-cellobiose octa-acetate were without significant differences.

When lactate is metabolized by *A. acetigenum* in absence of other sources of carbon it is mainly oxidized through acetate to carbon dioxide, though in certain liquid media it can serve as a source for formation of cellulose[3]. It seems probable that in our experiments the lactate played a dual part, some of it suffering oxidation and thereby sparing glycerol for cellulose synthesis, and some of it undergoing conversion to a metabolite on the pathway to cellulose. So far as we are aware, neither glucose nor cellobiose has hitherto been isolated from among the products of bacterial action on either glycerol or lactate, although the formation of glucose in cultures of *Poria vaillantii* on a glycerol medium has been reported by Sison and Schubert[4], while Horecker[5] has suggested a cyclic mechanism by which this conversion may be effected.

It is proposed to report the work in further detail elsewhere.

One of us (K. R.) acknowledges the receipt of an Imperial Chemical Industries Research Fellowship.

C. P. JACKSON
K. RAMAMURTI

College of Science and Technology,
University of Manchester.

[1] Hughes, R. C., and Whelan, W. J., *Chem. and Indust.*, 884 (1958)

[2] Lemieux, R. U., Bishop, C. T., and Pelletier, G. E., *Can. J. Chem.*, **34**, 1365 (1956).

[3] Bourne, E. J., and Weigel, H., *Chem. and Indust.*, 132 (1954).

[4] Sison, B. C., and Schubert, W. J., *Nature*, **181**, 1015 (1958).

[5] Horecker, B. L., *Brewers Digest*, **28**, 214 (1953).

Distribution of Protein-bound Aminoazo Dyes in the Rat Liver Microsome

EVIDENCE has been obtained that rat liver microsomes are the site where the formation of protein-bound aminoazo dyes occurs[1–3]. On the other hand, one of the most important parts played by the microsome is known to be protein synthesis. Littlefield *et al.*[4] further fractionated the microsome by means of sodium deoxycholate and pointed out that the protein in the deoxycholate-insoluble fraction, ribonucleoprotein particles, showed a particularly high turn-over rate, suggesting that protein is in fact synthesized in this fraction. This suggestion was supported by other authors[5–7].

In investigating the carcinogenesis due to aminoazo dyes, it is an inevitable question whether the protein-bound dye is detectable even in the fraction with such a high turn-over rate as the microsome ribonucleoprotein fraction. Despite the fact that Arcos and Arcos[3] are inclined to the view that no protein-bound dye was found in this fraction, we repeated a similar experiment but on a somewhat larger scale, since their evidence seemed to be inconclusive.

Rats which were fed 3′-methyl-4-dimethylaminoazobenzene coated on rice (0·06 per cent) were killed after 2 weeks when the protein-bound dye is considered to be a maximum. The liver microsomes were prepared according to Schneider's method[8] and washed once with 0·25 *M* sucrose solution. The unsedimented fluid was designated as 'supernatant fraction'. The microsomes were further fractionated by means of sodium deoxycholate as proposed by Littlefield *et al.*[4]. Thus we obtained three fractions, namely, deoxycholate-insoluble fraction (ribonucleoprotein fraction) and deoxycholate-soluble fraction from microsomes and the supernatant fraction. A small portion of each fraction was withheld for the protein[9] and ribonucleic acid[4] assays and the rest was subjected to protein-bound dye (polar dye) determination[10,11].

The results are summarized in Table 1. This clearly shows that a definite amount of protein-bound dye is detected in the ribonucleoprotein fraction. The total amount of this protein-bound dye in the ribonucleoprotein fraction is obviously lower than that in the other fractions. If, however, the protein-bound dye concentration is expressed on a per unit mgm. protein basis, the figures for the three fractions stand very closely to each other.

Table 1. DISTRIBUTION OF POLAR DYE AMONG CELL FRACTION

	Fraction	Microsome deoxycholate -insoluble	Microsome deoxycholate -soluble	Supernatant
Exp. 1	Liver used (gm.)	87		
	Protein (mgm.)	105	750	
	Ribonucleic acid (mgm.)	63	3·0	
	Polar dye (γ)*	2·6	27	
	Polar dye (γ)/100 mgm. protein	2·5	3·6	
Exp. 2	Liver used (gm.)	60		
	Protein (mgm.)	65	530	2,700
	Ribonucleic acid (mgm.)	56	18	
	Polar dye (γ)*	2·0	15	93
	Polar dye (γ)/100 mgm. protein	3·1	2·8	3·4

* The amount of polar dye is expressed in terms of DAB tentatively.

The significance of the finding must await further experiments, which are now being carried out here.

This experiment was supported partly by the grant from the Ministry of Education, Japan.

T. YAMADA
M. MATSUMOTO
S. KANDA
H. TERAYAMA

Department of Biophysics and Biochemistry,
Faculty of Science,
University of Tokyo,
Tokyo.

[1] Hultin, T., *Exp. Cell Res.*, **10**, 71, 697 (1956); **13**, 47 (1957).

[2] Gelboin, H. W., Miller, J. A., and Miller, E. C., *Cancer Res.*, **18**, 618 (1958).

[3] Arcos, J. C., and Arcos, M., *Biochim. Biophys. Acta*, **28**, 9 (1958).

[4] Littlefield, J. W., Keller, E. B., Gross, J., and Zamecnik, P. C., *J. Biol. Chem.*, **217**, 111 (1955).

[5] Alfrey, V. G., Daly, M. M., and Mirsky, A. E., *J. Gen. Physiol.*, **37**, 157 (1953).

[6] Hultin, T., *Exp. Cell Res.*, Supp., **3**, 210 (1955).

[7] Simkin, J. L., and Work, T. S., *Biochem. J.*, **65**, 307 (1957).

[8] Schneider, W. C., and Hogeboom, G. H., *J. Biol. Chem.*, **183**, 123 (1950).

[9] Lowry, O. H., Rosebrough, N. J., Farr, A. L., and Randall, R. J., *J. Biol. Chem.*, **193**, 265 (1951).

[10] Terayama, H., Kusama, K., Teruya, K., Kuroda, S., and Nakayama, T., *Gann*, **49**, 85 (1958).

[11] Terayama, H., Kusama, K., and Aoki, T., *Gann*, **49**, 97 (1958).

Water-soluble, Non-fibrous Deoxyribonucleoprotein from Calf Thymus Nuclei

A WATER-SOLUBLE, non-viscous form of deoxyribonucleoprotein has been isolated from purified calf thymus nuclei by a process that minimizes enzyme degradation. Previously the only preparation of deoxyribonucleoprotein generally accepted as undegraded has been the fibrous one, forming gels in water and only slightly soluble, with a molecular weight of 17 million[1].

Fresh calf thymus glands are frozen immediately on removal from the animal and ground to a powder in the frozen state in the presence of 'dry ice'. Only this procedure has been found to produce intact, round nuclei, as confirmed by microscopic examination, without excessive clumping, when the ground material is suspended in the purification medium at 0–4° C.

The purification medium is modified from those of Dounce *et al.*[2] and Philpot and Stanier[3], and is composed of 0·44 *M* sucrose, 40 per cent glycerol, 0·039 *M* sodium glycerophosphate, 0·019 *M* citrate buffer (*p*H 6·1, ionic strength 0·15).

Table 1. MOLECULAR WEIGHTS AND PARAMETERS FOR AVERAGE-SIZED PARTICLES OF FIBROUS AND NON-FIBROUS DEOXYRIBONUCLEOPROTEIN

Prep.	Solvent	ν_e (c.c./c.c.)†	a/b	Av. $S(20w) \times 10^{13}$	$M \times 10^{-6}$
A. Fibrous*	1 *M* NaCl-PO$_4$	4,030 ± 770	291 ± 31‡	43 ± 1·5§	15·9 ± 2·4
B. Non-fibrous, stored at 4°	1 *M* NaCl-PO$_4$	1,002	135	8·2	0·75
Non-fibrous, lyophilized	1 *M* NaCl-PO$_4$	674	108	9·5	0·79
Same	0·7 m*M* PO$_4$	591	96	7·3	0·49

* This preparation, entirely corresponding, was made and studied at Pollards Wood Research Station, Chalfont St. Giles, Bucks., England.

† This viscosity increment was obtained from the intrinsic viscosity at zero gradient, assuming a partial specific volume of 0·658 (ref. 8).

‡ Limits of error calculated to take into account the effect on viscosity of the known heterogeneity of the material.

§ The error is the standard deviation for the scattering of points from the straight line calculated by least mean squares obtained for the line portion of a typical sedimentation coefficient curve.

The intact nuclei are rapidly washed with this medium and centrifuged at 1,200*g*. The process is repeated four times, followed by a slow-speed centrifugation to remove whole cells and clumps. Immediately afterwards, the nuclei are extracted with water and centrifuged three times at 4° C. This washing with water appears to be of special significance for the chemical interactions determining the state of the deoxyribonucleoprotein, and will be the subject of a forthcoming publication. The swollen gel of nuclei is adjusted to 0·14 *M* sodium chloride and hand-homogenized mildly but rapidly, the process taking only about a minute. A finely divided mass of disrupted nuclei is thus obtained, giving a solution of non-fibrous deoxyribonucleoprotein after dialysis against 0·7 m*M* phosphate at *p*H 9, at 4° C. and, finally, clarification at 25,000*g*. The resulting solution was used for the viscosity and sedimentation work reported here.

It should be pointed out that fibrous deoxyribonucleoprotein is obtained from the nuclei washed in the medium, if, instead of the washing with water and hand homogenization in 0·14 *M* sodium chloride, the purified nuclei are dissolved directly in 1 *M* sodium chloride and clarified by centrifugation. The fibrous deoxyribonucleoprotein thus obtained and described here corresponds to preparations previously reported in the literature[1,4].

Viscosities were measured in 4-bulbed Ubbelohde viscometers, in those of the Frampton type[5], and in a Couette viscometer, to give a range of velocity gradients of 1–600 sec.$^{-1}$.

The distribution of sedimentation coefficients corrected to 20° C. in water was determined in the Spinco Model *E* analytical ultracentrifuge and calculated by the method of Shooter and Butler[6]. The solvent used was 1 *M* sodium chloride, 0·7 m*M* phosphate, *p*H 7·1 and 0·7 m*M* phosphate for the non-fibrous deoxyribonucleoprotein only. Ultraviolet absorption optics permitted measurements at concentrations as low as 0·01 per cent (optical density equal to 1) or less.

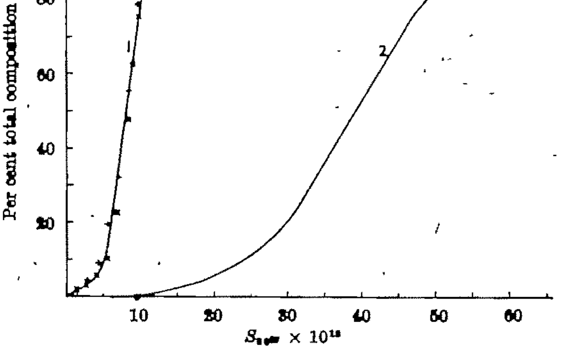


Fig. 1. Curves for distribution of sedimentation coefficients, corrected to water at 20° C., for non-fibrous and fibrous deoxyribonucleoprotein in 1 *M* sodium chlorate, 0·7 m*M* phosphate. Curve 1: Non-fibrous deoxyribonucleoprotein at a concentration of 0·091 mgm./c.c. Pluses—at 11·95 minutes after the extrapolated zero time (6); crosses—at 23·95 minutes after zero time. Curve 2: Fibrous deoxyribonucleoprotein from unextracted nuclei at 0·037 mgm./c.c. (courtesy of Dr. K. V. Shooter)

Concentrations were determined by nitrogen analysis and dry weight (indicating 17 per cent nitrogen in deoxyribonucleoprotein), or by the ultraviolet absorption at 260 mμ for preparations for which the extinction coefficients were known.

Viscosity and sedimentation determinations for both non-fibrous and fibrous deoxyribonucleoprotein, summarized in Table 1, show the striking contrast between these two forms. Fig. 1 shows that not only is the average sedimentation constant of the non-fibrous deoxyribonucleoprotein much lower than that of the fibrous, but also that it is distinctly more homogeneous; thus there is an increase in proportionate slope and also the last 5 per cent of highly aggregated material is eliminated for the non-fibrous sample. Whereas the fibrous deoxyribonucleoprotein shows an average sedimentation constant of 39 *S* at a concentration of 0·037 mgm./c.c. in molar salt, that observed for the non-fibrous preparation is strikingly lower, namely, 8·2 *S*. Paralleling this contrast is that observed for the axial ratio *a*/*b* for the fibrous form being 291 and that for the non-fibrous form 135 in molar salt or 96 in dilute buffer. Molecular weight calculations from these data lead to the values of 16 million for fibrous deoxyribonucleoprotein and 0·77 million for the non-fibrous form in molar salt for the average-sized particles, assuming effective hydrodynamic ellipsoids[7].

All the results clearly support the hypothesis that there are much smaller sub-unit particles of deoxyribonucleoprotein than those of fibrous deoxyribonucleoprotein, commonly accepted as such. Enzymatic degradation during the preparative steps is most unlikely; first, because the mild hand homogenization, the all-important step connecting fibrous preparations with the non-fibrous ones, is accomplished so rapidly, and secondly, because in a control experiment, nuclei washed with the purification medium only yielded fibrous deoxyribonucleoprotein after standing at 4° for as long as 4 days in 0·14 *M* sodium chloride.

Work now in progress indicates that the deoxyribonucleic acid obtained from the non-fibrous deoxyribonucleoprotein by salt and detergent dissociation has an average sedimentation coefficient of 5·3 *S* in molar salt, which is lower, as expected, than for the corresponding deoxyribonucleoprotein preparation. This finding lends further support to the view that the non-fibrous preparations are comprised of particles which are sub-units of the conventional fibrous particles.

This work was supported in part by a grant, No. *A* 2401, of the National Institutes of Health. I thank Prof. J. A. V. Butler for his hospitality, and Dr. K. V. Shooter for his collaboration and helpful advice.

RICHARD S. WELSH*

Chemistry Department, University of Redlands,
Redlands, California.

* Advanced Research Fellow of the American Heart Association.

[1] Doty, P., and Zubay, G., *J. Molecular Biol.*, 1, 1 (1959).

[2] Dounce, A. L., Witter, R. F., Monty, K. J., Pate, S., and Cottone, M. S., *J. Biophys. and Biochem. Cytol.*, 1, 139 (1955).

[3] Philpot, J. St. L., and Stanier, J. E., *Biochem. J.*, 63, 214 (1956).

[4] Mirsky, A. E., and Pollister, A. W., *J. Gen. Physiol.*, 30, 101 (1946). Frick, G., "Studies on Desoxyribonucleoprotein and Desoxyribonucleic Acid," dissertation, Uppsala (1954).

[5] Frampton, V. O., *J. Biol. Chem.*, 129, 233 (1939).

[6] Shooter, K. V., and Butler, J. A. V., *Trans. Farad. Soc.*, 52, 734 (1956).

[7] Scheraga, H. A. and Mandelkern, L., *J. Amer. Chem. Soc.*, 71, 536 (1949).

[8] Carter, A. O., *J. Amer. Chem. Soc.*, 63, 1960 (1941).

PHYSIOLOGY

Adenosine Triphosphate and Maintenance of Shape of the Human Red Cells

ALTHOUGH the mechanism with which red blood cells maintain their biconcave shape has been studied by a number of investigators, it has not yet been clarified. Some twenty years ago Furchgott and Ponder[1] proposed the existence of an antisphering factor in the blood plasma, but later Ponder[2] himself cast doubt on this. More recently, Prankerd[3] suggested that the red cell envelope might possess certain contractile properties dependent upon a continuous regeneration of adenosine triphosphate, according to the evidence that incorporation of phosphorus-32 is low in the esters of the stroma obtained from those species with spheroidal red cells or from patients with hereditary spherocytosis. However, no detailed experiment on the shape of the cells has been reported by Prankerd or by others.

In our experiment human red cells obtained by venipuncture were washed three times with physiological saline, and a 7 per cent suspension of these cells in physiological saline was incubated at 37° C. with a final concentration of 2×10^{-2} *M* sodium fluoride. During the incubation the discoidal shape of the cells changed to a crenate one at first, and after 6 hr. almost all the cells were transformed to smooth spheres. At this time the cells were washed with cold physiological saline four times in order to wash out the fluoride thoroughly and incubated further with 5×10^{-3} *M* glucose, 1×10^{-2} *M* inosine, and 2×10^{-3} *M* adenine sulphate to restore the content of adenosine triphosphate of the cells as in the previous experiments[4]. After 2 hr. the shape of the incubated cells turned to a biconcave disk or a shallow cup-form again. The disk–sphere transformation and vice versa could be repeated several times, and the phenomenon was also observed in red cells obtained from fresh or long-preserved human blood or from rat or pig blood as well.

In parallel with the morphological observation described above, the adenosine triphosphate in the cells was estimated as acid-soluble total phosphate adsorbed on and eluted from 'Norit *A*', by Fiske and Subbarow's[5] method, or the sum of adenosine triphosphate and adenosine diphosphate content was calculated from optical density at 260 mμ after separation by means of a slightly modified Cohn and Carter's ion exchange chromatography[6]. The results shown in Table 1 indicate that more than two-thirds of the original values of nucleotides was necessary for the maintenance of discoid shape, and that the cells change to smooth spheres as the level of nucleotides decreases to one-fourth or one-fifth of the original level. As it is well established that most of the nucleotides in the blood cells belong to adenosine phosphates, especially to adenosine triphosphate[7], the amount of nucleotide phosphates estimated as above approximately equals the amount of adenosine triphosphate.

The same transformation was also observed during the preservation of blood in ACD medium at 4° C.: the biconcave disk shape changed to crenated disk at

Table 1. SHAPE OF ERYTHROCYTES AND THEIR NUCLEOTIDE CONTENT. WASHED ERYTHROCYTES; INCUBATION TEMPERATURE 37° C; HÆMATOCRIT ABOUT 7 PER CENT

Incubation time	2 hr			4 hr.			6 hr.		
Conditions	Nucleotide P μ*M*/100 ml.	Nucleotide μ*M*/100 ml.*	Shape	Nucleotide P μ*M*/100 ml.	Nucleotide μ*M*/100 ml.*	Shape	Nucleotide P μ*M*/100 ml.	Nucleotide μ*M*/100 ml.*	Shape
Glucose 5×10^{-3} *M*	19·2		Biconcave disk	16·5		Biconcave disk	15·2		Biconcave disk
No addition	14·6		Biconcave disk	13·6		Biconcave disk, and crenated disk	12·4		Crenated disk
Sodium fluoride 2×10^{-2} *M*	12·4		Crenated sphere	9·5		Crenated sphere, and smooth sphere	5·7		Mostly smooth sphere
Reincubation after treatment with sodium fluoride at 37° C. for 6 hr									
Reincubation time	1 hr.			2 hr.			3 hr.		
No addition	3		Crenated sphere, and smooth sphere	3		Crenated sphere, and smooth sphere	3		Crenated sphere, and smooth sphere
Glucose 5×10^{-3} *M* Adenine 2×10^{-3} *M* Inosine 1×10^{-2} *M*		6·5	Crenated sphere, and biconcave disk		7·4	Crenated disk, and biconcave disk		7·3	Biconcave disk

* Adenosine tri- and di-phosphate μ*M*/100 ml. calculated from optical density at 260 mμ after separation by ion-exchange chromatography.

Table 2. SHAPE OF ERYTHROCYTES AND THEIR ADENOSINE TRIPHOSPHATE CONTENT DURING PRESERVATION AT 4° C. IN ACD MEDIUM

Period of storage	1 day	12 days	28 days	56 days	100 days
Shape of erythrocyte	Biconcave disk	Biconcave disk, crenated disk	Crenated sphere, and smooth sphere	Smooth sphere	Smooth sphere
Adenosine triphosphate μM/100 ml. cells	84	30	18	4 4	—
Adenosine triphosphate and adenosine diphosphate μM/100 ml. cells	98	70	34	5 1	—

first (after about two weeks), and then to crenated spheres and finally to smooth spheres (after more than about five weeks). Calculating from the results which were obtained by the gradient elution technique of ion-exchange column chromatography on 'Dowex 1' (formate system)[8], the adenosine triphosphate content of the cells is summed up again in Table 2 together with morphological observations. M. Nakao *et al.*[4] have reported recently that human red cells, which were spherical after storage for several weeks at 4° C. in ACD solution, transformed to a shallow bowl form after incubation with added adenine and inosine, being accompanied by a marked rise of adenosine triphosphate content in the cells.

According to earlier work[9], round ghost cells obtained from long-stored red cells changed to a goblet-like shape with the addition of 0·003–0·04 *M* or higher concentration of adenosine triphosphate (optimal *p*H 8), and they returned to the former shape upon addition of ethylenediamine tetraacetate in 0·004 *M* concentration shortly after the addition of adenosine triphosphate.

The observations presented here lead us to the following conclusions:

(1) The presence of blood plasma is not necessary for the red cells to maintain their discoidal shape.

(2) The disk–sphere transformation of red cells and vice versa can take place without any change in hydrogen ion and cation concentration and ionic strength in the medium.

(3) If adenosine triphosphate or adenine nucleotide content in red cells is greater than a certain level, the normal shape of the cells is maintained, and if it is below this level, the shape becomes crenate, and when it decreases further, below another lower level, the shape of the cells changes to a perfect sphere.

It remains obscure, however, whether the maintenance of the shape of red cells depends solely on the level of adenosine triphosphate or on the turn-over of adenosine triphosphate.

An experiment aimed at extracting actomyosin-like protein from red cell ghosts is now in progress.

MAKOTO NAKAO
TOSHIKO NAKAO
SABURO YAMAZOE

Department of Biochemistry,
School of Medicine,
Gunma University,
Maebashi, Japan.

---

[1] Furchgott, R. F., and Ponder, E., *J. Exp. Biol.*, **17**, 117 (1940).

[2] Ponder, E., *Blood*, **9**, 227 (1954).

[3] Prankerd, T. A. J., *Biochem. J.*, **58**, 622 (1954).

[4] Nakao, M., Nakao, T., Tatibana, M., Yoshikawa, H., and Abe, T., *Biochim. Biophys. Acta*, **32**, 564 (1959); *J. Biochem.* (Japan)

[5] Fiske, C. H., and Subbarow, Y., *J. Biol. Chem.*, **66**, 375 (1925).

[6] Cohn, W. E., and Carter, C. E., *J. Amer. Chem. Soc.*, **72**, 4273 (1950).

[7] Bishop, C., Rankine, D. M., and Talbott, J. H., *J. Biol. Chem.*, **234**, 1233 (1959)

[8] Tatibana, T., Nakao, M., and Yoshikawa, H., *J. Biochem.* (Japan), **31**, 679 (1959).

[9] Nakao, M., Nakao, T., Tatibana, M., and Yoshikawa, H., *J. Biochem.* (Japan), **47**, 694 (1960).

An Abnormal Serum Protein in Experimental Poisoning by Cadmium and other Metals

IT has been shown by Friberg[1] that men exposed for many years to the hazard of cadmium inhalation can excrete a protein having a low molecular weight in their urine. In order to investigate this phenomenon further, an investigation has been carried out on the changes in serum protein produced in the albino rat, following the administration of cadmium salts, using the starch-gel electrophoresis method of Smithies[2], together with the modification in the buffer system suggested by Poulik[3].

Among several other changes, it has been observed that following the intraperitoneal or subcutaneous injection of 1 mgm. per kgm. of cadmium as cadmium chloride, an abnormal protein appeared in the serum, which could be seen when the serum was analysed on

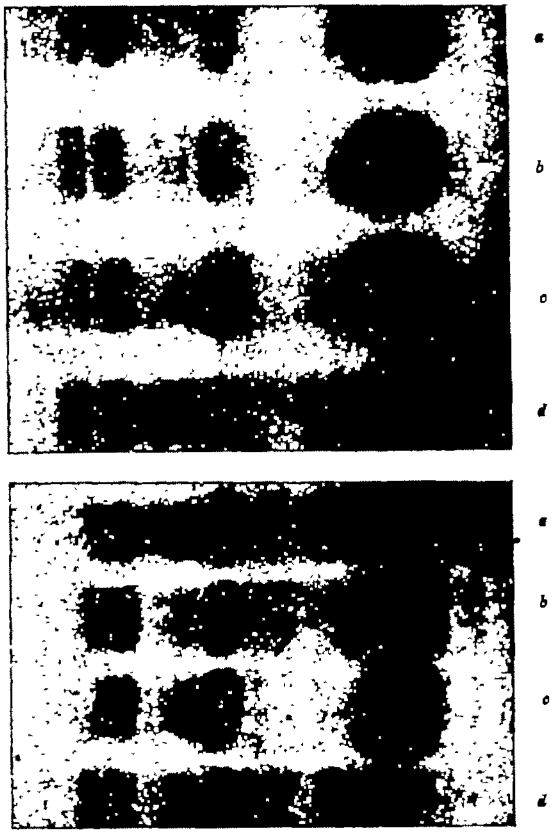


Fig. 1. Starch-gel electrophoresis of sera from albino rats, injected intraperitoneally with *a*, saline, *b*, cadmium, *c*, zinc and *d*, mercury, 1 mgm. per kgm. (as chloride) in each case. Top, continuous *tris*-citrate buffer system, 500 V., 10 m.amp., 2 V. cm.$^{-1}$ for 20 hr. Bottom, discontinuous borate, *tris*-citrate system, 500 V., 20 m.amp., 6 V. cm.$^{-1}$ for 4 hr.

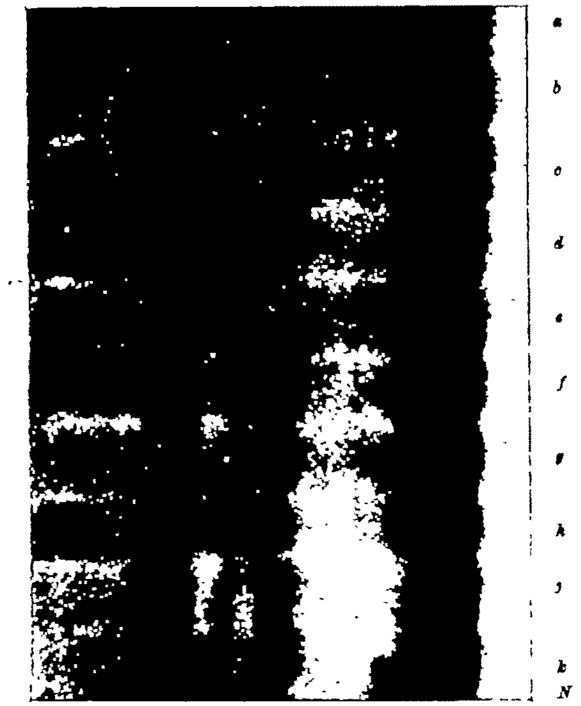


Fig. 2. Starch-gel electrophoresis of rat sera (continuous *tris*-citrate buffer system 500 V., 10 m amp., 2 V. cm.$^{-1}$ for 20 hr.) from rats injected with 1 mgm. per kgm. of the following metals. *a*, beryllium, *b*, cadmium, *c*, chromium, *d*, cobalt, *e*, copper, *f*, iron, *g*, lead, *h*, manganese, *j*, mercury, *k*, nickel, *N*, normal saline

a Connaught starch gel, as described by Smithies. Poulik described a discontinuous buffer system for use in starch-gel electrophoresis, and it has been found that an improved picture of this abnormal protein can be obtained by using the *tris*-citrate buffer, described by him, as a continuous buffer throughout the system.

The protein, following a single injection, usually appeared within 24 hr., and it slowly disappeared in about a week. Mercury was found to behave in a similar way, when administered in the same concentration, but zinc did not (Fig. 1). At a concentration of 20 mgm. per kgm., however, zinc gave rise to the abnormal protein.

This abnormal serum protein has been isolated from the serum of cadmium-poisoned rats as follows. Preliminary experiments had established that the protein was precipitated from serum by 37 per cent saturation by ammonium sulphate, and that it moved as an α-1-globulin when submitted to paper electrophoresis or to a cellulose electrophoretic column using phosphate borate buffer as described by Gedin and Porath[4]. Forty rats were given 1 mgm. per kgm. of cadmium chloride and after 24 hr. the blood was removed by cardiopuncture. After the blood had clotted, the serum was removed and saturated ammonium sulphate solution was added to give 40 per cent saturation. The mixture was left at 0° C. for 1 hr.; the precipitated protein was centrifuged off, dissolved in distilled water, dialysed free of ammonium sulphate, and finally freeze-dried. The resultant solid was dissolved in physiological rat saline, introduced into a Porath column 2 × 150 cm. and run for 48 hr., at 1,400 V. and a current of 24 m.amp., using the phosphate–borate buffer as described. The fractions from this column were dialysed and freeze-dried, and each fraction was analysed by starch-gel electrophoresis using the continuous *tris*-citrate buffer system. The appropriate fractions were combined, redissolved and freeze-dried. 0·6 gm. of the protein was isolated. As the cadmium chloride used in the experiment had been prepared from radioactive cadmium-115, radioactivity measurements showed that the protein did not bear any cadmium.

A group of other common metals, some generally considered toxic, and others present in trace amounts in the body, was administered, all at a dose-rate of 1 mgm. per kgm. body-weight. The response of the animals (so far as the production of the protein after 24 hr. was concerned) was in the following order: mercury > beryllium, cadmium, copper > manganese > chromium, nickel. Cobalt, lead and iron did not give a visible band under these conditions (Fig. 2).

The observation that mercury and cadmium salts produce the abnormal line, in the serum of rats, and can also give rise to proteinuria in man, when absorbed over many years, may help to clarify the mechanism of metal poisoning and proteinuria.

Experiments are in progress to locate the source of production of this protein using fluorescent antibody techniques, and also to elucidate possible auto-immune reactions to this protein in the rat, following our observation that the protein disappears from the blood after some 6–8 weeks of thrice-weekly doses of 0·5 mgm. per kgm. of cadmium, administered intraperitoneally.

A full account of this work will be published shortly.

D. J. LAWFORD

Medical Research Council,
Department for Research in Industrial Medicine,
The London Hospital.
Whitechapel,
London, E.1.

[1] Friberg, L., *Acta med. scand.*, Suppl. 240, 1 (1950).
[2] Smithies, O., *Biochem. J.*, 61, 629 (1955)
[3] Poulik, M. D., *Nature*, 180. 1477 (1957).
[4] Gedin, H. I., and Porath, J., *Biochim. Biophys. Acta*, 26, 157 (1957).

Comparison between the Effects of Cysteine and of Anoxia on the Rate of Mitosis in Lens Epithelium

BOTH anoxia and pretreatment with certain thiols will reduce the sensitivity to radiation of many types of living organisms. The possibility that thiols protect against radiation damage because they lower oxygen tension has been reviewed by Gray[1] and by Pihl and Eldjarn[2]. In spite of all the work done it is not yet clear whether the protective thiols act by inducing tissue anoxia or by some other means.

Pirie and Lajtha[3] found that injection of cysteine into a rabbit inhibited cell division in the lens epithelium, the mitotic inhibition beginning about 18 hr. after injection and lasting four days. von Sallmann[4] had previously shown that cysteine given before irradiation will prevent radiation cataract in the rabbit lens. Since measurement of mitosis in lens epithelium is a simple quantitative method of assessing an effect of cysteine *in vivo*—whether related to protection against radiation or not—we thought it worth while to compare the mitotic inhibition caused by cysteine with that caused by lack of oxygen.

Rats, aged 7–11 weeks old, were used, and comparisons were made between normal and treated litter mates. Cysteine treatment consisted in a single intravenous injection of 10 per cent cysteine, at a dosage of 100 mgm. cysteine/100 gm. body-weight. The rats were killed at about 8, 18, 24, 32 and 48 hr. after injection. Anoxia was achieved by keeping the rats in an atmosphere of about 5 per cent oxygen, 1 per cent carbon dioxide and 94 per cent nitrogen for up to 18 hr. Rats were killed after 7, 9 and 18 hr. anoxia, and after 18 hr. anoxia followed by 2, 6 or 30 hr. in the normal air. Total mitotic counts were made in whole flat preparations of lens epithelia[5].

The duration of anoxia is definite, but the length of time during which cysteine, plus cystine and other breakdown products, were present in the blood and aqueous humour is not known, nor is the necessary effective concentration. von Sallmann, Dische, Ehrlich and Munoz[6], however, have shown that, in the rabbit given a somewhat smaller intravenous dose of cysteine (70 mgm./100 gm.), the cysteine plus cystine reached maximum levels in the blood and aqueous humour within 1–2 hr., and in 6 hr. had fallen to well below half these values. It is reasonable to assume, therefore, that the length of time during which cysteine and its products were present at effective levels was certainly no longer than the 18-hr. period of anoxia.

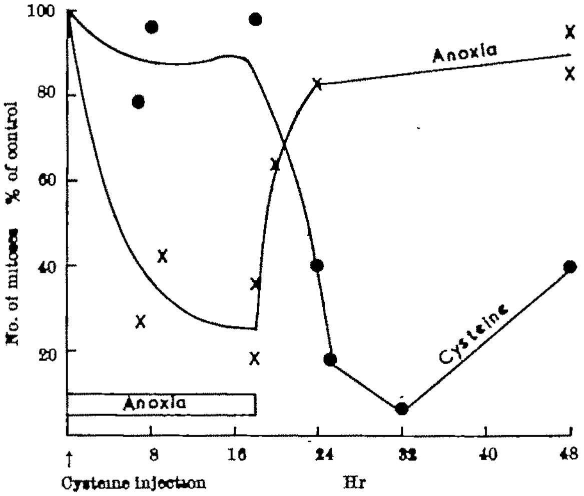


Fig. 1. Comparison between the effects of cysteine (●) and of anoxia (×) on the rate of mitosis in lens epithelium

The effect of cysteine, and of anoxia, on the number of mitoses in the lens epithelium is shown in Fig. 1. There were no damaged cells in any of the preparations. The figure shows that, after 7, 9 and 18 hr. of anoxia, the rate of mitosis had dropped to well below 50 per cent of normal; when the rats were returned to air there was a rapid return to the normal level, recovery being probably complete within 6 hr. With cysteine, on the other hand, there was no significant decrease in mitosis until 24 hr. after the injection, and the rate was still depressed at 48 hr.

Thus in this particular system, and under these particular conditions, the effect of cysteine can be clearly distinguished from that of anoxia.

We thank the National Council to Combat Blindness, New York, for a "Fight for Sight" grant.

ANTOINETTE PIRIE
RUTH VAN HEYNINGEN
Nuffield Laboratory of Ophthalmology.
University of Oxford.

---

[1] Gray, L. H., "Ann. Rev. Nuclear Sci.", 6, 353 (1956)

[2] Pihl, A., and Eldjarn, L., *Pharmacol. Rev.*, 10, 437 (1958).

[3] Pirie, A., and Lajtha, L. G., *Nature*, 184, 1125 (1959).

[4] von Sallmann, L., *Amer. Med. Assoc. Arch. Ophthal.*, 47, 305 (1952).

[5] Howard, A., *Stain Technol.*, 27, 313 (1952).

[6] von Sallmann, L., Dische, Z., Ehrlich, G., and Munoz, C. M., *Amer. J. Ophthal.*, 34, May, Pt. 2, 95 (1951)

Serotonin, a Melanocyte-stimulating Component in the Dorsal Skin Secretion of *Xenopus laevis*

IT is well known that a variety of substances are able to produce a dispersion or concentration of the pigment granules in the melanocytes of Amphibia *in vivo*. However, the number of compounds which produce a dispersion or concentration of these granules in melanocytes of isolated pieces of skin is much smaller. Any secondary reactions may be excluded by this latter *in vitro* method of testing. At the present stage of investigation, *in vitro* studies may be of value, though it should be realized that what happens in Nature may not be comparable.

In a series of investigations, using phenylalkylamines, Burgers[1] found a correlation between melanocyte activity *in vitro* and chemical structure. Furthermore, he described[2] a dispersion of the pigment granules of melanocytes in isolated webs of *Xenopus laevis* after administration of an extract of the dorsal skin secretion of the same species. The purpose of the present investigation was to determine the chemical nature of the active substance in this secretion.

After extraction of dried, defatted skin secretion with methanol, the presence of several indole derivatives could be demonstrated chromatographically, and one of these proved to be active in the *in vitro* test. Catecholamines could not be detected in the extracts. The ultra-violet absorption spectrum of the active indole compound showed a maximum at 275 mμ with a shoulder at 295 mμ, suggesting the presence of a hydroxy-group at position 5 (ref. 3).

The absorption maxima showed an acid-base shift, indicating a free hydroxy-group. This was confirmed by paper electrophoresis at *p*H 13 during which the indole component moved towards the anode. Adsorption of the active compound on 'Amberlite *HCG-50* (H$^+$)', migration to the cathode during paper electrophoresis at *p*H 7, and the fluorescence reaction of Shepherd *et al.*[4], suggested the presence of 5-hydroxytryptamine (serotonin) or its derivatives. Identity of the R_F-values of the active indole compound with

Table 1. R_F-VALUES OF THE ACTIVE INDOLE COMPOUND COMPARED WITH SYNTHETIC SEROTONIN

Developing liquid	Active indole compound	Synthetic serotonin
20 per cent aqueous potassium chloride	0·34	0·34
n-Butanol/hydrochloric acid (98 : 2), after impregnating in 0·5 *M* potassium chloride	0·41	0·43
n-Butanol/acetic acid/water (4 : 1 : 5)	0·49	0·49
iso-Butanol-1, saturated with water	0·19	0·22
Phenol/0·1 *N* hydrochloric acid (85 : 15)	0·49	0·48

synthetic serotonin in several chromatographic systems led us to the conclusion that the active compound is identical with serotonin.

Using the *in vitro* test, synthetic serotonin proved to be active. Activity of serotonin with respect to the melanocytes *in vivo* has been described by Davey[5], whereas Wright and Lerner[6] announced a concentrating effect of serotonin *in vitro* in *Rana pipiens*. The presence of serotonin in the venom of *Bufo marinus* has been ascertained by Udenfriend *et al.*[7], who stressed its role as a precursor of the well-known methylated derivatives bufotenine, bufotenidine, etc.

Whether there exists a correlation between the melanocyte activity *in vitro* and the chemical constitution of tryptamine derivatives is being investigated.

I am indebted to Prof. G. J. van Oordt for his interest and encouragement and to Miss A. W. van Wijngaarden, Mr. J. W. Huismans and Mr. A. D. F. Addink for their skilful assistance.

F. C. G. VAN DE VEERDONK

Zoological Laboratory,
Department of Endocrinology,
Janskerkhof 3,
Utrecht.

---

[1] Burgers, A. C. J., *Acta Physiol. Pharmacol. Neerl.*, 5, 263 (1957).

[2] Burgers, A. C. J., and van Oordt, G. J., *Acta Endocrinol.*, 23, 265 (1956).

[3] Stoll, A., Troxler, F., Peyer, J., and Hofmann, A., *Helv. Chim. Acta*, 38, 1452 (1955).

[4] Shepherd, D. M., West, G. B., and Erspamer, V., *Nature*, 172, 357 (1953).

[5] Davey, K. G., *Nature*, 183, 1271 (1959).

[6] Wright, M. R., and Lerner, A. B., *Nature*, 185, 169 (1960).

[7] Udenfriend, S., Clark, C. T., and Titus, E., *Experientia*, 8, 379 (1952).

Sodium and Potassium in Mitochondrial Membrane Fractions

In a preliminary attempt to explain the observations that muscle[1] and liver[2] mitochondria are able to transport actively potassium but not sodium, the concentrations of these ions in mitochondrial membrane fractions were studied and compared with those in intact mitochondria. The results indicated that the specific activity (μgm. sodium or potassium/mgm. dry weight) of sodium was several times greater in mitochondrial membrane fractions than in intact particles, whereas the reverse was found with potassium.

Heart mitochondria were isolated from 6–9 lb. male rabbits as described previously[3], and rabbit liver and kidney mitochondria were prepared as described by Hogeboom[4]. Mitochondria were washed three times with the same fluid used in homogenizing the tissues and then suspended with 0·25 *M* sucrose. To 9 ml. of the mitochondrial suspension, 1 ml. of a 3 per cent solution of deoxycholic acid was added and the mixture rapidly stirred with a glass rod until it became clear. The deoxycholic acid solution was freshly prepared for each experiment by adding 15 ml. water to 750 mgm. deoxycholic acid (Mann Research Laboratories), and then solubilizing the acid by stirring in 1·4 gm. *tris* [*tris*(hydroxymethyl)aminomethane] buffer. The *p*H of the solution was adjusted to 7·6 by slowly adding 5 *N* hydrochloric acid and then diluting to 25 ml. with water. To mitochondria which were not disrupted, 1 ml. of either 0·25 *M* sucrose or 0·46 *M tris* buffer (*p*H 7·6) was added. The rest of the procedure was similar to that described[5] for isolating a membrane fraction from 0·44 *M* sucrose suspensions of rat liver mitochondria. The pellet obtained by centrifugation of the 25,000*g* supernatant for 1 hr. at 105,000*g* was called the membrane fraction. Dry-weight determinations and analyses of sodium and potassium were carried out as described previously[1].

Table 1. SODIUM AND POTASSIUM CONTENTS OF INTACT MITOCHONDRIA AND MITOCHONDRIAL MEMBRANE FRACTIONS

Experiment		Sodium Intact mito.	 Membrane	Potassium Intact mito.	 Membrane
		(μgm. Na/mgm. dry weight)		(μgm. K/mgm. dry weight)	
		Liver			
(1)	0·44 *M* sucrose susp.	0·14	1·66	1·05	—*
(2a)	0·3% DOC	0·26	0·88	5·15	0·97
(2b)	0·5% DOC	0·26	1·66	5·15	1·06
(3a)	0·3% DOC	0·34	0·67	4·43	0·45
(3b)	0·6% DOC	0·34	1·46	4·43	1·27
(4a)	Fresh	0·20	1·66	4·99	0·75
(4b)	Aged 4 days	0·21	1·42	0·56	0·74
(5)	Water suspension, sonicated	0·97	1·78†	0·73	0·83†
(6a)	0·3% DOC	0·21	1·56	4·52	0·86
(6b)	Sucrose suspension, sonicated	0·21	4·02	4·52	3·79
		Kidney			
(7a)	0·3% DOC	0·27	0·66	2·22	0·44
(7b)	0·5% DOC	0·27	1·01	2·22	0·61
(8a)	Membrane unwashed	0·18	0·49	1·48	0·30
(8b)	Membrane washed 1 ×	0·18	0·58	1·48	0·22
(9a)	Control	—	—	1·72	1·19
(9b)	ATP + α-ketoglutarate	—	—	2·97	1·10
		Heart			
(10a)	0·3% DOC	0·22	0·73	1·88	0·30
(10b)	0·5% DOC	0·22	1·14	1·88	0·61
(11a)	Membrane unwashed	0·17	0·68	2·02	0·61
(11b)	Membrane washed 2 ×	0·17	0·72	2·02	0·54
(12a)	Fresh	0·31	1·37	0·86	0·57
(12b)	Aged 4 days	0·17	1·61	0·32	0·78

Unless otherwise indicated, mitochondria were suspended with 0·25 *M* sucrose and treated with deoxycholic acid (DOC) to give a final concentration of 0·3 per cent. All figures are usually the mean of 3 individual determinations.

* Too little potassium for determination.

† Mean of six determinations.

Table 1 presents a summary of the results obtained from experiments with liver, kidney, and heart mitochondria. Although results were also obtained for the sodium and potassium contents of the fraction isolated by centrifugation of the mitochondria treated with deoxycholic acid for 20 min. at 25,000*g*, they were not included because this fraction was not homogeneous and probably contained mostly mitochondria which were partially disrupted[6]. The specific activity of the sodium and potassium in this fraction ranged from 0·19 to 4·87 and from 0·15 to 1·98, respectively.

The results in Table 1 demonstrate that the specific activity of sodium in the membrane fractions from all three kinds of mitochondria treated with deoxycholic acid was 2–12 times greater than that in the intact mitochondria. The specific activity of potassium, however, was 1·5–10 times greater in the fresh intact particles than in the membrane fractions. Washing the membrane fraction once or twice with isotonic sucrose (Exps. 8 and 11) appeared to remove little, if any, potassium or sodium. In four experiments, a comparison was made between the ion contents of membrane fractions obtained from 0·3 per cent and 0·5 per cent (or 0·6 per cent) particles treated with deoxycholic acid since the higher concentration has been found to result in closely apposed membranes in contrast to the vesicular elements observed in the electron microscope after treatment with 0·3 per cent deoxycholic acid[6]. The results showed (Exps. 2, 3, 7, and 10) that the specific activity was significantly increased, generally more so for sodium than for potassium, with 0·5 per cent deoxycholic acid. Part of this increase in specific activity was probably a result of the decreased dry weight of the membrane fraction after treatment with 0·5 per cent deoxycholic acid, the average dry weights decreasing from 12·6 to 7·8 mgm. for liver, from 17·4 to 10·7 mgm. for kidney, and from 13·6 to 11·6 mgm. for heart.

In order to determine whether the increase in the potassium gradient, which occurs when mitochondria are incubated in a medium to which an adenine nucleotide and oxidizable substrate are added, is due to an increased amount of the ion in the membrane fraction or in the rest of the mitochondrial water, kidney mitochondria were incubated in a medium (0·25 *M* sucrose, 0·005 *M* magnesium sulphate, 0·005 *M* potassium phosphate buffer, *p*H 7·4, 0·005 *M* sodium phosphate buffer, *p*H 7·4) with or without the addition of 0·001 *M* adenosine triphosphate and 0·02 *M* α-ketoglutarate. After 20 min. incubation in air at 37°, deoxycholic acid was added to half the mitochondrial suspensions to give a final concentration of 0·3 per cent and the membrane fraction was isolated as described previously. Untreated suspensions were centrifuged[1] to separate the intact mitochondria from the suspending medium. The results showed that the potassium gradient:

$$\frac{\text{m.equiv. potassium/litre mitochondrial water}}{\text{m.equiv. potassium/litre suspending medium}}$$

increased from 1·56 to 2·83 when adenosine triphosphate and α-ketoglutarate were added to the medium, the specific activity of potassium increasing from 1·72 to 2·97 (Exp. 9). Since the specific activity of the membrane fraction of the two groups was practically the same, this experiment demonstrates that the increased potassium which is accumulated does not concentrate in the membrane. The rather small difference in specific activity between the intact mitochondria and the membrane fraction in this experiment may be a consequence of suspending the particles in a relatively potassium-rich medium for incubation.

The deoxycholic acid used in these experiments contained considerably less than 1 μgm. potassium/1 ml. solution, but it did contain 5 μgm. sodium/1 ml. solution. Since the total sodium in the membrane fraction was usually 5–15 μgm., a significant error would be introduced into the calculation of specific activity if some or all of the sodium from the acid became attached to the membrane fraction. In attempting to demonstrate that the differences in sodium concentration between the intact mitochondria and the membrane fraction were not an artefact, liver mitochondria suspended either in water or 0·25 *M* sucrose were subjected to ultrasonic vibrations for 1–5 min. in a 10 kc./s. Raytheon sonic oscillator at 250 watts and 1·25 amp. The ultrasonically treated particles were centrifuged for 20 min. at 25,000*g* and the resulting supernatant was centrifuged for 1 hr. at 105,000*g* to isolate a membrane fraction[6,7]. Although mitochondrial membranes isolated from sonically disrupted mitochondria apparently are not pure, in that matrix adheres to the membrane vesicles[5], the inhomogeneity of the membrane fraction probably would not affect markedly the specific activity of the sodium, especially since it is so low in the intact mitochondria. The results, although quantitatively different (Exps. 5 and 6), tended to confirm those obtained with deoxycholic acid. The very low potassium specific activity of the intact water-suspended mitochondria (Exp. 5) was undoubtedly due to leakage of the ion from the swollen particles since the supernatant after isolation of the mitochondria contained very much larger amounts of the ion than were found in the supernatant of 0·25 *M* sucrose-suspended mitochondria.

The data obtained from this work may provide an explanation for the observation that when muscle mitochondria are aged, the potassium content decreases approximately 50 per cent, whereas the sodium content remains virtually unchanged[1]. The decrease in potassium might be explained if one assumes that the small quantity of membrane potassium is firmly bound (see Exps. 8 and 11), while the rest of the mitochondrial potassium is either not bound or is bound to compounds which leak out of the particles during ageing. Since most of the mitochondrial sodium appears to be concentrated in the membrane fraction, ageing would not affect it, if one again assumed that it was tightly bound. In this connexion, the sodium and potassium in the membrane fraction of mitochondria aged for four days by suspending them in 0·25 *M* sucrose at 0° do not appear to change significantly (Exps. 4 and 12).

Whether the differences in sodium and potassium concentration in the mitochondrial membrane fraction have any connexion with the inability of muscle[1] and liver[2] mitochondria to transport sodium against a concentration gradient cannot be assessed at the present time. Further work on this problem is in progress.

This investigation was supported by grants from the National Institute of Arthritis and Metabolic Diseases and the American Heart Association. I am grateful for the very skilful technical assistance of Mrs. Patsy L. S. Smith and Mr. Arthur Nathanson.

FRANK ULRICH*

Department of Physiology,
Yale University School of Medicine,
New Haven 11, Conn.

* Established Investigator of the American Heart Association.

[1] Ulrich, F., *Amer. J. Physiol.*, 197, 997 (1959).

[2] Spector, W. G., *Proc. Roy. Soc.*, B, 141, 268 (1953).

[3] Ulrich, F., *Amer. J. Physiol.*, 198, 847 (1960).

[4] Hogeboom, G. H. in "Methods in Enzymology" ed. by S. P. Colowick and N. O. Kaplan, 1, 16 (Academic Press, N.Y., 1955).

[5] Watson, M., and Siekevitz, P., *J. Biophys. Biochem. Cytol.*, 2, 639 (1956).

[6] McMurray, W. C., Maley, G. F., and Lardy, H. A., *J. Biol. Chem.*, 230, 219 (1958).

[7] Kielley, W. W., and Bronk, J. R., *J. Biol. Chem.*, 230, 521 (1958).

Antigonadotropic Function of the Pineal Gland and the Oxytocin of the Neurosecretory Hypothalamic System

THE existence of an active substance in the pineal gland capable of inhibiting gonadotropic hormones is supported by most authors who have studied this problem. On the other hand, nothing has been revealed concerning the mechanism which causes this inhibition. The existence of a direct interaction between the pineal-inhibiting factor and gonadotropic hormones does not seem likely. In connexion with investigations carried out on anti-androgenic fractions of bovine pineal gland, one of us claimed that the antigonadotropic function of the pineal gland was exerted at the level of the subcortical centres inhibited by it[1].

On the other hand, the work of Shibusawa *et al.*[2] and Martini *et al.*[3] seems to indicate that oxytocin represents the releasing factor for gonadotropic hormones.

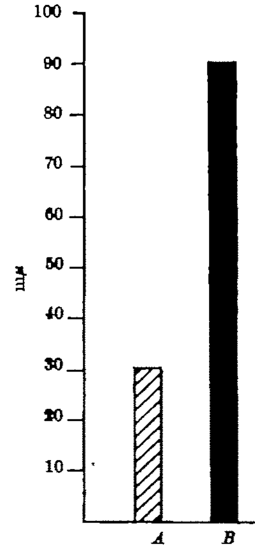


Fig. 1. Oxytocic activity of dog paraventricular nucleus (mean values of 6 animals). *A*, normal activity (30 ± 9 mμ); *B*, 5 hr. after administration of pineal extract (90 ± 12 mμ). The means and their standard errors are given as mμ, in terms of U.S. Pharmacopoeia reference standard

If this hypothesis is correct, the antigonadotropic function of the pineal gland ought to be exerted through the blocking of the oxytocin as a releasing factor in the nuclei of the neurosecretory hypothalamic system.

Our experiment was performed on 12 adult male dogs weighing about 15 kgm. The animals were divided into 2 groups: 6 animals served as controls and another 6 were given intravenous injections of 10 ml. protein extract of bovine pineal gland containing a nitrogen equivalent of 0·03 mgm./ml. The animals were killed 5 hr. after the administration of the pineal extracts, with as little psychic disturbance as possible, by the rapid intravenous injection of magnesium as a 25 per cent w/v aqueous solution of the sulphate. The whole brain and pituitary body were removed in about 10 min. and placed in 20 vol. of anhydrous acetone. The supra-optic nuclei, the paraventricular nuclei, the tuber cinereum and the neurohypophysis were isolated. Extraction was performed according to the method of Van Dyke *et al.*[4]. Holton's method[5] was used for the assay of oxytocin. All determinations were performed in comparison with U.S. Pharmacopoeia posterior pituitary reference standard.

The normal amounts of oxytocin that we found in the paraventricular nucleus is in strong agreement with those of Van Dyke *et al.*[4].

Five hr. after the intravenous administration of 10 ml. protein extract of bovine pineal gland, the oxytocic activity of the paraventricular nucleus increased from 30 ± 9 to 90 ± 12 mμ (Fig. 1). We consider this increased concentration of oxytocin to be due to blocking of this polypeptide under the action of the pineal extract.

In a recent paper[6], a very low oxytocic activity was described in the nuclei of the neurosecretory hypothalamic system during the releasing of gonadotropic hormones. In the present work, concomitantly with the blocking of gonadotropic hormones, there is a significant increase of the oxytocic activity in the nuclei of the neurosecretory hypothalamic system. This parallelism between the releasing or blocking of gonadotropic hormones and releasing or blocking respectively of oxytocin in the neurosecretory hypothalamic system supports the hypothesis of Shibusawa and Martini according to which oxytocin or an active substance associated with it represents the releasing factor for the gonadotropic hormones. On the other hand, this experiment shows that the antigonadotropic function of the pineal gland is achieved through blocking of the oxytocin or of an active substance associated with it in the neurosecretory hypothalamic system, and not through the direct interference with gonadotropic hormones. The antigonadotropic function of the pineal gland is in fact an antigonadotropic hormone function. This hypothesis is strongly supported by Milin's histophysiological investigations[7]. He found a lowered activity of the nuclei of the neurosecretory hypothalamic system in the rabbit during the blocking of the gonadotropic hormones by darkness and an increased activity of these nuclei during the releasing of gonadotropic hormones caused by light. In the first case, the pineal gland is hyperactive, in the second hypoactive. Investigations which are under way concerning the action of pineal extracts on vasopressin in the neurosecretory hypothalamic system make us assume that the anticorticotropic function of the pineal gland is exerted through the intermediary of vasopressin as a releasing factor of a substance associated with it, and not through the direct interference with adrenocorticotropic hormone.

Thus, it seems that the antigonadotropic mechanism consisting in the blocking of releasing factors represents a general pattern according to which the pineal gland exerts its antitropic functions. Investigations now being carried out will, we hope, furnish new data on the relationship between tropic hormones and the releasing factors in the neurosecretory hypothalamic system.

S.-M. Milcou
S. Pavel

Institute of Endocrinology,
Bucharest.

[1] Milcou, S.-M., "Epifiza glandă endocrină", Cong. Nat. Sci. Med., Bucuresti (May, 1957).

[2] Shibusawa, K., Saito, S., Fukuda, M., Kawai, T., Yamado, K., and Tomizawa, K., *Endocrinol.* (Japan), 2, 3 (1955).

[3] Martini, L., Mira, L., Pecile, A., and Saito, S., *Acta Endocrinol.*, Supp. 38 (1958).

[4] Van Dyke, H. B., Kardis, Adamson, jun., and Stanford, L. Engel, in "Recent Progress in Hormone Research", 1 (Academic Press, New York, 1956).

[5] Holton, P., *Brit. J. Pharm. Chem.*, 3, 328 (1948).

[6] Milcou, S.-M., Pavel, S., and Pterescu, S., *Rumanian Med. Rev.* (in the press).

[7] Milin, R., Cong. Nat. Sci. Med. Bucuresti (May, 1957).

Autonomic Nerve–Smooth Muscle Transmission

Despite extensive work on the morphology and pharmacology of autonomic effector systems, very little is known about the mechanism of transmission of excitation from nerve to smooth muscle. In the present work our approach has been to apply modern electrophysiological methods to a suitable autonomic nerve–smooth muscle preparation in a manner similar to that described for the skeletal neuro-muscular junction[1].

Smooth muscle cells from the longitudinal layer of the vas deferens of the guinea pig were impaled with capillary microelectrodes and membrane potential

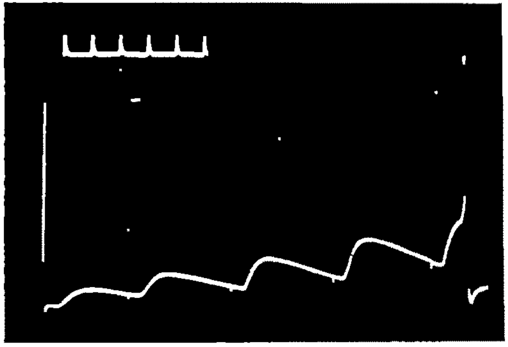


Fig. 1. Membrane potential recorded from a single smooth muscle fibre of the vas deferens of the guinea pig during repetitive stimulation of the hypogastric nerve (stimuli 1 msec. duration). Successive 'junction potentials' increase in amplitude and rate of rise. Summation occurs until at a critical depolarization a spike is initiated

changes recorded during repetitive stimulation of the hypogastric nerve. The vas deferens was never spontaneously active. In the experiment illustrated in Fig. 1, the resting potential was 65 mV. Five successive stimuli resulted in depolarizations of progressively greater amplitude until, at a critical membrane potential (37 mV.), a spike was initiated and a vigorous contraction occurred. The membrane potential at which the spike arose was remarkably constant for the majority of cells (35–38 mV.). The number of stimuli required to reach this threshold, however, was variable.

The mean resting potential of the vas deferens was 57 mV. ($SE_M = 6$ mV.). The spike was similar in configuration to those recorded from the taenia coli of the guinea pig[2] and the uterus of the rat[3]. Spike amplitudes of up to 84 mV. were recorded (mean 68 mV., $SE_M = 8$ mV.); overshoots were up to 20 mV. The positive phase of the spike (after-hyperpolarization) generally brought the membrane potential back to, or beyond, its resting-level.

We have decided to call the successive depolarizations in response to nerve stimulation 'junction potentials'. We felt that the term 'end-plate potential' was best reserved for tissues where a definite end plate region could be distinguished; the term 'post synaptic potential' did not seem appropriate since, at present, there is no histological evidence for any structure resembling a neuronal synapse in smooth muscle.

Both the amplitude and the rate of depolarization of the junction potentials increased with successive stimuli, this facilitation occurring even when the interval between stimuli exceeded 500 msec. The rate of depolarization of the junction potential was slow compared with other post-synaptic potentials. The rate of decay of the junction potential varied greatly from preparation to preparation. We think it is unlikely that this slow decay is dependent on the time-constant of the membrane, but that it may represent slow destruction of the transmitter. Brown and Gillespie[4] suggested that at least 100 msec. were required for destruction of the noradrenaline released from cat spleen by splenic nerve stimulation.

Junction potentials could be recorded in cells along the entire surface of the vas deferens. Their amplitude and latency varied somewhat from cell to cell, but there was no indication of a defined end-plate region. The functional distribution of nerve endings therefore appears to resemble that of crustacean muscle[5]. The amplitude of the junction potentials was dependent on the number of nerve fibres stimulated. If the hypogastric nerve was stimulated submaximally, the amplitude of junction potentials all over the muscle was reduced.

In the absence of nerve stimulation small 'miniature junction potentials' were recorded which presumably indicated the spontaneous release of transmitter. Their frequency was lower than that observed at the skeletal neuromuscular junction[6]. Their amplitude was larger (up to 18 mV.); but this may be accounted for in terms of the small diameter of the muscle fibres[7].

The response of the vas deferens to hypogastric nerve stimulation was unaffected by hexamethonium (5×10^{-6}) and atropine (10^{-6}), but was blocked by the anti-adrenergic drug darenthin (5×10^{-6}). Thus, stimulation appears to have been post-ganglionic and the transmitter is most likely to be noradrenaline.

These results will be published in detail elsewhere.

We wish to thank Dr. Michael Rand for introducing us to this preparation and for assisting us with the pharmacology.

G. Burnstock
Mollie E. Holman

Departments of Zoology and Physiology,
University of Melbourne,
Victoria.

[1] del Castillo, J., and Katz, B., "Progress in Biophysics", 6, 122 (Pergamon Press, London and New York, 1956).
[2] Holman, Mollie E., *J. Physiol.*, 141, 464 (1958).
[3] Marshall, Jean M., *Amer. J. Physiol.*, 197, 935 (1959).
[4] Brown, G. L., and Gillespie, J. S., *J. Physiol.*, 138, 81 (1957).
[5] Fatt, P., and Katz, B., *J. Exp. Biol.*, 30, 433 (1953).
[6] Boyd, I. A., and Martin, A. R., *J. Physiol.*, 132, 61 (1956).
[7] Katz, B., and Thesleff, S., *J. Physiol.*, 137, 267 (1957).

PSYCHIATRY

Paradoxical Blocking and Arousal in the Drowsy State

THERE have been many attempts to investigate the hypnotic state making use of the electroencephalograph. Though clinically the subject might have the appearance of sleep, the electroencephalograph was not found to be different from that found in the wide-awake hypnotized state. Darrow *et al.*[1] believed that the electroencephalograph in hypnosis had characteristics that distinguished it from both true sleep and full consciousness. Our experience does not confirm either of these views, but we have not found the electroencephalograph of a hypnotized person to have any distinctive characteristics. Rather the electroencephalograph of the hypnotized person can be characteristic of the waking or drowsing electroencephalogram without hypnosis, depending upon the situation and the suggestions given. This finding is therefore in accord with those of older writers on the subject, including Paul Schilder[2].

In the case we are describing, the patient had been hypnotized several times. Suggestions were given to "Allow yourself to go deeper and deeper asleep . . ." with explanations to the effect that the word 'sleep' was here being used in a special sense, because the subject was told that he could still hear and comprehend the experimenter. On other occasions he was urged to go to sleep and become "oblivious to everything and be completely relaxed". On one such occasion when the record gave evidence of drowsiness

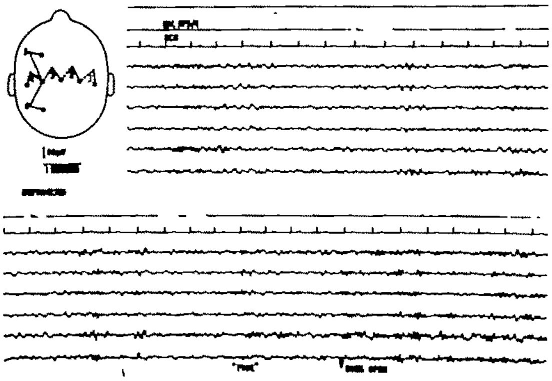


Fig. 1

(in this instance for 40 sec.) it was suggested that after the experimenter had counted from 1 to 5, he would be able to open his eyes. No change in the electroencephalograph occurred during counting or while the instruction was being given. Three seconds after the count of 5 the patient opened his eyes and there was at this time paradoxical blocking of the alpha rhythm (that is, the alpha appeared on eye opening). Despite the fact that the instruction was obeyed, arousal from the drowsy state, as illustrated by the electroencephalogram, did not occur until the patient actually opened his eyes. Therefore opening the eyes was the first external change observed, and the electrical change coincided with this. Since the instruction was obeyed, one would have expected the record to change while the instruction was being given. On other occasions different tasks had been set, to be obeyed on counts of 3 or 5; it is therefore unlikely that on this occasion the correct response was a chance occurrence. There was one other occasion when the patient was instructed to rub his face with his hand after a count of 5. During the instruction the record was that of drowsiness, but when he started to rub his face some 6 sec. after the count of '5', the alpha rhythm appeared. The alpha rhythm here is therefore an index of arousal. The arousal occurred when the instruction was obeyed and not when it was given. This is of interest in view of the finding by Oswald *et al.*[3] that in light sleep *K*-complexes occurred more often to certain names, especially the subject's name, rather than to meaningless sounds. They concluded that the censorship controlling arousal was in the cortex. On the other hand, our example seems to pose again the question asked by Adrian[4]: "If patterns arrive at the cortex, who reads the patterns?" Adrian[4] also said, "The meaning of the stimulus is there before the mind comes to understand it". Our example perhaps supports this statement, the instruction having been received and then apperceived, and the stimulus for arousal comes into being as a result of the significance of the instruction for the sleeper. We would agree more with Adrian[4] that the diencephalon is mostly concerned. "The physical intensity of the stimulus is not as important as the emotional associations"[5]. This statement is supported by our observation. The instruction is received and the mechanism of response put in train (? understood). Electroencephalograph arousal, when it occurs, is not therefore to the auditory stimulus of the instruction given nor to the internal mechanism set in train to provide the ultimate response, but takes place when this response occurs. Arousal is then a response to the emotion evoked by the performance of the act itself and the meaning of it to the sleeper.

L. Goldie
J. M. Green

Department of Clinical Neurophysiology,
Institute of Psychiatry,
Maudsley Hospital,
London, S.E.5.

---

[1] Darrow, C. W., Henry, C. E., Brenman, M., and Gill, M., *EEG. Clin. Neurophysiol.*, 2, 231 (1950).

[2] Schilder, P., "The Nature of Hypnosis", trans. by Gorvin, G. (International Universities Press, New York, 1956).

[3] Oswald, I., Taylor, A., and Treisman, M., *EEG. Clin. Neurophysiol.*, 11, 603 (1959).

[4] Adrian, E. D., in "Brain Mechanisms and Consciousness", edit. by Delafresnaye, J. F., 237 (Blackwell Scientific Publications, 1954).

[5] Adrian, E. D., *Irish. J. Med. Sci.*, 138, 237 (1937).

RADIOBIOLOGY

Dye-sensitized Photo-reactivation of X-ray Damage in Diploid Yeast

In an investigation of the binding of amino-acridine dyes to deoxyribonucleic acid in living cells we have shown that the nucleic acid fluorochrome, acridine orange (3,6,-*bis*-dimethylaminoacridine), sensitizes both haploid and diploid yeast (*Saccharomyces cerevisiae*) to visible light[1]. The significance of the survival curves obtained for this acridine orange-sensitized photo-inactivation was further examined by experiments involving additivity of X-rays, ultra-violet and visible light. In the course of these additivity studies[2] a new effect appeared: dye-sensitized visible-light reactivation of X-ray damage in diploid cells. This effect is of special interest because, although ultra-violet damage having a nucleic-acid action spectrum is partially reversible by visible light, previous attempts at reactivation of X-ray damage with visible light have not been successful[3].

The techniques for handling and irradiating the yeast have been described elsewhere[4]. In the present experiments cells which had grown for seven days at room temperature on potato dextrose agar were suspended in *p*H 7 phosphate buffer to make a final concentration of 10^6 cells/ml. This suspension was exposed first to a dose of X-rays (dose-rate 330 r./min.) sufficient to inactivate a predetermined fraction of the population. Then purified acridine orange (1 : 2,000) was added to make a final dye concentration of 1 : 200,000 or $1 \cdot 8 \times 10^{-6}$ *M*; after 20 min. in the dye the cells were irradiated with visible light (10^4 ergs/cm.^{2}/sec.). The light source was a General Electric *R*-52 750-watt flood lamp. The output of this lamp was filtered through a copper sulphate solution and a Corning filter No. 3389 to remove infra-red and near ultra-violet components which cause inactivation in the absence of the dye.

The results of a typical experiment are shown in Fig. 1. Here, the suspension was irradiated with X-rays until 85 per cent of the original population was inactivated (that is, to the 15 per cent survival-level). (Similar results are obtained for both lower and higher levels of survival.) In all cases, subsequent irradiation with low doses of visible light (in the presence of dye) increases this surviving fraction, thus indicating a repair or by-pass of part of the damage produced by the X-rays. With increasing dose, simultaneous killing by the visible light first lessens and finally overrides the observed reactiva-

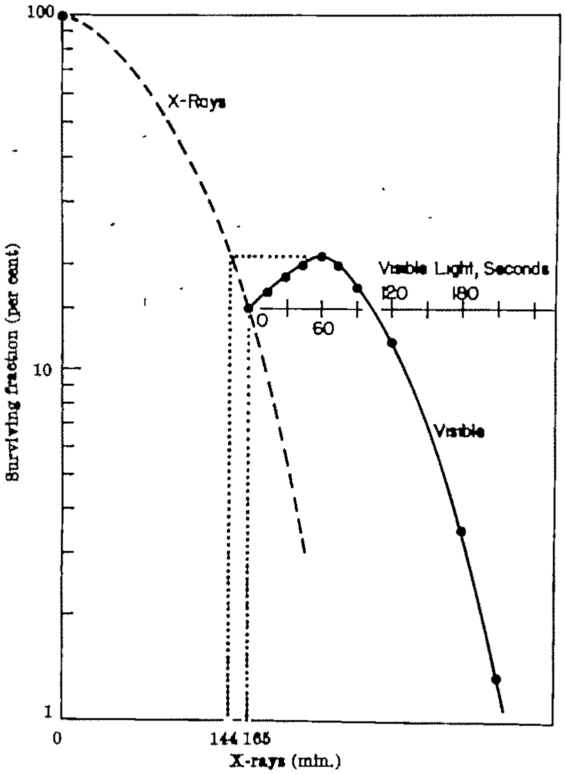


Fig. 1

tion. At the apparent maximum (60 sec.), the dose reduction factor for X-ray damage is 165/144 = 1·14. The actual maximum degree of reactivation is probably much higher and could ordinarily be determined graphically by subtracting the normal visible light inactivation curve, were it not for the quantitatively unknown degree of additivity of X-rays and visible light. (The visible light inactivation curve which would occur in the absence of reactivation is steeper than the ordinary curve for a non-pre-irradiated population because of the existence of common sites for X-ray and visible light damage.)

This reactivation of X-ray damage is not found in haploid yeast. Since the dye-sensitized visible light survival curve for haploid cells surviving X-irradiation is identical with that for non-pre-irradiated cells, there is not only no increase in survival, but also no interaction of the two irradiations at all. This lack of haploid reactivation suggests some difference between the inactivation process for the two ploidies that is not necessarily associated with simple genetic duplication. Clearly, either the reactivable site in the diploid accounts for, at most, a very small part of the X-ray damage in the haploid (which implies some independence in the X-ray sites of the haploid and diploid), or the site is present in both haploid and diploid; but, because of some difficulty in the dye-binding or sensitization process, it is not reactivable in the former. It is difficult to separate these possibilities, since from additivity and survival experiments we have been able to conclude only that for X-rays and visible light (with dye) some of the haploid sites are also diploid sites and some of the X-ray sites are also visible sites; we have not yet been able to determine the degree of overlap or to equate one part with another. Reactivation by visible light involving a dye which binds deoxyribonucleic acid nevertheless strengthens the view that part of the X-ray damage to a cell is damage to deoxyribonucleic acid molecules.

It has been reported that X-ray damage in yeast can also be repaired, in part, by ultra-violet light[5]. In this case, also, there is a decreased effect in the haploid, although in a genetically related non-respiring haploid the effect is the same as in the diploid. However, since ultra-violet reactivation of X-ray damage is found only with actively budding cells rather than the resting cells used in the present work, a comparison is probably not valid, especially since there are striking differences in the X-ray curves for resting and budding populations[6].

This investigation was aided by research grant C-2739 from the National Cancer Institute of the United States Public Health Service. One of us (D. F.) was supported by a National Science Foundation pre-doctoral fellowship.

DAVID FREIFELDER*
ROBERT B. URETZ

Committee on Biophysics,
University of Chicago,
Chicago 37, Illinois.

* Present address: Department of Biology, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Freifelder, D., and Uretz, R. B., *Nature*, 186, 731 (1960).
Freifelder, D., Ph.D. thesis, University of Chicago (1959).
Jagger, J., *Bact. Rev.*, 22, 99 (1958).
Uretz, R. B., *Rad. Res.*, 2, 240 (1955).
Elkind, M. M., and Sutton, H., *Science*, 128, 1082 (1958).
Beam, C. A., *Rad. Res.*, Supp. 1, 372 (1959).

Influence of Localized Ultra-violet Irradiation on the Incorporation of Adenine-8-^{14}C and D,L-Methionine-^{35}S in *Acetabularia mediterranea*

We have shown recently[1,2] that methionine labelled with sulphur-35 is incorporated in a decreasing apico-basal gradient in the unicellular alga *Acetabularia mediterranea*. The existence of this gradient suggested a possible relationship between methionine incorporation, ribonucleic acid metabolism and the production of morphogenetic substances in this alga. We have now examined the effects of localized ultra-violet irradiation, delivered to algal stem tips or rhizoids, on morphogenesis and adenine and methionine incorporation, in order further to evaluate the reality of this relationship and its implications.

The present observations were made on whole algae shortly before cap formation. Irradiations were limited to either the first 3 mm. of stem tip or the rhizoid. The ultra-violet dose applied was equivalent to 8 × 10^{3} ergs/mm.[3]. This dose, while effective, produces no demonstrable lethality[3]. Incubation with labelled precursors (adenine-8-^{14}C at 0·1 μc. and 0·02 μM/ml., D,L-methionine-^{35}S at 0·1 μc. and 0·002 μM/ml.) occurred over a 48-hr. period immediately following irradiation. Incorporated radioactivity was detected autoradiographically by the methods described by Ficq[4].

While some retardation and partial inhibition of morphogenesis was noted regardless of the point of irradiation, the inhibition of cap formation was considerably more pronounced when the tip was irradiated (about 50 per cent) than when the irradiation was restricted to the rhizoid (about 14 per cent inhibition). Quantitative analysis of the autoradiographs of unirradiated algae showed an adenine-^{14}C incorporation gradient which was qualitatively similar to that observed with methionine[3,4], but which differed in sharpness; methionine incorporation was ten times more intense in tip cytoplasm than in the cytoplasm of the rhizoid; the adenine incorporation ratio between the two morphological extremities was only 3 : 1.

Irradiation of the rhizoid led to a marked reduction (about 50 per cent) in the incorporation of both adenine and methionine, without modifying the characteristic apico-basal gradients of either; the inhibition produced by rhizoid irradiation was thus a general one. Irradiation of the stem tip, however, resulted in a specific inhibition of adenine and methionine incorporation in the irradiated region; the cytoplasm of the rhizoid was even more strongly labelled after stem tip irradiation than in control algae.

These results suggest that the rhizoid, or more probably the nucleus which is located there, exerts a control, direct or indirect, on the synthesis of ribonucleic acid[5] and that of sulphur-containing proteins[1,2]; these proteins and ribonucleic acid accumulate in the apical extremity of the alga. Ultra-violet irradiation restricted to the apical region inhibits both morphogenesis (that is, cap development) and the accumulation of these substances at the stem tip. These new results provide further support for the notion that ribonucleic acid and sulphur-containing proteins play an important part in the morphogenesis of *Acetabularia mediterranea*[6].

J. BRACHET
M. J. OLSZEWSKA*

Laboratoire de Morphologie animale,
Université libre de Bruxelles.

---

* Fellow of the Rockefeller Foundation. Present address: Laboratory of Plant Anatomy and Cytology, University of Łódź, Łódź, Poland.

[1] Olszewska, M. J., and Brachet, J., *Arch. Internat. Biochem.* (in the press).
[2] Olszewska, M. J., and Brachet, J., *Exp. Cell Res.* (in the press).
[3] Herrera, M., and Vanderhaeghe, F., *Exp. Cell Res.*, 13, 1 (1957).
[4] Ficq, A., *Arch. Biol.*, 66, 509 (1955).
[5] Stich, H., and Plant, W., *J. Biophys. Biochem. Cytol.*, 4, 119 (1958).
[6] Brachet, J., *Exp. Cell Res.*, Supp. 6, 78 (1959).

Identification of Transplanted Bone Marrow Cells in Radiation Chimæras

THE beneficial effect of bone marrow transfusion in acute radiation syndrome is now well established. This effect seems to depend on the survival of transfused cells and their proliferation in the depleted hæmopoietic tissues of the recipient[1]. In view of this, there arises the problem of identification of donor cells. Various methods were devised to this end, each permitting the recognition of a certain percentage of a particular cell series[1].

The purpose of this work was to find if rabbits, complete heterozygous carriers of the Pelger anomaly, may be used as donors and if transfused cells may be identified by their characteristic morphological appearance. This consists in specific structure of chromatin in all nucleated blood and bone marrow cells, early blast stages and orthochromatic erythroblasts excepted. Moreover, the granulocytes and megakaryocytes are characterized by hyposegmentation of their nuclei[2].

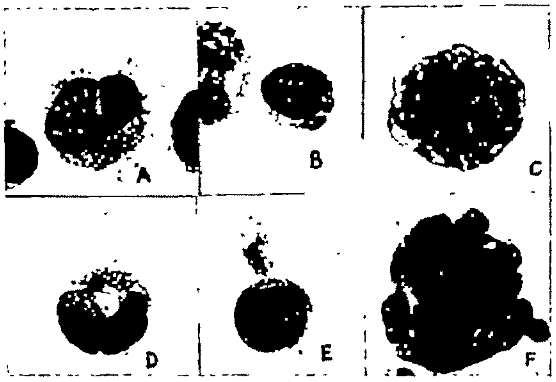


Fig. 1. A comparison between Pelger and normal bone marrow cells. Pelger cells: *A*, Metamyelocyte; *B*, polychromatic erythroblast; *C*, naked megakaryocytic nucleus; *D*, *E*, *F*, normal counterparts. Photomicrograph from a bone marrow smear from a radiation Pelger chimæra

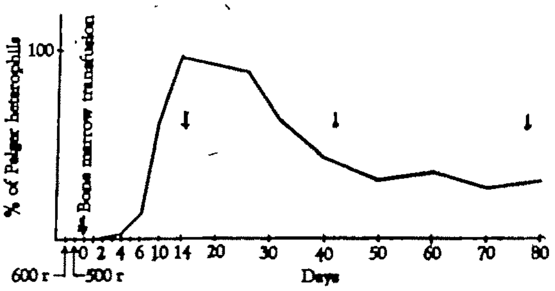


Fig. 2. Curve representing the percentage of Pelger heterophils in the peripheral blood of a Pelger radiation chimæra. 100 per cent = all heterophils in the blood. Arrows indicate bone marrow biopsy

39 rabbits were exposed to total-body X-irradiation (1,100 r.: initial dose of 600 r., followed after 24 hr. by 500 r.). To 5 rabbits an injection of bone marrow cell suspension obtained from Pelger rabbits was administered; 16 animals (males) were injected with bone marrow cell suspension from female donors according to the technique described by Porter[3]. The remaining rabbits served as controls, their mean survival-time being 10 days.

In the first experimental group all donors exhibited Pelger traits in all nucleated blood and bone marrow cells, especially in the granulocytic erythroblastic and megakaryocytic series (Fig. 1), with the above-mentioned exceptions. All recipients were examined beforehand for the presence of Pelger traits, because of the frequent occurrence of partial carriers among rabbits[2]. Following successful bone marrow transplantation, donor cells could be easily identified in peripheral blood (especially heterophils, Fig. 2) of the recipients. We obtained two rabbit-radiation-Pelger-chimæras, which survived longer than 30 days. Fig. 2 illustrates the findings in one of these (peripheral blood). Donor cells could be identified also in the bone marrow, which may be illustrated by the findings of bone marrow biopsy performed the fourteenth day on the same animal, as in Fig. 2.

Table 1

Cell series (per cent)	Granulocytic	Erythroblastic	Megakaryocytic
Pelger (donor) cells	82	46	46
Host's cells	8	34	33
Unidentified cells	10	20	21

In the second experimental group the transfused cells were identified by the presence of sex chromatin in heterophils, as described by Porter[3]. This group served as controls for the Pelger group, showing a similar survival-time. The time-course of increase in donor cells in the blood of the recipients was also similar, although the percentage of Pelger cells was much higher.

We believe that this method for the identification of transplanted bone marrow cells may be useful in experiments on rabbits, making it possible to follow the course of cytological changes during the recovery period in the bone marrow and peripheral blood as well. Moreover, this method may be applied for the simultaneous identification of all three donor bone marrow cell series and is more convenient than former methods.

We wish to express our thanks to Dr. E. Undritz, of the Sandoz Laboratories, for kindly supplying Pelger rabbits.

P. CZERSKI
O. ROSIEK
J. SABLIŃSKI

Institute of Nuclear Research,
Department of Health Protection,
Dorodna 16, Warsaw.

---

[1] Congdon, C. C., in "Progress in Haematology", edit. by Tocantins, L. M., 2 (Grune and Stratton, New York, 1959).

[2] Undritz, E., *Folia Haematol.*, 67, 249 (1943).

[3] Porter, K. A., *Brit. J. Exp. Path.*, 38, 401 (1957).

Urinary Excretion of β-Amino-*iso*butyric Acid after Injection of Thymidine labelled with Tritium

β-AMINO-*iso*BUTYRIC acid is a metabolic degradation product of thymine[1,2], but its relation to the catabolism of endogenous deoxyribonucleic acid has remained uncertain. In the present communication we present results which elucidate the catabolic fate of that fraction of thymine originating from endogenous deoxyribonucleic acid and reflected in the urinary excretion of β-amino-*iso*butyric acid.

Each of five rats weighing 130 gm. was injected intraperitoneally with $4 \cdot 5 \times 10^7$ c.p.m. of ^{3}H-thymidine in three equal doses given at 3-hr. intervals. The ^{3}H-thymidine used was prepared as described previously[3]. Pooled urine samples were collected from these animals during successive 24-hr. intervals throughout the 30-day experimental period. The rats were killed at various times after the injection of ^{3}H-thymidine. Deoxyribonucleic acid was isolated from several organs, as described previously[3], and β-amino-*iso*butyric acid from the urine specimens. A new method was used to determine β-amino-*iso*butyric acid[4]. This involved the initial conversion of β-amino-*iso*butyric acid to its dinitrophenyl derivative and the quantitative chemical determination thereof on the basis of the optical density at 360 mμ. Radioactivity of this dinitrophenyl derivative was determined in the manner described previously[3] using a gas-flow counter. The error involved in the determination of the specific activity of urinary β-amino-*iso*butyric acid was of the order of 10 per cent.

A plot of the specific activity of β-amino-*iso*butyric acid *versus* time is presented in Fig. 1. As can be seen, the specific activity decreased rapidly during the initial three days but only gradually thereafter. Presumably, the marked initial decrease in the specific activity results mainly from the utilization of thymidine for biosynthesis of deoxyribonucleic acid or degradation of thymidine *via* dihydrothymine and β-amino-*iso*butyric acid. Since on the second day the specific activity of tissue deoxyribonucleic acid exceeds that of urinary β-amino-*iso*butyric acid it appears reasonable to assume that at this time the breakdown of deoxyribonucleic acid contributes significantly to the labelling of β-amino-*iso*butyric acid. The rapid replacement of labelled deoxyribonucleic acid of intestine and hæmatopoietic tissue is thought to cause the initial decrease in the specific activity of urine. In other organs, such as liver or muscle, replacement of deoxyribonucleic acid is slower and may contribute radioactivity to β-amino-*iso*butyric acid at the later time period. The specific activity of deoxyribonucleic acid isolated from several organs on the third day is cited here for the purpose of comparison with the specific activity of β-amino-*iso*butyric acid, namely, liver, 2,800, muscle, 3,300, intestine, 7,400, and spleen, 6,300. The specific activity of intestinal deoxyribonucleic acid 24 hr. after injection of thymidine was 34,000. All values represent c.p.m./μmole of thymidine.

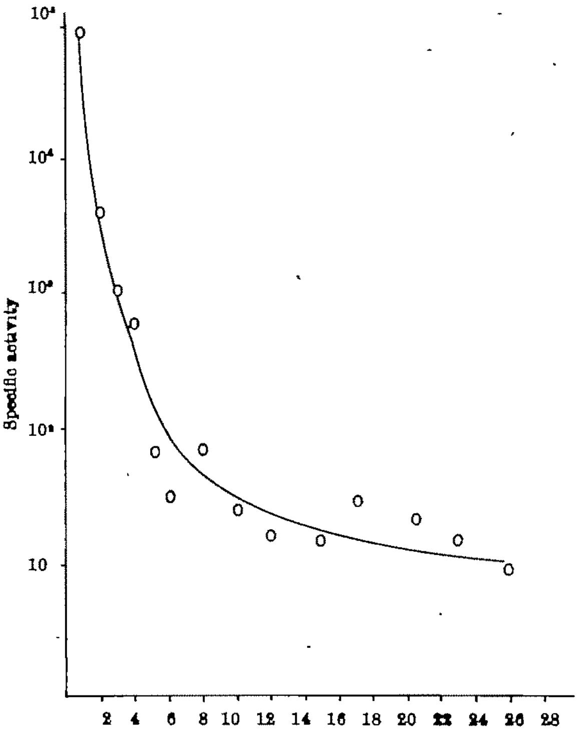


Fig. 1. Plot of specific activity *versus* time of urinary β-amino-*iso*butyric acid. The specific activity is expressed as the logarithm of c.p.m./μmole and time in days

Since ^{3}H-thymidine may undergo exchange reaction during the metabolic conversion to β-amino-*iso*butyric acid, the fraction of thymidine which participates in the synthesis of deoxyribonucleic acid cannot be assessed quantitatively, although this could be accomplished by using thymidine labelled suitably with carbon-14.

Two other radioactive compounds were detected in the urine of these rats. One of these has been identified tentatively as dihydrothymine and resembles β-amino-*iso*butyric acid with respect to its curve of specific activity *versus* time. The second compound has not been identified as yet.

This work was supported, in part, by the United States Atomic Energy Commission.

Georg B. Gerber
Gisela Gerber
Kurt I. Altman

Division of Experimental Radiology,
University of Rochester
School of Medicine and Dentistry,
Rochester, New York.

[1] Crumpler, H. R., Dent, C. E., Harris, H., and Westall, R. G., *Nature* 167, 307 (1951).

[2] Fink, K., Henderson, R. B., and Fink, R. M., *Proc. Soc. Exp. Biol. Med.*, 78, 135 (1951).

[3] Gerber, G. B., Gerber, G., and Altman, K. I., *J. Biol. Chem.*, 235, 1433 (1960).

[4] Gerber, G. B., Gerber, G., and Altman, K. I., *Clinica Chimica Acta*, 5, 607 (1960).

BIOLOGY

Electrical Sensitivity of the Ampullæ of Lorenzini

Electrophysiological investigation has shown that the ampullæ of Lorenzini of elasmobranch fishes are sensitive both to slight changes of temperature[1] and also to weak mechanical stimuli[2]. But neither sensory modality is convincing as the biologically adequate stimulus, for the temperature-sensitive regions are buried deep in the body (there being no apparent reason for the great anatomical development of the tube system), and the mechanical sensitivity is quantitatively less than that of the lateral line without being qualitatively very distinct.

There is, however, a third possibility. I have found that in rays the ampullæ are sensitive to slight changes in the electrical potential field surrounding the fish (*Raia clavata*, *R. naevus*, *R. montagui* and *R. brachyura* were used). The impulse discharge from single units in the mandibular group of ampullæ was recorded with the fish submerged about 1 cm. in a large dish of sea water; voltage gradients in the water over the sense organs were established from electrodes near the tail. Under such conditions the threshold d.c. potential gradient (that is, which produced approximately 10 per cent change of impulse frequency at make and break) was 1–2 μV./cm. (8 fish). The gradient had to lie along the line of the tubes, with the opening of the tubes negative to the capsule for an increase in frequency, and the opening positive for decrease. In each case there were opposite after-effects at break. The adaptation was almost complete, with a time-constant of about 5 sec. as is found with direct galvanic polarization of the sensory nerves[3].

With the preparation out of water, the ampullæ could be stimulated by passing a current between a small test probe and the body of the fish. When the probe was placed exactly on the opening of the tube from which the single fibre of the recording ran, a current of 0·005 μamp. (the smallest which could at the time be measured) was considerably greater than threshold; the frequency was increased when the probe was cathodal. But if the probe was displaced slightly from the opening, for example, by 0·5 mm., the threshold became far higher. Thus the stimulating currents would appear to be channelled along the jelly-filled tubes. In this connexion the conductivity of the jelly has been shown (Murray, R. W., and Potts, W. T. W., unpublished work) to be high (85–90 per cent of sea water) compared with that of the body fluids (40–45 per cent of sea water) and presumably the tissues have an even lower conductivity.

There would seem to be at least three possible ways in which this electrical sensitivity could be of direct use to the fish.

(1) It is known that rays have small electric organs derived from part of the tail musculature[4] which produce second-long pulses of up to 4 V. The potential gradients resulting from these would be at least 1,000 times stronger than those which I have found to be threshold for the ampullæ. Lissmann's suggestion[5] is therefore feasible, that this system could act as a navigation device, with the ampullæ detecting the changes in the field produced by the electric organs when an object with a conductivity different from the sea water comes near the fish. The ampullæ could of course act as the receptors for such a navigational system only in elasmobranchs, as they are not found in the teleosts with electric organs.

(2) I have some evidence that the ampullæ are sensitive to changes in the salinity of the sea water at their openings of about 5 per cent. The mechanism for this sensitivity could be electrical, depending on the differences in the diffusion potentials caused by dilution.

(3) When a conductor is moved through the Earth's magnetic field, potential gradients are set up in it. Under certain conditions it is possible to detect by this means the strength and direction of a tidal stream or ocean current. It is, however, theoretically improbable that a fish being carried along by the water movement, and therefore subject to the same influences, could detect these small potentials, although it might be able to determine whether the current was, for example, easterly or westerly by swimming up from a position at rest on the bottom.

R. W. Murray

Department of Zoology
and Comparative Physiology,
University of Birmingham.

[1] Sand, A., *Proc. Roy. Soc.*, B, 125, 524 (1938).

[2] Murray, R. W., *J. Exp. Biol.*, 37, 417 (1960).

[3] Murray, R. W., *J. Physiol.*, 145, 1 (1959).

[4] Fessard, A., edit. by Grassé, P.-P., "Traité de Zoologie", 13, 1143 (1958).

[5] Lissmann, H. W., *J. Exp. Biol.*, 35, 156 (1958).

Development of Delayed-type Hypersensitivity in Guinea Pig Embryos

Several modalities of the immune response of embryos have been previously investigated. These include: (*a*) induction of immunological tolerance[1]; (*b*) antibody formation[2]; (*c*) capacity to reject homografts[3]. There have been no analogous studies of the capacity of the embryo to develop the delayed type of hypersensitivity to protein antigens.

Previous attempts to induce tuberculin skin reactivity in new-born guinea pigs by active sensitization[4] or by passive transfer with leucocytes[5] have been unsuccessful. Weiss[6] injected guinea pig embryos with tubercle bacilli, and elicited tuberculin reactions in some of these animals several weeks after birth.

In the present work, guinea pig embryos were injected *in utero* usually 1–2 weeks before the expected date of their delivery. In early experiments, the injections were made after laparotomy. Afterwards, injections were performed through the intact abdominal wall, using a 23-gauge needle directed at the position of the peritoneal cavity of the embryo, which was held between the fingers of the operator's other hand. In this fashion, 1–10 μgm. of protein antigen contained in 0·1 ml. of complete Freund's adjuvant (including killed *Mycobacteria butyricum*) were injected into the embryo. Only two embryos in each litter were injected, since more injections greatly increased the rate of abortion. After birth, attempts to identify those embryos which had been injected were unsuccessful, despite the use in several experiments of proteins trace-labelled with iodine-131, and the inclusion of Evans blue dye in the suspension. This failure was probably due in part to the small amount of antigen injected and the slow release of the injected material from the saline-in-oil suspension. New-born guinea pigs were usually skin-tested on the first day of life with 3 μgm. of specific antigen. If the sensitizing injection had been administered less than five days before delivery, the skin testing was postponed until five days after sensitization.

Delayed-type reactions to diphtheria toxoid, ovalbumin, or bovine serum albumin similar to those previously described in adult animals[7] were elicited in 31 new-borns during the first five days of life. The average diameter of the reactions varied from 11 to 23 mm. Since a total of 83 injections were attempted in the embryos that survived, the sensitive animals probably represent a minority of those injected. Four skin reactions at 18–24 hr. and one reaction at 48 hr. after intradermal challenge were biopsied. Histological examination revealed pronounced infiltrations of lymphocytes, histiocytes and a smaller number of polymorphonuclear leucocytes throughout the dermis and subcutaneous tissue with an absence of vasculo-necrotic lesions (Fig. 1). Such lesions are typical of 'tuberculin-type' skin reactions[8].

Almost all the delayed-type skin reactions were obtained in animals weighing more than 90 gm. at birth, although an equal number of new-borns weighed between 50 and 90 gm. Since the weight of new-born guinea pigs is mainly a function of their intrauterine age[9], the capacity of guinea pig embryos to become sensitized probably depends in part on their general maturation.

In order to determine whether lymphoid cells were available in the smaller animals to participate in inflammatory reactions, total and differential white cell counts were carried out on three new-born animals that weighed 70 gm. each, and again on these animals two weeks later when they weighed 132–145 gm. At age one day the average white count was 2,800 with 41 per cent lymphocytes, compared to 4,900 with 65 per cent lymphocytes two weeks later, suggesting that there are an adequate number of lymphocytes in the circulation of the smaller new-born animal.

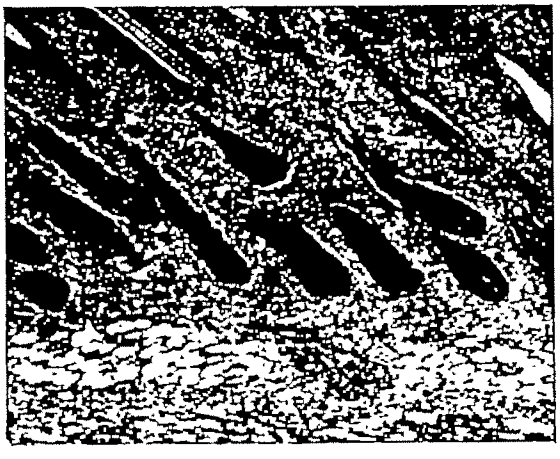


Fig. 1. Delayed-type skin reaction at 20 hr. elicited in a one-day old guinea pig. Haematoxylin and eosin. (× 45)

Table 1. DELAYED-TYPE HYPERSENSITIVITY IN ONE-DAY OLD GUINEA PIGS PREVIOUSLY SENSITIZED *in utero*

Sensitizing antigen	Birth-weight (gm.)	Delayed skin reaction (mm)	Passive cutaneous anaphylaxis test for serum antibody	
			Negative on day	Positive on day
Diphtheria toxoid	104	17 × 18	5	11
	104	11 × 12	11	—*
	94	22 × 25	11	—
	110	13 × 10	—	13
	124	18 × 17	—	11
	112	15 × 15	—	9
	96	15 × 15	—	9
Bovine serum albumin	112	20 × 20	3	6
Ovalbumin	100	17 × 16	2	10
	96	20 × 16	3	8
	88	17 × 18	3	8
	113	23 × 24	3	6

* Not done.

To ensure that delayed-type hypersensitivity in new-born animals was not the result of maternal sensitization and passive transfer across the placenta, twelve pregnant guinea pigs were injected intramuscularly 1–2 weeks before delivery with 1–10 μgm. of ovalbumin or toxoid in complete adjuvant. The new-born animals were skin-tested after their weight reached 100 gm. and none of fifteen animals showed delayed-type reactions.

Table 1 shows the positive skin reactions obtained in one-day old new-born animals in which antibody results using passive cutaneous anaphylaxis were also available. As seen in this table, antibody can be demonstrated in the serum of sensitive animals as early as one week after birth. When diphtheria toxoid was used as the antigen, the same serum in which antibody was demonstrated by passive cutaneous anaphylaxis failed to reveal antitoxin by the neutralization test for diphtheria toxin in rabbit skin. This is probably due to the production of antitoxin of low avidity, rather than to differences in sensitivity or specificity of the two tests. The possibility that antibody was produced against only non-toxoid diphtherial proteins is unlikely, since bovine serum albumin, which is less antigenic than toxoid for guinea pigs, stimulated detectable antibody formation.

To see if all new-born guinea pigs could be sensitized, twelve one-day old animals were injected either intramuscularly or in all four footpads with 1–10 μgm. of ovalbumin in complete Freund's adjuvant. Skin testing with 3 μgm. of ovalbumin 7–10 days later revealed delayed-type reactions in all those immunized in the footpads, but in only three of six immunized intramuscularly. Since the adult animal can be consistently made to acquire delayed-type hypersensitivity by the intramuscular route (if mycobacteria are included) it is possible that the new-born animal is sensitized less readily.

The capacity of one-day old animals to exhibit other hypersensitivity reactions was investigated, because of previous reports of the 'non-reactivity' of the skin of new-born guinea pigs[10]. To sensitize for passive cutaneous anaphylaxis reactions, 1 μgm. of rabbit anti-ovalbumin was injected intradermally into each of two new-born animals. Five hr. later, 1 mgm. of ovalbumin and Evans blue dye were injected intravenously. Blue reactions measuring 10 mm. by 10 mm. and 19 mm. by 17 mm. were obtained, but they were less intense than those simultaneously induced in adult animals. To produce passive Arthus reactions, two new-born guinea pigs were injected intravenously, and two intraperitoneally, with 700 μgm. rabbit anti-ovalbumin followed 24 hr. later by intradermal injection of 30 μgm. ovalbumin. The intravenously sensitized animals developed typical Arthus reactions with maximal intensity at 4 hr., at which time the lesions averaged 45 mm. in diameter with a central hæmorrhagic area measuring 8–10 mm. in diameter. By 24 hr. the lesions had almost completely regressed. The animals sensitized intraperitoneally displayed milder reactions. Large necrotic lesions were also produced in neonatal animals by the intradermal injection of 0·025 MLD. of diphtheria toxin.

Our finding that delayed-type hypersensitivity can be induced in some guinea pig embryos is consistent with the relative maturity of this species at birth.

This work was aided by grants from the National Institutes of Health (*E* 1821 (*C*-2)) and the Commission on Immunization of the Armed Forces Epidemiological Board.

JONATHAN W. UHR

Departments of Microbiology and Medicine,
New York University School of Medicine,
New York.

[1] Billingham, R. E., Brent, L., and Medawar, P. B., *Nature*, **172**, 603 (1953).

[2] Fennestad, K. L., and Borg-Petersen, C., *Nature*, **180**, 1210 (1957). Sterzl, J., Kostka, J., Riha, I., and Mandel, L., *Folia Microbiologica*, **5**, 29 (1960).

[3] Schinkel, P. G., and Ferguson, K. A., *Austral. J. Biol. Sci.*, **6**, 533 (1953).

[4] Freund, J., *J. Immunol.*, **13**, 285 (1927).

[5] Waksman, B. H., and Matoltsy, M., *J. Immunol.*, **81**, 235 (1958).

[6] Weiss, D. W., *J. Exp. Med.*, **108**, 83 (1958).

[7] Uhr, J. W., Salvin, S., and Pappenheimer, jun., A. M., *J. Exp. Med.*, **105**, 11 (1957).

[8] Gell, P. G. H., and Hinde, I. T., *Brit. J. Exp. Path.*, **32**, 516 (1951).

[9] Ibsen, H. L., *J. Exp. Zool.*, **51**, 51 (1928). Draper, R. L., *Anat. Rec.*, **18**, 369 (1920).

[10] Freund, J., *J. Immunol.*, **17**, 465 (1929).

Insects attacking *Striga*

WORKING in Ibadan, Nigeria, Williams and Caswell[1] have recently noted *Smicronyx* sp. (Curculionidae : Coleoptera), the larva of which lives within the fruits feeding on the immature seeds of *Striga* sp. The only other reference mentioned is that of Agarwala and Naqvi[2] on *Striga* in Bihar, India. Williams and Caswell have apparently missed references on the subject, especially that on *Smicronyx albovariegatus* Faust. recorded on *Striga*.

The first published record of an insect attacking *Striga* was that of Murthy and Rao[3], who observed the caterpillars of *Precis orithya* Swinhoeii (Fam. Nymphalidæ, Lepidoptera) feeding on leaves, flower buds and tender fruits of *Striga* in the former Hyderabad State, India. Following the publication of that observation, Uttaman[4] pointed out that during the course of work on *Striga* in Malabar, India, he had noted grubs of a beetle (Sub-fam. Galerucinae) feeding on stem, leaves and the pods. While continuing work on the insect fauna of this root parasite in Hyderabad, I collected *Striga* stem galls in numbers caused by a curculionid weevil grub, and Mani[5], on the basis of the plant material sent from Hyderabad, described briefly the structure of the gall. Work was later initiated on the above insect at the Entomological Laboratory, Government Agriculture Research Station, Rudroor, Hyderabad State, and the weevil was identified as *Smicronyx albovariegatus* Fst. by the Commonwealth Institute of Entomology, London. A brief account of the above insect was afterwards given by Khan and Murthy[6]. The adult weevils appear early in September and galls were noticed from the middle of September until January. A single grub is found in each gall. The number of galls per plant may vary from 1 to 30. When full grown, the grub comes out of the gall and pupates in the soil. The incidence of the weevil varies from 40·7 to 62·0 per cent. The grub not only causes stem galls but also eats into the seed capsules. During later work in Mysore State, another mode of injury caused to *Striga* plants by this weevil was recorded, namely, the formation of root galls by the grub[7]. It was observed that on account of the presence of root-galls there is weakening of the *Striga* plant which may perhaps be due to the impaired absorption of nutrients due to root damage.

Other insects recorded on *Striga* in India are *Monolepta signata* Oliv. (Galerucinae; Chrysomelidae), caterpillars of a *Pterophorid* moth eating into the seed capsules[4,8] and a species of aphid awaiting determination.

While working in the Entomological Division, Government Agriculture Research Station, Rudroor, a detailed investigation was carried out on the possibilities of biological control of *Striga*, which is to be published shortly. It has been found that both *P. orithya swinhoei* and *S. albovariegatus* do exercise certain natural checks on the growth and development of *Striga* in the field. While no natural enemies have been encountered against *S. albovariegatus*, I have recorded[9] the caterpillars of *P. orithya swinhoei* being attacked by the tachinid endoparasite, *Sturmia* (*S. Str.*) *flavohalterata* Bisch, the percentage incidence ranging from 2·5 to 52·5. The eggs are also occasionally attacked by *Trichogramma* sp.

I am grateful to Drs. M. Q. Khan, joint director of agriculture, Andhra Pradesh, and M. Puttarudriah, Government entomologist, Mysore Agriculture Department, India, for facilities and for guidance and encouragement given during the course of this work.

D. V. MURTHY*

Division of Entomology,
Department of Agriculture,
Seshadri Road,
Bangalore 1.

* Formerly working in the Division of Entomology, Department of Agriculture, Hyderabad State. Present address: Chesterford Park Research Station, nr. Saffron Walden, Essex.

[1] Williams, C. N., and Caswell, G. H., *Nature*, **184**, 1668 (1959).

[2] Agarwala, S. B. D., and Haider Naqvi, S. Z., *Proc. Bihar Acad. Agric. Sci.*, **2**, 121 (1953).

[3] Murthy, D. V., and Rao, A. S., *Curr. Sci.*, **9**, 342 (1949).

[4] Uttaman, P., *Curr. Sci.*, **9**, 445 (1949).

[5] Mani, M. S., *Agra Univ. J. Res.* (*Science*), **2**, 2, 246 (1953).

[6] Khan, M. Q., and Murthy, D. V., *Ind. J. Ent.*, **17**, 3 (1955).

[7] Murthy, D. V., *Curr. Sci.*, **28**, 502 (1959).

[8] Khan, M. Q., and Murthy, D. V., *Sci. and Cult.*, **21**, 3, 175 (1955).

[9] Murthy, D. V., *Curr. Sci.*, **28**, 256 (1959).

Age Determination of Seals

A WORD of warning is necessary when the number of cementum rings in the canine teeth of seals is used to determine the age of some species of Phocidae. As Mansfield and Fisher[1] have stated, they were able to count 18–20 rings in a tooth of a harbour seal (*P. vitulina* L.) of 19 years of age. For practical purposes this is good enough in the higher range of years, but the possible error becomes disproportionately large if applied to years 1–10; years which contain the critical years of sexual maturity both potential and actual.

Great care is needed in assessing the age of young seals, since the doubt inherent in the statement '18–20' is derived from real difficulties met with in counting the rings deposited in the earlier years of life, and in assessing the value of the 'last' ring.

Some years ago it became desirable to know the exact age of specimens of the grey seal (*Halichoerus grypus* Fab.). The rings in the dentine are not obvious, and in any event, as Laws[2] had shown, the teeth (canine as well as the others) rapidly become filled with dentine so that after the first few years no further deposition is possible. The rings of the cementum offered an alternative provided they were annual. Thanks to the kindness of Mr. Colin Matheson, of the National Museum of Wales, a longitudinal section was obtained in June 1956 of the canine tooth of a cow grey seal which died at the age of at least 26½ [3]. In this at least 25–26 rings could be counted, but the exact number was doubtful. However, the supposition that the rings were annual in origin was upheld. In November 1958 a cow grey seal, exactly six years old, died in the Zoological Gardens, Regent's Park, London, and a section of the canine tooth showed six clear and complete rings. Meanwhile, grey seals approximately 6½ months and 7½ months old had been obtained, marked on the Farne Islands in the previous November. These two showed clearly the deposition in part of the first annual ring of cementum. More recently, younger grey seals have been obtained which show that cementum is first deposited about 3–4 months after birth, somewhat unevenly in two bands on the root. These bands afterwards coalesce.

The primary cause of the difficulty in counting the rings is that the earlier ones are broad without sharply defined edges. The evidence so far suggests that these broader rings are deposited before sexual maturity. The fact that they are visible at all suggests that the semi-starvation during the moult is responsible. Thus the 'years' measured by cementum rings are 'years' following moult. If the moult is many months after the breeding period (birthday) it is possible to count only, say, five rings when the seal is in its sixth year of life. Thus the 'last' ring must be looked for very carefully and the degree of its deposition related to the period of moult, if known.

Sufficient material (118 specimens) has now been collected for the grey seal and a paper giving full details and relating age with sexual maturity is in preparation. Much of this work must be repeated if the technique is to be applied critically to other species of Phocidae.

H. R. HEWER

Dept. of Zoology,
Imperial College of Science
and Technology,
London, S.W.7.

[1] Mansfield, A. W., and Fisher, H. D., *Nature*, 186, 92 (1960).
[2] Laws, R. M., Falkland Is. Depend., Survey, Sci. Rep., 2 (1953).
[3] Matheson, C., *Nature*, 166, 73 (1950).

Abnormal Crimping in Merino and Polwarth Wools

AN abnormal wool, more apparent on older sheep and known as 'doggy' wool, is a cause of considerable financial loss in some Merino and Polwarth flocks. Such wool is frequently lustrous and is characterized by reduced frequency of crimps, so that in extreme cases the fibres are almost straight and hair-like. Preliminary evidence is presented here that doggy wool is associated with hyperplasia and cyst formation of the outer root-sheaths of a considerable proportion of the follicle population of affected sheep.

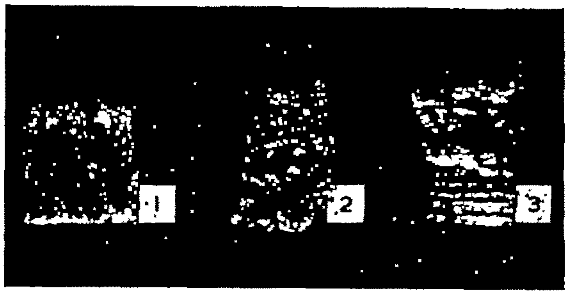


Fig. 1. Crimp deterioration in fine Merino and Polwarth wools in changing from normal (1) to 'doggy' (3)

In changing from normal to doggy, fine and medium Merino and Polwarth wools pass through an intermediate phase with secondary waves superimposed on the normal crimp; in strong Merino wool the change seems to be directly to a broader or irregular crimp. Fig. 1 illustrates the changes in fine Merino and Polwarth wools. The stages of crimp deterioration are somewhat similar to the changes produced in wool by a diet deficient in copper, but unlike the latter are not corrected by copper supplementation. The crimp aberrations are generally seen first in the loin, hip and thigh regions of the fleece, and the whole fleece may be affected within 1–2 years. The age at which the abnormality appears varies from 2 to 5 years in different strains of the Australian Merino, and the incidence also varies among the strains.

The main point of difference between normal and doggy wool is the changed crimp frequency. Routine examination of histological transverse sections of skin at the level of the sebaceous glands does not reveal any differences of significance. However, serial transverse and longitudinal sections of skin reveal grossly enlarged outer root-sheaths just above the bulbs of many follicles in the skin of sheep with crimp aberrations. Both primary and secondary follicles are involved, and in some follicles one or more localized enlargements form cysts, each of which is attached to the outer root-sheath by a narrow bridge of cells. Serial sections have established that these cysts are outgrowths from the outer root-sheaths. Fig. 2*a* shows a longitudinal section through a follicle with a cyst formed on an enlargement of the outer root-sheath, and Fig. 2*b* a transverse section of a number of follicles with outer root-sheath enlargements and cysts.

While occasional cystic sebaceous glands may be seen in the skin of sheep growing normal wool, particularly in aged sheep, the proportion of follicles with enlargements and cysts of the outer root-sheaths

Table 1. PERCENTAGES OF FOLLICLES SHOWING ABNORMALITIES IN MID-SIDE SKIN SAMPLES FROM SHEEP WITH DIFFERENT DEGREES OF CRIMP ABERRATION

Sheep	Crimping	Abnormal follicles (per cent)	
		With enlarged outer root-sheaths	With cysts
8- and 9-year old fine-wool Merinos	Normal	6	6
	Moderately doggy	34	7
	Very doggy	49	18
3 years old Polwarths	Well crimped	9	2
	Moderately irregular	25	8
	Very irregular	48	21

increased with severity of crimp deterioration (Table 1). Direct evidence of the association between enlargement of the outer root-sheath and reduction in crimping was obtained by plucking the straightest fibres from pieces of skin from sheep with different degrees of crimp aberration, and then sectioning the follicles longitudinally. In each instance of a follicle without a fibre there was enlargement of the outer-root-sheath either with or without cysts.

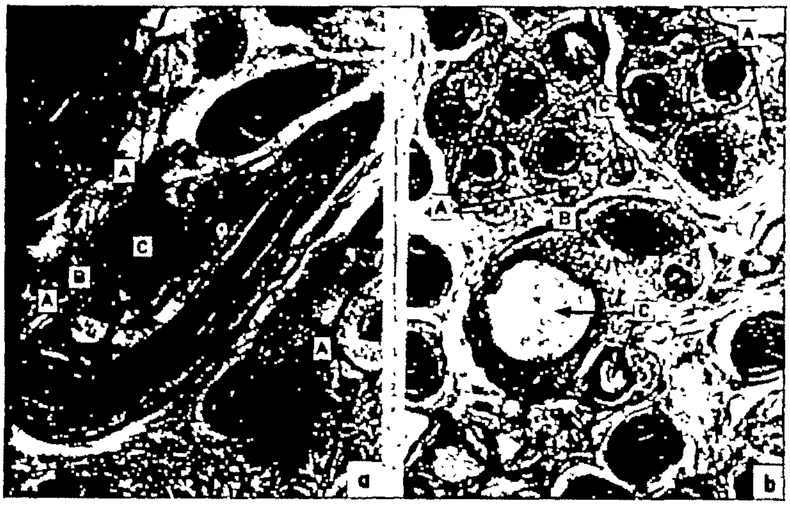


Fig. 1. *a*, A longitudinal section and *b* a transverse section through abnormal follicles showing enlargements of the outer root-sheaths (*A*) with cysts (*C*) attached by bridges of cells (*B*)

Although structures similar to these cysts have been described by others[1,2], to our knowledge the association between enlargement of the outer root-sheath and crimp deterioration has not been previously recorded. According to our evidence the outer root-sheath plays an important part in the process of fibre crimping. It may be, for example, that cyclic movement of the follicles is involved in the normal crimping of the fibres, and that these crimp irregularities are due to the added and variable resistance to movement of follicles with enlarged sheaths. The cysts could act as additional anchors, as they are frequently as large as the follicle bulbs and sometimes much larger. The observed proliferation of outer root-sheath cells is presumably accompanied by changed biochemical activity. This could conceivably alter the surface properties of the fibres, thus producing the lustrous appearance, and affect the process of crimping.

Abnormal crimping also occurs in fleeces of Corriedale sheep, and observations are being extended to this and other breeds. A detailed comparison is being made with the effects produced by a deficiency of copper in the diet, and this will be reported elsewhere.

R. E. Chapman
B. F. Short

Division of Animal Physiology,
Commonwealth Scientific and Industrial
Research Organization,
Prospect,
New South Wales.

P. G. Hyland

District Agricultural Centre,
Department of Agriculture,
Hamilton, Victoria.

[1] Ryder, M. L., and Auber, L., *Nature*, 174, 743 (1954).

[2] Ryder, M. L., *J. Agric. Sci.*, 47, 187 (1956).

Banana Fruit-spot ('Speckle') caused by *Deightoniella torulosa* (Syd.) Ell.

Deightoniella torulosa (Syd.) Ell. (syn. *Brachysporium torulosum* Syd.; *Cercospora musarum* Ashby; *Helminthosporium torulosum* (Syd.) Ashby) has been recorded on banana leaves and fruits in most major growing regions (Commonwealth Mycological Institute, Kew, Surrey, Distribution Map No. 175). The majority of earlier references to this fungus have concerned a leaf disease known as 'black-spot'[1-3] and a blackening of the tips of banana fruits[4,5].

A serious spotting of Lacatan bananas known in Jamaica as 'speckle' or 'swamp-spot' causes considerable wastage, particularly during rainy seasons. Fruit-spot may be observed in the field on fruit at all stages of maturity, the intensity of spotting increases with maturity being most noticeable at the time of harvest. In immature, green bananas, disease is first manifest as minute, reddish-brown spots each having a characteristic halo of dark green, apparently water-soaked tissue. As the spot increases in size, its outline remains circular, or nearly so. The largest spots observed so far had diameters of about 4 mm.: in these cases, the centre of the spot was dark brown or black and slightly depressed. The large proximal ('butt-end') hand of the bunch is usually more severely affected than the smaller, more distal ones. On each finger (that is, individual banana fruit), spots tend to be concentrated, on the outer face, towards the tip, and, on the inner face, towards the finger-stalk. There is evidence to suggest that the severity of spotting increases during ocean transportation and subsequent ripening of fruit.

External symptoms and anatomical details of the Jamaican fruit-spot are similar to those of a spot described by Johnston[6] and Johnston and Slocum[7] on Gros Michel bananas in Central and South America. These workers considered fruit-spot to be in the nature of a physiological disorder. Wardlaw[8] described several forms of spotting of bananas in Trinidad, but none of them would appear to be identical with Jamaican 'speckle'.

In the present investigation, *D. torulosa* was consistently isolated from spots of various diameters: no other fungus (or bacterium) appeared on the isolation plates. Pathogenicity tests were carried out in the laboratory and in the field by spraying the surface of apparently healthy fruit with a conidial suspension of *D. torulosa*. After 48 hr. under high humidity conditions, small but typical spots appeared on all inoculated fruit. Control fruit, sprayed with sterile water only, did not develop spots. *D. torulosa* was consistently re-isolated from artificially induced spots.

In a film of water on the surface of banana fruit peel, conidia of *D. torulosa* germinated after 1 hr.: after about 6 hr. one of, or both, the germ-tubes produce a swollen appressorium. Vertical microtome sections, 8–10μ thick and stained with 1 per cent cotton blue in lactophenol, showed that the appressorium soon produces an infection hypha which penetrates the cuticle and epidermal wall by mechanical means. This stage of infection was observed after 12–20 hr. After penetration has occurred, the epidermal cell becomes filled with a reddish-brown, granular substance. Further tissue invasion occurs by hyphal penetration of cell walls.

Similar stages in this infection process were observed on naturally infected fruit.

From the evidence outlined above it seems clear that *D. torulosa* is the organism causing fruit-spot of Jamaican Lacatan bananas. A detailed account of this work will be published elsewhere.

D. S. Meredith

Banana Board Research Department,
10 South Avenue, Kingston, Jamaica.

April 18.

[1] Ashby, S. F., *Bull. Dep. Agric., Jamaica*, 2, 96 (1913).

[2] Wardlaw, C. W., *Trop. Agric.* (Trin.), 11, 13 (1934).

[3] Stahel, G., *Trop. Agric.* (Trin.), 11, 138 (1934).

[4] Ogilvie, L., *Phytopath.*, 18, 531 (1928).

[5] Wardlaw, C. W., *Trop. Agric.* (Trin.), 9, 3 (1932).

[6] Johnston, J. R., Res. Dep. United Fruit Co., Boston, Mass., Bull. No. 43 (1932).

[7] Johnston, J. R., and Slocum, A. H., Res. Dep. United Fruit Co., Boston, Mass., Bull. No. 41 (1932).

[8] Wardlaw, C. W., *Trop. Agric.* (Trin.), 11, 8 (1934).

A Method for the Isolation of Plant Protoplasts and Vacuoles

The isolation of bacterial[1] and fungal protoplasts[2,3] following the use of enzymes digesting the cell wall suggested that protoplasts might be obtained from plant cells by treatment with cellulase. Root tips of tomato seedlings (*Lycopersicum esculentum* Mill. var. Sutton's 'Best of All') were selected for investigation, and a fungal cellulase obtained from *Myrothecium verrucaria*[4] (kindly supplied by Dr. D. R. Whitaker, National Research Council, Canada) was employed.

0·5-cm. root tips of tomato seedlings grown under aseptic conditions were treated at 27° C. with 5 per cent *Myrothecium* cellulase in 0·02 *M* phosphate buffer *p*H 6·0, containing 0·6 *M* sucrose as an osmotic stabilizer. Microscopic examination of the root tip, mounted under a cover slip, showed the formation of numerous spherical protoplasts after 2 hr. of treatment with cellulase. Two types of protoplast were identified. One type was unvacuolated (Fig. 1), and could be seen to be formed from the cells of the unvacuolated meristematic region of the root tip. The other type of protoplast was vacuolated with one or more vacuoles (Fig. 2) and was formed from vacuolated cells approximately 1 mm. from the root cap. Prior to their liberation these vacuolated protoplasts could be seen inside the remains of the partly digested cell walls, and it was evident that plasmolysis of cells by the hypertonic buffered sucrose was assisting in the ready isolation of intact vacuolated protoplasts.

These vacuolated protoplasts were stable in 0·3 *M* sucrose (0·02 *M* phosphate buffer, *p*H 6·0) for at least 6 hr. at 27° C. However, when suspended in 0·1 *M* sucrose (0·02 *M* phosphate buffer, *p*H 6·0) rapid lysis ensued with bursting of the plasmalemma and concomitant release of intact, yet swollen, vacuoles together with the protoplasmic contents. A typical group of such isolated vacuoles surrounded by their tonoplasts with adhering protoplasmic material is shown in Fig. 3. It was noteworthy that protoplasts were not formed from cells of the more differentiated region of the root tip bearing root hairs. The failure to isolate protoplasts from cells of this region was probably related to the different state of the cell wall[5] and to the presence of plasmodesmata linking the protoplasts of adjacent cells[6].

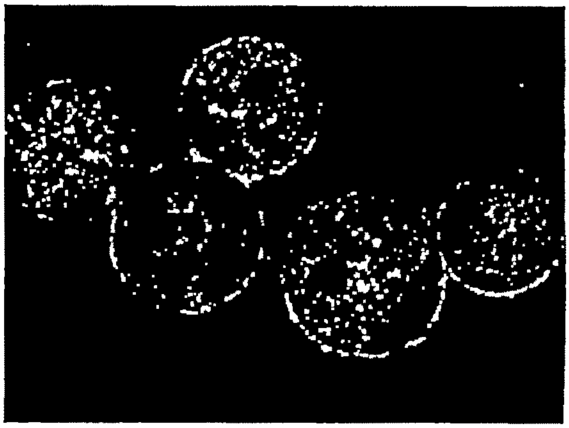


Fig. 1. Unvacuolated protoplasts (phase contrast)

It is clear that the vacuolated structures shown in Fig. 2 are protoplasts as defined on the basis of the criteria of Brenner *et al.*[7], since they are structures formed from that part of the cell which lies inside the cell wall and which can be plasmolysed away from the cell wall. In the case of the unvacuolated structures, shown in Fig. 1, it is more difficult to establish on the basis of similar criteria that these are in fact protoplasts, since they are formed from meristematic cells which are not readily plasmolysed[8] in which the cell wall is very intimately associated with the protoplasm[6]. Nevertheless, it was possible to observe various stages in the removal of the cell wall of these unvacuolated cells before attainment of the final

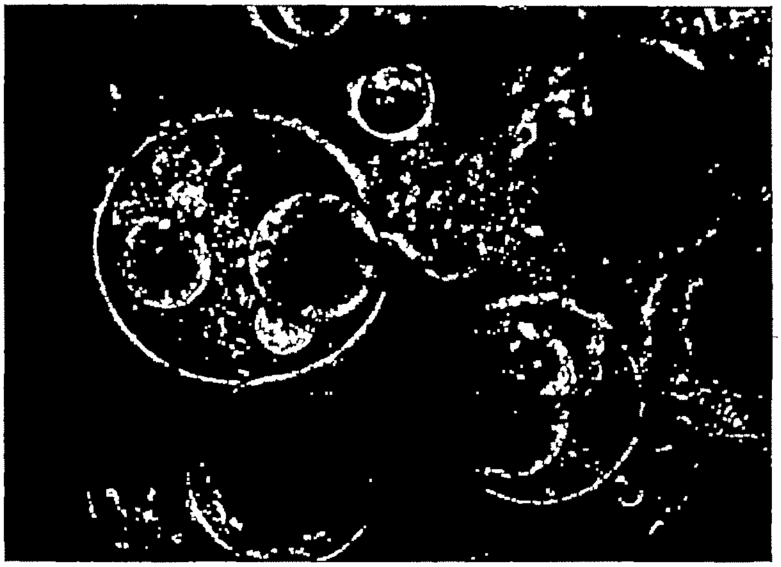


Fig. 2. Vacuolated protoplasts (phase contrast)

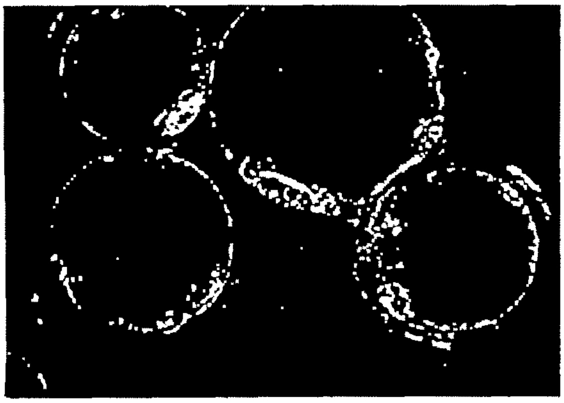


Fig 8. Vacuoles (phase contrast)

spherical form, both in cellulase-treated root tips and in cellulase-treated single unvacuolated cells isolated from root tips by the action of ethylenediamine tetraacetic acid[9].

E. C. Cocking

Department of Botany,
University of Nottingham.

---

[1] Weibull, C., "Ann Rev. Microbiol.", 12, 1 (1958).

[2] Eddy, A. A., and Williamson, D. H., *Nature*, 179, 1252 (1957).

[3] Bachmann, B. J., and Bonner, D. M., *J. Bact.*, 78, 550 (1959).

[4] Whitaker, D. R., *Arch. Biochem. Biophys.*, 43, 253 (1953).

[5] Preston, R. D., "The Molecular Architecture of Plant Cell Walls" (Chapman and Hall, London, 1952).

[6] Meeuse, A. D. J., *Bot. Rev.*, 7, 249 (1941).

[7] Brenner, S., Dark, F. A., Gerhardt, P., Jeynes, M. H., Kandler, O., Kellenberger, E., Klieneberger-Nobel, E., McQuillen, K., Rubio-Huertos, M., Salton, M. J. R., Strange, R. E., Tomcsik, J., and Weibull, C., *Nature*, 181, 1713 (1958).

[8] Bennet-Clark, T. A., in "Plant Physiology", edit. by Steward, F. C., 2 (Academic Press, 1959).

[9] Cocking, E. C., *Biochem. J.* (in the press).

ENTOMOLOGY

Bacteria as a Source of Food for Black-Fly Larvæ

Black-fly larvæ (Diptera : Simuliidae) are almost entirely confined to flowing water. They have long been known as 'filter-feeders', but the minimum particle-size acceptable as food by the several instars has not been previously investigated. Several authors have reported the occurrence of larvæ in sewage-contaminated waters ; but Petersen[1] was apparently the first to suggest that they might feed on suspended particles as small as bacteria.

This hypothesis is under investigation at Saskatoon in an attempt to determine some of the causes of destructive outbreaks of the black-fly, *Simulium arcticum* Mall. Larvæ of this species are sometimes excessively abundant in the north and south branches of the Saskatchewan River which originate in the Rocky Mountains of western Canada and discharge up to 140,000 c.f.s. into the confluence. During the spring and early summer, when these larvæ are most abundant, this river is generally in flood and the water very muddy with up to 1,000 p.p.m. of suspended solids. At the same time, macroplankton, the usual food of black-fly larvæ, are relatively scarce but bacteria are abundant. Species of bacteria present indicate an origin in sewage from the several cities situated on the river as well as from soil erosion.

In preliminary experiments at Saskatoon an attempt was made to rear first-instar larvæ of *S. vittatum* Zett. and *S. venustum* Say in sterile solutions of soluble nutrient in water flowing at 0·3–1·4 ft. per sec. In the absence of discrete particles these larvæ failed to develop beyond the second instar[2]. In similar, but non-sterile, solutions the larvæ developed to maturity, and adults were produced. Five species of bacteria, including three commonly found in soil and water, were isolated by Dr. G. Dempster, University of Saskatchewan, Saskatoon.

In further experiments 90 adults of these two species of black-flies were reared from 1,360 first-instar larvæ in distilled water containing only a washed suspension of *Bacillus subtilis* (Ehr.) Cohn, a normal component of soil. Fresh bacteria were added at 2- to 3-day intervals, keeping populations at about 160,000 viable bacteria per ml. of aquarium water. Microscopic examination showed that the bacteria were not clumped, and that most were present as single cells rather than in chains. About 65 per cent of the larvæ were lost in the first instar, possibly as a result of injuries received in handling. Rate of development was comparable to that in Nature : 21 days from hatching to the first pupa and a further 6 days to the first adult. These investigations are continuing and a detailed report will be published later.

Laboratory experiments have thus far been confined to larvæ of *S. vittatum* and *S. venustum* because of the difficulty in providing rapidly flowing water as in aquaria required by *S. arcticum*. However, the mouth-parts of these three species are very much alike, and thus similar results with the latter species may eventually be obtained.

The fact that all instars of larvæ of *S. vittatum* and *S. venustum* can obtain adequate nutriment from particles as small as *B. subtilis* is significant from two points of view : (1) Sewage bacteria entering a river may serve as food for black-fly larvæ. Thus the severity of black-fly outbreaks originating in rivers such as the Saskatchewan, Mississippi, Danube, Leine, Nile, etc., may be expected to increase as the amount of sewage entering them is increased. Reports[3,4] and personal observations indicate that livestock losses as a result of black-fly outbreaks along the Saskatchewan River have increased in the past 40 years. Enigk[5] reports that black-flies are appearing in larger numbers in Germany, and suggests that this is due to increased soiling of brooks and rivers. Losses adjacent to the Danube River appear to have been increasing during the past two hundred years[6]. (2) This suggests an unusual food-chain in the Saskatchewan River and perhaps other rivers which seasonally contain relatively little macroplankton but considerable bacteria and numerous filter-feeding black-fly larvæ. Fish, including *Moxostoma aureolum* (Le Sueur) and *Hiodon alosoides* Raf., containing black-fly larvæ were collected from the Saskatchewan River. Numerous larvæ-eating fish are known from the Danube[6].

F. J. H. Fredeen

Research Station,
Canada Department of Agriculture,
Saskatoon, Saskatchewan.

---

[1] Petersen, Axel, *D. Kgl. Danske Vidensk. Selsk. Skrifter*, Afd. 8, R., 4 (1924).

[2] Fredeen, F. J. H., *Canadian Ent.*, 91, 2, 73 (1959).

[3] Cameron, A. E., Canada Dept. Agric. (Tech.) Bull 5 (n s) (1922).

[4] Rempel, J. G., and Arnason, A. P., *Sci. Agric.*, 27, 428 (1947).

[5] Enigk, Karl, *Monatshefte fur Tierh.*, 7, 11, 241 (1955).

[6] Zivkovic, Vera, Serbian Acad. Sci., Special Issue, Book 245 (1955).

Accessory Glands of Gené's Organ in Ticks

DURING dissection of gorged adult females of *Hyalomma excavatum*, *Rhipicephalus sanguineus* s.str. and *Boophilus annulatus*, we noted two hitherto undescribed groups of accessory glands, one on each side of Gené's organ.

The glands become evident soon after the onset of feeding and continue to develop during the period of digestion of the blood meal. In *Ripicephalus*, which oviposits 2–3 days after gorging, the development is completed during this interval; in *Hyalomma*, in which oviposition occurs ten days after gorging, the development is correspondingly slow. The glands attain full development by the time oviposition begins. They were not detected in the starved female or the nymph. We did not find these glands in adult *Ornithodorus tholozani*.

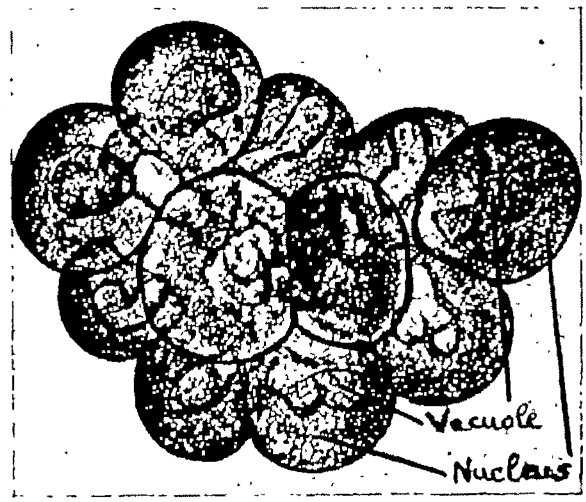


Fig. 1 New accessory gland from a female of *Rhipicephalus sanguineus* s.str., on the third day of oviposition. (× 140)

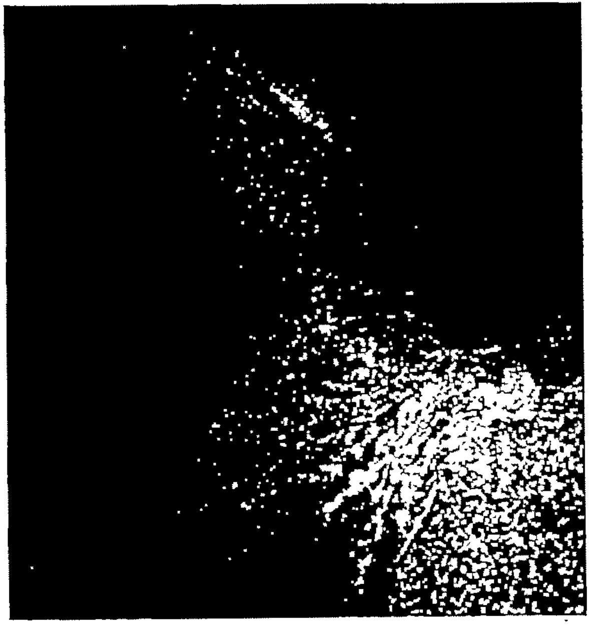


Fig. 2. Droplets of secretion on their way through the intracellular channel from a laying female of *Rhipicephalus sanguineus* s.str. (× 660)

Each group of glands consists of about 40 units in the case of *Hyalomma* and between 20 and 25 in the case of *Rhipicephalus*.

Each gland consists of about 10–13 cells. In general the cells are arranged roughly in a circle (Fig. 1). The large nucleus (up to 85μ) is situated in the lateral part of the cell; it contains several nucleoli. In each cell there is a large vacuole which grows continuously and attains a size of about 100–130μ at its maximum development. Each gland has a duct issuing from its centre; a narrow intra-cellular channel passes from each vacuole to the narrow main duct. On staining with methylene blue, droplets can be traced on their way from the vacuole via the narrow intra-cellular channel into the duct (Fig. 2).

These glands apparently contribute to the secretions of Gené's organ which protect the eggs in their external environment.

This investigation was supported by Research Grant No. 4531 from the National Institutes of Health, U.S. Public Health Service.

B. FELDMAN-MUHSAM
Y. HAVIVI

Department of Parasitology,
The Hebrew University,
Jerusalem.

CYTOLOGY

Induced Fluorescence with Acridine Orange, after Osmium Fixation

THE differential staining of nucleic acids with fluorochromes[1] has provided a useful tool for the study of virus-infected tissue cells[2]; but its value has been limited by the fact that the common fixatives which permit the use of this method also tend to produce artefacts, such as the gross nuclear vesiculation observed in cells infected with some types of adenovirus[2], but not observed by phase-contrast examination of the living infected cell[3].

This serious limitation could be overcome if the technique could be adapted for use with fixation by osmium tetroxide, which has been shown to preserve faithfully most of the structural features of the living cell[4,5]. Up to the present, however, this has not proved possible, and reports indicate practically no affinity between the diamino-acridines and nucleic acids fixed in osmium tetroxide[3].

Recent work in this laboratory has shown that this lack of affinity may be overcome if staining is carried out with acridine orange in alcoholic solution, in place of the buffered aqueous solution, as usually practised. The technique described is simple and uniformly successful, giving vivid colour differentiation and even staining over the entire preparation. Acridine orange *R* (2,8-*bis*-dimethylamino-5-phenylacridine hydrochloride, Colour Index No. 792) in 1 : 1,000 dilution in industrial methylated spirit ('Methool') was used, and this was filtered before use. The end result was found to be the same, however, using dilutions of lesser or greater strength, and allowing for an appropriate alteration in the staining time.

Cells of the 'ERK' cell line[6] were grown on glass microscope slides to form a near-confluent monolayer. The medium was washed off with phosphate-buffered saline, *p*H 7·2, and sample slides were then fixed either in the vapour from 1 per cent osmium tetroxide for 10 min., or in the buffered osmium tetroxide solution of Palade[5] for the same length of time. Both sets of cultures were thoroughly washed in several changes of distilled water, during half an hour, and this was followed by a brief rinse in 'Methool'. They were then transferred to a covered staining jar containing the alcoholic solution of acridine orange, and stained for 10 min. On removal, the slides were thoroughly washed in phosphate buffer made up of potassium dihydrogen phosphate 4·5 gm., ammonium chloride 0·5 gm., ammonium sulphate 0·5 gm., per litre adjusted to pH 7·6 with sodium hydroxide and finally mounted in liquid paraffin.

Examination was carried out with a simple system using a projector lamp of the solid-source filament type, an Abbé type condenser, a cupro-ammonium cell of suitable density, and a yellow eye-piece filter. An alternative system, using a high-discharge mercury vapour lamp, dark ground condenser, and appropriate filters, did not materially improve the picture obtained.

Both methods of fixation gave equally good results, with sharp differentiation of the cellular elements corresponding to the nucleic acid pattern. The nucleoplasm of interphasic cells appeared homogeneous, fluorescing as a clear, bright greenish-yellow. Nucleoli showed prominently as discrete, red bodies with their surrounding zone of 'associated' deoxyribonucleic acid seen as a halo of more brightly fluorescing yellow. The ribonucleic acid of the cytoplasm was uniformly intense, deep red. In dividing cells, mitoses were distinctive by their brilliant golden fluorescence and sharp configuration.

Semi-permanent preparations of this type, allowed to remain on the bench at room temperature for at least a month after sealing, have shown no deterioration. Liquid paraffin was chosen as the mountant, in preference to either glycerine, or glycerine–saline, since the fluorochrome is apparently unaffected by it, and no extraction of the dye occurs even after prolonged contact. Finally, it is a simple matter to renew bleached preparations, by removing the liquid paraffin with washes of alcohol and then repeating the treatment with alcoholic acridine orange.

W. J. RANDLES
Microbiological Research Establishment,
Porton,
Wilts.

---

[1] Armstrong, J. A., *Exp. Cell Res.*, 11, 640 (1956).

[2] Anderson, H. S., Armstrong, J. A., and Niven, J. S. F., Ninth Symp. Soc. Gen. Microbiol., 224 (1959).

[3] Armstrong, J. A., and Hopper, P. K., *Exp. Cell Res.*, 16, 584 (1959).

[4] Porter, K. R., Claude, A., and Fullam, E. F., *J. Exp. Med.*, 81, 233 (1945).

[5] Palade, G. E., *J. Exp. Med.*, 95, 285 (1952).

[6] Westwood, J. C. N., MacPherson, I. A., and Titmuss, D. H. J., *Brit. J. Exp. Path.*, 38, 138 (1957).

A Polyploidizing Principle in the Spleen

IN previous experiments it has been found that 120 hr. after traumatization of the uterus the number of large homogeneous cells in the antimesometrial part of the deciduomata was doubled in splenectomized rats[1]. In other experiments the animals were partially omentectomized or unilaterally nephrectomized. But there was no difference in cell count between these animals and the non-splenectomized controls[2]. The proportion of the volume of the nuclei of the large decidua cells between normal rats and spleenless ones[3] was approximately 2 : 1. The number of countable nucleoli in each nucleus shows the same ratio[4].

These changes, appearing after the extirpation of the spleen, can be prevented by saline extracts of the spleen from rat, cattle and horse. Further, it has been shown that a linear relation exists between the logarithms of the quantity of injected saline extract and the number of large decidua cell nuclei. From these experiments one may conclude that the discernible changes in the nuclei after splenectomy were dependent on changes of the degree of ploidy. Therefore a substance producing a polyploidizing effect was supposed to exist in the spleen[1]. The direct evidence of that polyploidizing effect was obtained by counting the chromosomes.

With female inbred rats of an average body-weight of 200 gm. a pseudo-pregnancy was induced by sterile copulation. 'Spirocid' (167 mgm./kgm. body-weight/day) was then given orally for three days to prevent the manifestation of a latent infection with *Bartonella muris ratti* after splenectomy. 96 hr. after the sterile copulation the animals were operated under ether anæsthesia: both horns of the uterus were traumatized by making several stitches through the lumina. In six animals the spleens were removed in addition; in three animals serving as controls parts of the omentum were excised. The splenectomized animals were divided into two groups. One group remained untreated. The other group was subcutaneously injected with saline extract of cattle spleen immediately after the operation and for the following four days. 120 hr. after operation all animals received 0·2 mgm./100 gm. body-weight colchicine intracardially and were killed by carbon monoxide 2 hr. later. Then the

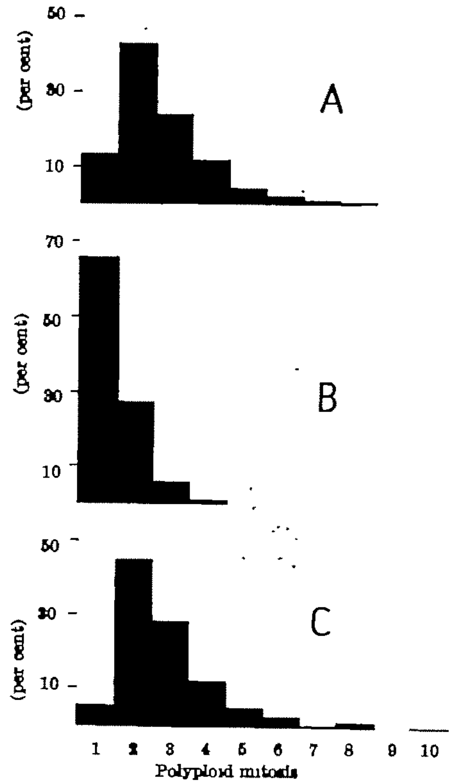


Fig. 1. Three histograms demonstrating the distribution of the degree of ploidy in metaphase plates of the large decidua cells. Each histogram is based on 500 mitoses of three rats. *A*, omentectomized rats; *B*, splenectomized rats; *C*, splenectomized rats which received saline extract of cattle spleens

uteri were prepared, the myometrium was dissected and the antimesometrial decidua was cut out. After removing the adhering blood the tissue was cut into small pieces which were suspended in 0·00075 *M* 8-oxychinoline solution for 1 hr. The tissue was then fixed for 3 hr. in ethanol–acetic acid, 3 : 1, and afterwards preserved in 70 per cent ethanol. For further preparation these pieces of tissue were stained for 30 min. in carmine–acetic acid containing 10 per cent glycerol[5]. Then they were picked with needles into tiny pieces and squashed under a cover-glass. The chromosomes were counted by means of a phase-contrast microscope at 2,000- or 3,000-fold magnification. Only metaphase plates were examined. Each mitosis was counted independently by two persons. In each group the chromosomes in 500 mitoses were counted. The numbers we found were classified as to the degree of ploidy. The haploid set of chromosomes was: $n = 21$. The limits of these degrees of ploidy were fixed as: $n \pm 10$, $2n \pm 10$, $3n \pm 10$ . . . . In total, 1,500 metaphases were counted in the antimesometrial part of the rat deciduomata. The results of these counts are demonstrated in Fig. 1.

From this it may be concluded that in the spleen there exists a polyploidizing substance, the chemical nature of which is not yet known.

I. Bouvier
R. Rigler
W. Rosenkranz

Institute of Physiology,
University of Graz,
Harrachgasse 21,
Graz.

---

[1] Rigler, R., and Rosenkranz, W., *Z. Naturforsch.* 13, b, 291 (1958).

[2] Rigler, R., and Rosenkranz, W., *Wien. klin. Wschr.*, 69, 445 (1957).

[3] Rosenkranz, W., and Rigler, R., *Z. ges. exp. Med.*, 129, 627 (1958).

[4] Rigler, R., and Rosenkranz, W., *Z. Naturforsch.*, 13, b, 543 (1958).

[5] Marquardt, H., and Glass, E., *Chromosoma*, 8, 617 (1957).

SOIL SCIENCE

C Horizon of the Soil Profile

In the course of recent investigations on the pedology of fluvial soils located in the area of Durham City, no true *C* horizon could be observed in the numerous profiles and sections examined. In the case of so-called transported soils, it is, of course, well known that the *D* horizon will usually be unrelated to the solum. But the finding that the *C* horizon is absent in some of these soils is of pedological importance, and, so far as we are aware, has not previously been reported for soils of the United Kingdom. Nevertheless, the occurrence of soil profiles of this type would seem to be of more than local significance and may well be widespread.

The area under study formed part of the floor of a large glacial lake, which came into existence towards the end of the Pleistocene epoch, when varying thicknesses of fluvioglacial deposits were laid down. These deposits, which are often lenticular, are both heterogeneous and variable, particularly in texture, structure, colour, depth and drainage; they show clear evidence of water-sorting in the morphology of the profiles and sections.

The alluvial soils studied are located in an old flood plain of the River Wear and thus represent the results of the resorting and deposition by the action of water on the glacial and fluvioglacial deposits left after the retreat of the ice. They are therefore of similar mineral content to the local fluvioglacial deposits. These deposits are also extremely heterogeneous.

In general, the study of the profiles and sections of both fluvioglacial and alluvial soils revealed two distinct horizons—a zone of eluviation and a zone of illuviation; but it was not possible to distinguish a true *C* horizon although the investigation extended to Carboniferous age bedrock (shale) encountered between 19 and 24 ft. The *C* horizon is by definition the unconsolidated parent material substantially similar to that from which the solum has developed. Before such a horizon can be identified there must be evidence of this similarity, and this is not apparent in the profiles and sections studied. In these soils the parent material of the upper layer of the soil profile has been completely transformed into the *A* horizon. Probably it was different from the parent material of the *B* horizon and was not necessarily identical with any mineral material that can now be observed in the regolith. The relationship between the different soil horizons is dependent on pedological processes acting on parent material horizontally bedded and initially heterogeneous. The horizons below the zone of illuviation must be regarded as *D* horizons, because any unconsolidated material beneath the solum not characterized as parent material is so designated[1]. In these soils the succession of horizons is therefore *A,B,D*.

It will be seen that the absence of a *C* horizon is, in effect, the result of one or more relatively thin layers of transported material originally constituting the upper zone of the deposits. A parallel case of interest has been recorded in the United States in regard to certain deposits of loess only 30 in. deep[2]. It is known that the *C* horizon may also be absent in the profile of soils developed *in situ* where the parent material is sufficiently resistant to weathering to result in the rate of formation of the solum keeping pace with the rate of rock weathering.

A further relevant experience has recently been encountered in an investigation of types of rendzina profiles developed on the magnesian limestone of Co. Durham: Glacial till was found to overlie the bedrock in some of the profiles studied. In cases where the layer of till was thin the typical rendzina profile was developed, but the *A* horizon has been formed from varying proportions of both till and the residues remaining from the weathering of magnesian limestone. In many cases the effective contribution of till is sufficiently great to preclude the underlying weathering magnesian limestone from being classified as parent material. In the case of these soils, the succession of horizons is therefore *A,D*.

It is hoped shortly to present elsewhere detailed reports of all these investigations.

S. G. Willimott

Department of Geography,
The Durham Colleges in the
University of Durham,
South Road,
Durham.

D. W. Gilchrist Shirlaw

Durham School of Agriculture,
Houghall,
Co. Durham.

---

[1] Lyon, T. L., Buckman, H. O., and Brady, N. C., "The Nature and Properties of Soils", fifth ed., 327 (Macmillan Co., New York, 1952).

[2] Thompson, L. M., "Soils and Soil Fertility", second ed., 127 (McGraw-Hill, New York, Toronto and London, 1957).

Effect of Surface Density of Charge on the Physical Swelling of Lithium Montmorillonite

THE crystalline swelling of lithium montmorillonite before and after heating has been investigated by several workers[1–3]. Hofmann and Klemen[1] suggested that, on heating, the small lithium ion migrated into the crystal lattice to occupy a vacant octahedral site with consequent neutralization of the charge originating in that layer due to the isomorphous replacement of Al^{3+} by Mg^{2+}. They termed this 'place exchange'. This process gives rise to marked reduction in crystalline swelling.

Greene-Kelly[3] has followed by an X-ray technique the loss in glycerol adsorption for Li^{+} saturated minerals over the range of composition from montmorillonite to beidellite. For less than 70 per cent octahedral substitution he has found some penetration of glycerol. Complete penetration was obtained at about 10 per cent octahedral substitution. In other experiments he studied the effect of only partly saturating the exchange complex of montmorillonite with lithium; the other ions balancing the negative charge were normal in their behaviour after dehydration. At about 44 per cent saturation with lithium complete penetration of glycerol was observed, but for 68 per cent saturation with lithium only about one quarter of the internal surface was accessible to glycerol.

Recently, Johns and Tettenhorst[4] have demonstrated that the order of penetration into dehydrated crystals is ethylene glycol > glycerol > water. It was thought that a study of the physical swelling of Wyoming bentonite containing varying proportions of lithium and sodium might give useful information on the minimum surface density of charge required for large intracrystalline expansion.

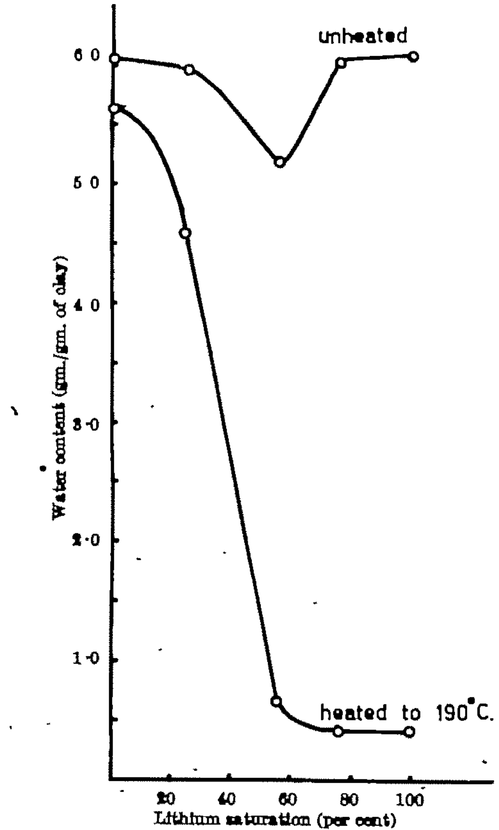


Fig. 1. Effect of percentage lithium saturation and heating on the water content of clay cores at 100 cm. of water suction

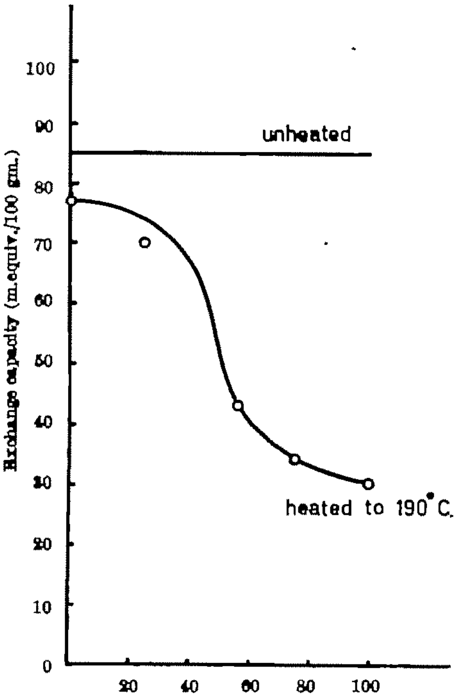


Fig. 2. Effect of percentage lithium saturation and heating on the exchange capacity of montmorillonite

Compressed cores of the clays were manufactured[5,6] from the control and heated clay powders. These cores were allowed to swell slowly to equilibrium with a hydrostatic suction of 100 cm. of water. The wetting liquid was distilled water and the results plotted in Fig. 1 reveal that at 56 per cent lithium saturation the clay has lost its capacity for large intracrystalline swelling as the control water content is greater than 5 c.c./gm. and the heated clay has a water content of 0·62 c.c./gm. This latter result can be compared with that for sodium montmorillonite in the presence of *M* sodium chloride when the solution content was found to be 0·90 c.c./gm.; for these circumstances the intracrystalline spaces of sodium montmorillonite do not expand beyond a basal spacing of 19 Å. (ref. 7). The lower water content (0·62 c.c./gm.) for the heated montmorillonite indicates considerable but not complete loss of internal surface. The water content for 75 and 100 per cent lithium saturation is a little more than 0·4 c.c./gm. This water content indicates limited swelling between crystals since the initial porosity of the clay core was 0·11 c.c./gm.

In Fig. 2 the exchange capacity of the clay samples, used in the swelling work, is plotted against lithium percentage prior to heating. The exchange capacities determined by the method used by Greene-Kelly and by strontium saturating were in good agreement; the strontium content of the clay was determined by an X-ray spectrographic method. The exchange capacity (0·80 m.equiv./gm.) for the lithium-saturated clay was much higher than reported earlier. This exchange capacity decreased to 0·20 m.equiv./gm. when the clay was heated to 300° C. These values for the exchange capacity appear to be too large to be accounted for by exchange on the external surfaces of the crystals since the crystals would have a surface area in the region of 50 m.^{2}/gm.

It appears that about 75 per cent saturation with lithium and heating to 190° C. are able to prevent crystalline expansion. At 56 per cent lithium saturation there is some penetration into intracrystalline spaces but large crystalline swelling is not observed. At 25 per cent lithium saturation, montmorillonite exhibits large physical swelling as the result of expansion beyond a potential barrier at a silicate sheet separation of 19 Å.

It can be concluded that large crystalline swelling is not obtained at a surface density of charge of about $0{\cdot}6 \times 10^{-7}$ m.equiv./cm.^{2}, but it is obtained at a surface density of charge of 1×10^{-7} m.equiv./cm.^{2}.

We are indebted to Dr. K. Norrish for the determination of strontium.

J. P. QUIRK
B. K. G. THENG

Department of Agricultural Chemistry,
Waite Agricultural Research Institute,
University of Adelaide.

[1] Hofmann, U., and Klemen, R., *Z. anorg. Chem.*, 62, 95 (1950)
[2] Greene-Kelly, R., *Clay Minerals Bull.*, 2, 52 (1953).
[3] Greene-Kelly, R., *Min. Mag.*, 30, 604 (1955).
[4] Johns, W. D., and Tettenhorst, R. T., *Amer. Min.*, 44, 894 (1959).
[5] Aylmore, L. A. G., and Quirk, J. P., *Nature*, 183, 1752 (1959).
[6] Aylmore, L. A. G., and Quirk, J. P., National Clay Conference, Purdue University (1960) (in preparation).
[7] Norrish, K., and Quirk, J. P., *Nature*, 173, 255 (1954).

MATHEMATICS

Theory of Optimal Games

THEORY of games, and also theory of fair games, are well-known subjects, but a theory of good (or optimal) games does not seem to exist.

To theory of optimal games there would, for example, belong the question: Why, among serious poker-players, is it accepted as 'better' to play the game with a full pack and a hand of five cards rather than with, say, two Piquet packs shuffled together and a hand of seven cards? (The historical reason for this acceptance is not known, for the origin of poker is as obscure as is that of its name.)

That a game may possess different states of goodness is well seen from the varieties of two-handed whist. These may be epitomized thus: n full packs are shuffled together and equally divided among the two players; of the $26n$ cards that each player receives, kp are dealt face down to form k packets of p cards each; k are dealt face up, one on top of each packet, and the remaining $26n - k(p + 1)$ cards form the player's hand, from which, before the trump is declared, he must throw away r cards face down. When one of the k top cards is played, the card underneath it is turned up; and so on. In these games, obvious examples of zero goodness are (for all n), first, $k = r = 0$, and, secondly, $p = r = 0$, $k = 26n$; whereas, empirically, $n = 2$, $p = 3$, $k = r = 8$ 'makes rather a good game'.

In the context of theory of optimal games, it may be that croquet should receive consideration, for, in its (fairly short) history, it has, more than once, been felt non-optimal, and its controllers have altered the rules fundamentally (the most traumatic alterations being, perhaps, the decisions, first, to abandon play by rotation of colour, secondly, to award an optional lift against a player who is 'doing too well').

There would arise also the question: How far is competition a prerequisite of goodness? In patience games, this element is, naturally, lacking, yet many of the games are clearly 'very good', most notably, perhaps, those of the *Miss Milligan* series (of which Miss Milligan itself is, by trial and error, the optimal member). Croquet is a competitive game: the player of black-and-blue achieves success if he 'goes round' before the player of red-and-yellow; but there seems no reason why a 'croquet-patience', in which the two players combine to get all four balls round in as few turns as possible, should not be an equally good game.

Clearly, the great difficulty in theory of optimal games will be the establishment of a criterion, or measure, of goodness, and it may be that this establishment will not fall within the domain of mathematics; but, once a measure has been established, some mathematical analysis or, at least, a mathematical envisagement, of the problem might well be possible.

ALAN S. C. ROSS

University of Birmingham.

A Remark on Stochastic Path Integrals

VARIOUS stochastic functionals of the type:

$$S(t) = \int_0^t V(X(u), u)\, du \qquad (1)$$

where $X(u)$ is a stochastic process, have been studied in recent years (see, for example, Kac[1]). It seems worth noting that for $X(u)$ Markovian, there is often no particular difficulty in setting up characteristic function equations, of the type derived in my book[2] on stochastic processes (see especially the end of chapter 3), applicable not only to (1) but also to rather more general types of integral. Thus for:

$$S(t) = \lim_{\Delta u \to 0} \sum_{u=0}^{t} v(X(u), u, \Delta X(u), \Delta u) \qquad (2)$$

provided

$$E\,[\{\exp(i\theta\Delta S + i\varphi\Delta X) - 1\}|\, X(t) = x] = \Psi_S\,(i\varphi, i\theta, t, x)\Delta t + o(\Delta t)$$

we may set up an operator equation of the form:

$$\frac{\partial C}{\partial t} = \Psi_S\,(i\varphi, i\theta, t, \frac{\partial}{\partial i\varphi})\, C \qquad (3)$$

where $C \equiv E\,\{\exp(i\theta S(t) + i\varphi\, X(t)\,)\,\}$. A particular case given on page 86 of my book is $v \equiv X(u)\Delta u$. As further examples, consider $v \equiv [\Delta X(u)\,]^2$, for (i) the normal linear Markov process (which includes 'Brownian motion' as a special case) and (ii) the simple birth-and-death process, for which $S(t)$ records the total number of transitions. For (i), $S(t)$ then increases regularly with t (as is well known); for (ii), C is readily evaluated, either by (3) or even more easily from the corresponding 'backward' equation. A further amplification of these points will be given elsewhere.

M. S. BARTLETT

The University,
Manchester 13.
July 28.

[1] Kac, M., "Probability and Related Topics in Physical Sciences" (New York, 1959).
[2] Bartlett, M. S., "An Introduction to Stochastic Processes" (Cambridge, 1955).

FORTHCOMING EVENTS

Monday, September 12

Bone and Tooth Society (at 234 Great Portland Street, London, W.1), at 4.30 p.m.—Scientific Papers.

Saturday, September 17

British Interplanetary Society (in the Tudor Room, Caxton Hall, London, S.W.1), at 6 p.m.—Mr. P. A. E. Stewart: "A Programme for the Surface Exploration of the Moon".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Botanist or Biochemist, Scientific Officer grade (with an interest in field work), to grow and test plants for suitability as sources of protein—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (September 20).

Lecturer (with a particular interest in industrial organization or in advanced economic theory) in Economics—The Registrar, King's College, Newcastle upon Tyne 1 (September 24).

Senior Lecturer in Surgery—The Registrar, The University, Sheffield (September 30).

Lecturer (with special qualifications or interests in cytogenetics or experimental taxonomy) in Botany in St. Salvator's College—The Joint Clerk to the University Court, College Gate, St. Andrews (October 1).

Lecturer (with an honours degree, and preferably with a higher degree in chemistry with postgraduate experience of academic or industrial research) in Physical Chemistry—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3 (October 1).

Assistant Lecturer (with special qualifications in physical chemistry) in Chemistry—The Registrar, The University, Manchester 13 (October 15).

Lecturer (with an honours degree in psychology and some knowledge of statistical methods) in Psychology in the Department of Education—The Secretary, Cambridge University Department of Education, 17 Brookside, Cambridge (November 3).

Assistant Lecturer in Physics—The Registrar, The University, Nottingham.

Biochemist or Chemist (preferably with some experience in protein or enzyme work or in the natural product field), for work of a fundamental nature on the chemistry and biochemistry of plant proteins—The Director, Arthur D. Little Research Institute, Inveresk, Midlothian, Scotland.

Entomologist (with a good honours degree in zoology or entomology, preferably with postgraduate research experience in forest or timber entomology) at the West African Timber Borer Research Unit, Kumasi, Ghana, to undertake studies of the biology, ecology and control of timber and lumber pests—Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.197/510/01/01.

Fisheries Research Officer, Senior Scientific Officer or Scientific Officer grade (with a good honours degree in zoology and at least two years suitable postgraduate research experience or training) with the East African Fisheries Research Organization, Jinja, Uganda, for research on ecology and fish physiology—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/194/02/01.

Geologists (with a first- or good second-class honours degree in geology with emphasis on metamorphic and igneous rocks and/or structural geology, some previous experience is desirable), for duties in Tanganyika including the regional geological survey of metamorphic and igneous rock terrains and preliminary investigation of mineral deposits—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/8/03/T.

Hydrologists (with a university degree in civil engineering and preferably with a postgraduate diploma in hydrology, with at least two years relevant experience; consideration would also be given to candidates with a degree in applied science with some direct experience in applied hydrology) with the Ministry of Works, Kenya, for duties including the measuring of river flows, assessment of flood discharges, rainfall run off studies and assessment of groundwater resources, with recharge and depletion—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.112/7/01/T.

Lecturer or Junior Lecturer in the Department of Zoology and Comparative Anatomy, to participate in the teaching of medical and postgraduate students and with good opportunity to undertake research work—The Secretary, St. Bartholomew's Hospital Medical College, West Smithfield, London, E.C.1.

Plant Pathologist (with a good honours degree in a biological science and postgraduate experience in research or advisory work in plant pathology) in Tanganyika, for research and specialist advisory services in plant pathology—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/06/T.

Research Assistant, for chemical and radiochemical analytical work on minerals—Dr. J. R. Butler, Geology Department, Imperial College of Science and Technology, London, S.W.7.

Research Assistant (with an honours degree in physiology, physics or a biological subject), to assist in teaching and for experimental research in human lung function—Finance Officer, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Research Assistants (honours graduates in physics), for work on problems concerned with counting techniques and high energy physics, gas discharges, spectroscopy or electronics—The Clerk to the Governors, Northern Polytechnic, Holloway Road, London, N.7.

Research Associate in Chemistry, for work on the physical chemical properties and syntheses of heteropoly compounds—Prof. Egon Matijevic, Department of Chemistry, Clarkson College of Technology, Potsdam, New York, U.S.A.

Research Fellow (with qualifications in biochemistry), for work with Dr. P. T. Grant on the enzymic aspects of oxidase systems present in mammalian trypanosomes—The Secretary, University of Aberdeen, Marischal College, Aberdeen.

Senior Scientific Officer or Scientific Officer (with a first- or good second-class honours degree in zoology, and preferably some evidence of aptitude for original research) with the East African Trypanosomiasis Research Organization, Tororo, Uganda, for work on the ecology of Glossina populations with special reference to sampling methods and to the factors determining population density and their relationship to modern methods—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/198/013.

Lecturer/Senior Lecturer (with at least an honours degree in mathematics, or equivalent qualification, and preferably with some research experience) in the School of Mathematics, University of New South Wales, to lecture and undertake research in the field of pure mathematics and preferably in the field of modern algebra—The Agent General for New South Wales, 56–57 Strand, London, W.C.2 (October 7).

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Bulletin of the British Museum (Natural History). Botany. Vol. 2, No. 7: The Identity of *Isopyrum aquilegioides* L. By Sir Gavin de Beer and William T. Stearn. Pp. 193–202. 6s. Entomology. Vol. 9, No. 3: Sphecidae (Hym.) Récoltés en Tripolitaine et en Cyrénaique. Par Jacques de Beaumont. Pp. 219–251. 12s. Geology. Vol. 4, No. 5. A Review of the Upper Jurassic Pliosaurs. By Lambert Beverly Tarlo. Pp. 145–189 + plates 20–28. 24s. (London: British Museum (Natural History), 1960.) [236

Ministry of Health. National Health Service. Electrical Safety in Hospitals—Electro Medical Apparatus. Pp. 2. (H.M. (60) 49). (London: Ministry of Health, 1960.) [236

Department of Scientific and Industrial Research and Fire Offices' Committee. Joint Fire Research Organization. Sponsored Fire-Resistance Tests on Structural Elements. By L. A. Ashton and P. M. T. Smart. Pp. xiii + 84. (London: H.M. Stationery Office, 1960.) 7s. 6d. net. [236

British Association for Commercial and Industrial Education. A Guide to the Use of the Telephone in Business. Third edition. Pp. 20. (London: British Association for Commercial and Industrial Education, 1960.) 3s. net. [236

University of Leeds. Publications and Titles of Theses, 1957–58. Pp. 74. (Leeds: The University, 1960.) 2s. 6d. [236

Agricultural Research Council. A Bibliography of Farm Buildings Research, 1945–1958. Part 2: Buildings for Potato Storage. Pp. 31. (London: Agricultural Research Council, 1960.) 2s. [236

Lister Institute of Preventive Medicine. Report of the Governing Body, 1960. Pp. 33. (London: Lister Institute of Preventive Medicine, 1960.) [236

National Council for Technological Awards. Report for the period April 1959 to March 1960. Pp. 26. List No. 11: Diploma in Technology—List of 95 Courses (at 23 Colleges) which are now recognized by the Council as leading to the Diploma in Technology. Pp. 5. Memorandum on the Industrial Training of Students following Courses recognized as leading to the Diploma in Technology. Pp. 11. (London: National Council for Technological Awards, 1960.) [246

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 1019, Vol. 252 (23 June 1960): A Contribution to the Structure of Coals from X-ray Diffraction Studies. By L. Cartz and P. B. Hirsch. Pp. 557–604. (London: Royal Society, 1960.) 15s. [246

The Beginnings of the Royal Society. By Margery Purver and Dr. E. J. Bowen. Pp. 16 + 2 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1960.) 2s. net. [276

Department of Scientific and Industrial Research. Moiré Fringes for Measurement and Control: a Booklet for the Machine-Tool and Engineering Industries. Prepared by the National Physical Laboratory and the National Engineering Laboratory. Pp. 11. (London: Department of Scientific and Industrial Research, 1960.) [276

The Ecology of Psychology: an Inaugural Lecture delivered on 3 February 1960. By Prof. George Seth. Pp. 20. (New Lecture Series No. 8). (Belfast: The Queen's University, 1960.) 2s. 6d. net. [276

Review of Coal Tar Technology, July–December 1959 (Vol. XI, Part 2). Pp. ii + 85–161. (Gomersal, Leeds: Coal Tar Research Association, 1960). 10s. [276

Association of British Chemical Manufacturers. The Chemical Industry: a Career for You. Pp. 29. Appendix listing Chemical Firms offering opportunities for Careers. Pp. 39. (London: Association of British Chemical Manufacturers, 1960.) [276

Ministry of Power. The Nuclear Power Programme. Pp. 4. (Cmnd. 1083). (London: H.M. Stationery Office, 1960.) 4d. net. [286

Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act, 1954, for 1959. North Western Division. By R. H. Clough. Pp. iii + 29 + 4 plates. (London: H.M. Stationery Office, 1960.) 3s. net. [306

Electrothermal Engineering, Ltd. Resistors, Valve Retainers, and other Electronic Components. Pp. 22. (London: Electrothermal Engineering, Ltd., 1960.) [306

Courtaulds Limited. Report and Accounts, 1959–60. Pp. 30. (London: Courtaulds, Ltd., 1960.) [306

Ministry of Housing and Local Government: Department of Health for Scotland. Alkali, etc., Works Regulations Act, 1906; Alkali, etc., Works Orders 1930–50; Alkali, etc., Works Regulations (Scotland) Acts, 1906 and 1951, and Alkali, etc., Works (Scotland) Orders, 1952 and 1959. Ninety-Sixth Annual Report on Alkali, etc., Works, by the Chief Inspectors, 1959. Pp. 60. (London: H.M. Stationery Office, 1960.) 4s. net. [306

Other Countries

Institut Royal Météorologique de Belgique. Publications, Série A, No. 12: Annuaire Climatologique pour 1958. Pp. 94. Observations Ionosphériques, Station de Dourbes. Novembre, 1958. Pp. 26. Decembre, 1958. Pp. 26. Janvier, 1959. Pp. 26. Février, 1959. Pp. 26. (Uccle-Bruxelles: Institut Royal Météorologique de Belgique, 1960.) [136

Colony of Fiji. Geological Survey Department—Annual Report for the year 1959. Pp. ii+21. (Council Paper No. 6 of 1960.) (Suva: Geological Survey Department, 1960.) 2s. [136

Institut Royal des Sciences Naturelles de Belgique. Mémoire No. 144: Écologie d'Une Mare Oligotrophe et des Biotopes Contigus (Colonster, Province de Liége). Par Serge Jacquemart et Eugène Leloup. Pp. 50+3 planches. Mémoire No. 145: Essai d'Étude Statistique des Cyrtospirifer du Frasnien de la Belgique. Par Dr. Antoine Vandercammen. Pp. 175+5 planches. Deuxième Série, Fasc. 58: Recherches sur l'Aile des Chrysomeloidea (Coleoptera), Deuxième Partie. Par Dr. Pierre Jolivet. Pp. 152+planches 21–40. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1958 and 1959.) [136

Tea Research Institute of East Africa. Pamphlet No. 18: Elementary Notes on Tea Manufacture, Part 1: Withering. By Dr. R. Child. Pp. 16+4 plates. (Nairobi: Tea Research Institute of East Africa, 1960.) [146

Consejo Superior de Investigaciones Científicas. Publicaciones del Instituto de Química "Alonso Barba", Vol. 13, Año 1959. Pp. ii+278. (Madrid: Instituto de Química "Alonso Barba", 1960.) [146

Geological Survey of Uganda. Report No. 2: Explanation of the Geology of Sheet 87 (Rakai). By Dr. W. J. Phillips. Pp. iv+48+2 plates+sheet 87. (Entebbe: Government Printer, 1959.) Shs. 15. [156

Centro Brasileiro de Pesquisas Fisicas. Notas de Fisica. Vol. 5, No. 18: Note on the Effects of Polarization of an Incident Photon Beam on the Azimuthal Angular Distribution of the (γ,p) Reaction Products. By A. G. de Pinho Filho. Pp. 257–269. Vol. 5, No. 19: Causality and Dispersion Relations for Fixed Momentum Transfer. By H. M. Nussenzveig. Pp. 273–307. (Rio de Janeiro: Centro Brasileiro de Pesquisas Fisicas, 1960.) [156

Republic of the Sudan. Annual Report of the Government Analyst for the year 1958–1959. Pp. ii+40. (Khartoum: Government Analyst, Wellcome Chemical Laboratories, Ministry of Health, 1960.) [226

Merentutkimuslaitoksen Julkaisu: Havsforskningsinstitutets Skrift. No. 185: Finnish Light-Ship Observations on Currents and Winds in 1955, 1956 and 1957. By Svante Nordström. Pp. 70. No. 186: The Baltic Cruise with *R/V Aranda* 1957—Hydrographical Data. By Ilmo Hela and Folke Koroleff. Pp. 16. No. 187: Die Eisverhältnisse in den Finnland Umgebenden Meeren im Wintern 1957–1958. Redigiert von Erkki Palosuo. Pp. 22. No. 188: Die Eisverhältnisse in den Finnland Umgebenden Meeren in den Wintern 1938–45 und die Baltischen Eiswochen in den Wintern 1938–39. Von Risto Jurva und Erkki Palosuo. Pp. 69. No. 189: Vedenkorkeusarvoja 1958: Vattenståndsvärden 1958. (English summary: Water Level Records for the year 1958). By Eugenie Lisitzin. Pp. 59. No. 190: The Frequency Distribution of the Sea-Level Heights along the Finnish Coast. By Eugenie Lisitzin. Pp. 37. No. 191: Jaatalvi 1958/59 a Suomen Merialueilla. (Ice Winter 1958/59 along the Finnish Coast). Pp. 18. (Helsinki: Merentutkimuslaitos, Havsforskningsinstitutet, 1958 and 1959.) [226

United States Department of Commerce: Weather Bureau. Technical Paper No. 29: Rainfall Intensity—Frequency Regime. Part 5: Great Lakes Region. Pp. iv+31. (Washington, D.C.: Government Printing Office, 1960.) 1.50 dollars. [226

Museum of Comparative Zoology at Harvard College. Annual Report of the Director, 1957–1958. Pp. 28. Breviora. No. 125 (May 27, 1960): The Luminous Organs of *Proctoporus* (Sauria, Reptilia)—a Re-evaluation. By Willard D. Roth and Carl Gans. Pp. 12. Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 122, No. 6: A Transcription of Darwin's First Notebook on "Transmutation of Species". Edited by Paul H. Barrett. Pp. 245–296. Vol. 122, No. 7: Skeleton and Musculature of the Thorax of *Gelastocoris oculatus* (Fabricius) (Hemiptera Heteroptera). By Margaret C. Parsons. Pp. 297–357. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1960.) [226

Berichte des Deutschen Wetterdienstes. Nr. 65 (Band 9): Beitrag zu einer Theorie Stationärer Antizyklonen. Von Hans Haarländer. Pp. 29. Nr. 66 (Band 9): Jahreskarten des Wärme- und Wasserhaushaltes der Ozeane. Von Fritz Albrecht. Pp. 19. (Offenbach a. M.: Selbstverlag des Deutschen Wetterdienstes, 1960.) [226

University of California Publications in Botany. Vol. 32, No. 3: A Morphological Study of Three South African Gigartinales. By Florence Ellen Hewitt. Pp. 195–234+plates 26–32. 75 cents. Vol. 30, No. 5: Morphological Aspects of Parasitism in the Dwarf Mistletoes (*Arceuthobium*). By Job Kuijt. Pp. 337–436+plates 34–48. 2 dollars. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1960.) [226

United States Department of Agriculture. Home and Garden Bulletin No. 67: Insects and Related Pests of House Plants—How to Control Them. Pp. 16. (Washington, D.C.: Government Printing Office, 1960.) 15 cents. [226

Publications de l'Institut National l'Étude Agronomique du Congo Belge. Série Scientifique. No. 82: Insectes Nuisibles aux Fruits et aux Graines. Par Karl E. Schedl. Pp. 133. 70 francs. No. 83: Hôtes Entomologiques du Bois. 1: Espèces Relevées à Yangambi. Par Prof. R. Mayné, avec la collaboration de Prof. C. Donis. Pp. 116. 125 francs. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1960.) [236

United States Department of Commerce: U.S. Coast and Geodetic Survey. Special Publication No. 254: Principles Underlying the Interpretation of Seismograms. Prepared originally by Frank Neumann. Revised (1959) edition. Pp. iii+41. (Washington, D.C.: Government Printing Office, 1960.) [illegible] dollars. [236

Commonwealth Scientific and Industrial Research Organization, Australia. Soil Publication No. 15: The Measurement of the Ion-exchange Properties of Soils. By B. M. Tucker. Pp. 40. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1960.) [236

Tobacco Research Board of Rhodesia and Nyasaland. Bulletin No. 8: The Production of Turkish Tobacco. Pp. 28. (Salisbury: Tobacco Research Board of Rhodesia and Nyasaland, 1960.) [236

Transactions of the American Philosophical Society. New Series, Vol. 50, Part 5: The Dal Pozzo-Albani Drawings of Classical Antiquities in the British Museum. By Cornelius C. Vermeule, III. Pp. 78. (Philadelphia: American Philosophical Society, 1960.) 2 dollars [236

United States Department of the Interior: Fish and Wildlife Service. Fishery Bulletin No. 173: Systematics and Biology of the Gizzard Shad (*Dorosoma cepedianum*) and Related Fishes. By Robert Rush Miller. Pp. iv+371–392. (Washington, D.C.: Government Printing Office, 1960.) 25 cents. [236

United States Department of the Interior: Geological Survey. Geological Survey Topographic Instructions. Multiplex Plotter Procedures: Instructions in the Standard Operating Procedures for the Multiplex Plotter, including a description of Equipment. (Book 2—Mapping Procedures. Part 3F—Stereocompilation Procedures. Chapter 3F4—Multiplex Plotter Procedures). Pp. viii+45. (Washington, D.C.: Government Printing Office, 1960.) 45 cents. [236

United States Department of Commerce: Coast and Geodetic Survey. Publication 60–2: Geodetic Operations in the United States and in other Areas through International Co-operation, January 1, 1957, to December 31, 1959. (Report to the International Association of Geodesy of the International Union of Geodesy and Geophysics, International Council of Scientific Unions.) Pp. vi+38. (Washington, D.C.: Government Printing Office, 1960.) [236

National Academy of Sciences—National Research Council. Science in Space: a Report by the Space Science Board. Chapter 2: The Nature of Gravitation. Pp. iv+21. 1 dollar. Chapter 3: The Earth. Pp. iv+36. 1 dollar. Chapter 4: The Moon. Pp. iv+10. 1 dollar. Chapter 5: The Planets. Pp. iv+13. 1 dollar. Chapter 7: Physics of Fields and Energetic Particles in Space. Pp. iv+58. 1 dollar. (Washington, D.C.: National Academy of Sciences—National Research Council, 1960.) [236

National Academy of Sciences—National Research Council. Nuclear Science Series. NAS–NS 3006: The Radiochemistry of Americium and Curium. By R. A. Penneman and T. K. Keenan. Pp. vi+62. 0.75 dollars. NAS–NS 3008: The Radiochemistry of Rhodium. By G. R. Choppin. Pp. vi+22. 0.50 dollars. NAS–NS 3009: The Radiochemistry of Molybdenum. By E. M. Scadden and N. E. Ballou. Pp. vi+38. 1.50 dollars. (Washington, D.C.: Office of Technical Services, Department of Commerce, 1960.) [236

World Health Organization. Classification of Pharmaceutical Preparations: a Survey of Existing Legislation. Pp. 56. (Originally published in the *International Digest of Health Legislation*, 1960, 11, 4–56.) (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) 2 Swiss francs; 3s. 6d.; 0.60 dollars. [236

Annals of the New York Academy of Sciences. Vol. 85, Article 1: The Metabolism of Oral Tissues. By Philip Person and 48 other authors. Pp. 1–499. (New York: New York Academy of Sciences, 1960.) 4.50 dollars. [236

Smithsonian Institution: Bureau of American Ethnology. Bulletin 173: Anthropological Papers, Numbers 57–62. Pp. iii+498+61 plates. (Washington, D.C.: Government Printing Office, 1960.) [236

British Honduras. Annual Report of the Forest Department for the year 1958. Pp. 24. (Belize: Forest Department.) [236

National Academy of Sciences—National Research Council. Penetration of Charged Particles in Matter: Proceedings of an Informal Conference, Gatlinburg, Tennessee, September 15–18, 1958. (Nuclear Science Series, Report No. 29. Publication No. 752). Pp. x+174. (Washington, D.C.: National Academy of Sciences—National Research Council, 1960.) 2 dollars. [236

Mellon Institute Research 1959–1960: The Annual Report of the Chairman, Matthew B. Ridgway, to the Board of Trustees of the Institute, for the fiscal year ended February 29, 1960. Pp. vi+33. (Pittsburgh: Mellon Institute, 1960.) [236

New Zealand. Report of the Committee on New Zealand Universities, December 1959. Pp. 130. (Wellington: Government Printer, 1960.) [236

Tropical Fish Culture Research Institute, Malacca. Report for the two years 1957/8 and 1958/9. Pp. 15+5 plates. (Batu Berendam, Malacca: Tropical Fish Culture Research Institute, 1960.) [236

Ontario Research Foundation. Annual Report, 1959. Pp. 40. (Toronto: Ontario Research Foundation, 1960.) [246

Canada: Department of Mines and Technical Surveys. Annual Report Calendar Year 1958. Pp. vii+142. (Ottawa: Queen's Printer.) 1 dollar. [246

Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Memoir 309: Permian Rocks and Faunas of Grinnell Peninsula, Arctic Archipelago. By P. Harker and R. Thorsteinsson. Pp. ix+80+25 plates. (Ottawa: Queen's Printer, 1960.) 2 dollars. [246

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world.

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

Pure C
SC
92, Upper Circular Road.
CALCUTTA.
26.10.60.

SUPPORT FOR UNDER-DEVELOPED COUNTRIES

ONE of the most interesting, and possibly most significant, features of the annual report of the Colonial Development Corporation for 1959* is the stress laid on man-power. Some reference is made to this question in three sections of the general review of the year, although in that dealing with public relations no more is said than that a well-informed and interested staff are needed in the Corporation's work and that all staff at home and overseas are helped to realize that, while concentrating on their own particular work, they are contributing a significant part to a widespread and many-sided enterprise. The references made under management and under training schemes are of much wider significance, and illustrate the importance of much that Mr. Kenneth Younger urged in his Sydney Bull Lecture last November on "Trained Man-power for New States: the Scope for International Action", and in his subsequent study in some problems of trained man-power published under the title "The Public Service in New States"†. It might be added that Dr. E. B. J. Portman, rector of the Netherlands College for Representation Overseas, described the Dutch experiment in training staff for foreign posts to the Royal Society of Arts last January.

With enterprise so diverse in character and so widespread in location as that of the Colonial Development Corporation, it is impossible to over-stress the importance of efficient management, and in this latest annual report it is urged that such an organization can only be successful when there is full confidence in the reliability and competence of local management. The Corporation constantly gives special attention to this problem both in the selection of managers for those projects controlled directly or through subsidiary companies, and by making satisfactory expert management a necessary condition for financial participation in any development enterprise. As a result of the continued emphasis given to this aspect, the Corporation has accumulated much experience in judging the best form of management for many different kinds of undertakings, and has also built up a considerable team of trusted managers.

This management and the continued recruitment of suitable young people will only continue to be possible, however, if there is general confidence that the Colonial Development Corporation will be given the chance to grow, and if it is not constantly threatened with a contraction in its scope. Here, moreover, there are two aspects of the problem—organization and training—and both alike can affect recruitment. On the first, the report comments that important as is the selection of good management in the first instance, the process of watching the progress of that management and making changes where necessary is even more important, and it claims that the Corporation's methods of supervision through its regional organization are especially useful.

There can be no doubt from much independent criticism of technical assistance schemes that management has frequently proved one of the weakest points. This may have been due on occasion to bad selection, but more generally it is due to the lack of suitable managers or to imperfections of training. The Colonial Development Corporation is convinced that successful development of under-developed territories requires more than finance; capital investment must be guided and controlled by skilled and experienced management, and it is particularly important that development should proceed as a partnership with the local people in each country.

Through its regional organizations, subsidiary companies and projects, the Corporation is helping suitable people in British overseas territories to undergo business training to equip them to hold responsible posts in any commercial organization. Several candidates from Nigeria, Malaya and the West Indies have already received training in management in the regional and London offices of the Corporation, and scholarships at Commonwealth universities are now being offered in the West Indies and in North Borneo. Training for technical and supervisory positions is being given on projects in the West Indies, the Far East and in various parts of Africa.

In this field, therefore, the Corporation is making a contribution to educational co-operation in the Commonwealth that is by no means negligible, and which underlines both the urgency and the importance of the task of education in the dependent and newly independent territories alike. Mr. Younger's lecture, and even more his book, help to put it in a wider perspective. Both the lecture and the book are concerned primarily with the new States, and accordingly with a field where the Colonial Development Corporation, for example, does not operate. Apart, however, from the fact that these States, most of which are former Colonial dependencies, face many of the same problems as all under-developed territories, the newly independent States have usually a fairly extensive trained administration, consisting largely of expatriates, and their national life and economy are geared to the existence of this corps of trained administrators, many if not most of whom are likely to leave, at or soon after, independence.

These trained administrators cannot be replaced immediately, and Mr. Younger is not concerned simply with the problem of educating and training the people of these States to fulfil such positions, or with the special problem of maintaining relatively modern and sophisticated services during a vital transitional period before such indigenous trained man-power is adequate. He is equally concerned, more especially in his book, with what could be done before independence is reached to ease this transitional period. Moreover, while the major burden of creating a supply of trained man-power must inevitably fall on the new States themselves, which cannot escape the long process of building up a population generally educated for the needs of a modern society, Mr. Younger points out that the process can be accelerated by the conscious adoption of certain priorities in education and training, and that substantial assistance can be given from outside.

---

* Colonial Development Corporation. Annual Report and Statement of Accounts for year to 31.12.59. Pp. v+77. (London: H.M. Stationery Office, 1960.) 5s. net.

† The Public Service in New States: a Study in Some Trained Manpower Problems. By Kenneth Younger. Pp. viii+113. (London: Oxford University Press, 1960.) 12s. 6d. net.

This, Mr. Younger believes, should be one of Britain's main pre-occupations with her overseas territories, and it is of course one of the main purposes both of the Commonwealth Scholarship and Fellowship Plan and of the other measures of Commonwealth educational co-operation resulting from the Commonwealth Education Conference. Like Dr. B. V. Bowden, of Manchester, he points out that even where there is a substantial element of trained man-power, as in Ghana, it is ill-balanced ; and while there may be a full or excessive complement of lawyers alongside a desperate shortage of scientists and engineers, even the existing supply of the latter may be ineffectively used for lack of sufficient technicians or craftsmen. Little has been done until recently to correct the tendency of young scholars in such territories to prefer the arts to science ; but the measures resulting from the Commonwealth Education Conference offer a much better opportunity of correcting their preference by planning higher studies and overseas scholarship programmes with the view of meeting the most pressing needs of particular territories.

Discussing more particularly this transitional period, Mr. Younger points out that while the extent to which expatriate long-service administrative officers and professional and technical officials have been replaced by locally recruited men in the independent territories varies from one territory to another, it rarely much exceeds 50 per cent and is frequently much less in the senior grades. The ideal solution in such circumstances is a phased run-down of the old service, as locally recruited men become available, and this may take anything from three to fifteen years. The process has been successfully worked in the Federation of Malaya and was not unsuccessful in Ghana, while the prospects for Nigeria are reasonable. Success is only possible in favourable political circumstances. In Indonesia, the Sudan and Guinea, for example, a sound relation between the new Government and the old Colonial Service was unattainable for political reasons, and sources of man-power had to be sought apart from the former Colonial power.

No international organization yet exists on a scale which would enable it to step in and make good major deficiencies in trained man-power in an emergency, and Mr. Younger in his lecture suggests that such situations could be far more advantageously handled if international organizations were suitably expanded and strengthened. Once this transition is past, new States are on the same footing as all other underdeveloped territories and have to build up education at all levels, increasingly in their own countries, and with their own teachers. Mr. Younger stresses this indigenous aspect strongly. While he emphasizes that Britain deserves much credit for creating the existing institutions of higher education in Africa, he points out that these are only a small nucleus of what is required, and he has formed the impression that the Governments of highly developed nations, for example, the United States, Britain and France, find it easier to provide scholarships in their own institutions than to give help in developing local institutions.

Whether this is true or not—and it could in part be a consequence of the shortage of trained man-power, especially of scientists and technologists in these countries—the United Nations Technical Assistance Administration has undoubtedly found, in the promotion of training facilities on the spot in various areas, a field which has been neglected by others. Considering the relatively small scale of United Nations activity which Member States have so far been willing to finance, Mr. Younger thinks the United Nations can claim to be making an outstanding contribution in this limited field, although its current annual budget for the Expanded Programme of Technical Assistance is only just over 33 million dollars, supported, however, by substantial counterpart funds in local currency from recipient Governments. Further, successful projects tend to set in motion activities eventually out of all proportion to the initial cost. Some 86 countries have contributed to the programme, and 140 territories have benefited from it : in 1958 experts were drawn from 64 different countries and senior men were sent for training to 68. The experts are mostly international officials, paid by and answerable to the United Nations, and the service has been fairly stable in size for several years. It differs from the more recent Operational and Executive Service of the United Nations, now known officially as Opex, put into operation in 1959 with a maximum of 25 officials, who go out as employees of the Government requesting assistance.

Mr. Younger does not foresee a spectacular growth of this service on the purely administrative side, but on the professional and technical side it might grow considerably and the demand remain steady almost indefinitely. He suggests, therefore, that it should be given some relative permanence, so that it could hope to include a proportion of men who make international overseas service their career and consequently become genuinely expert in its techniques. It would, he suggests, be little if at all easier for Britain than for the United Nations to provide a constant stream of first-class professional and technical men on contract, which is the main requirement to-day. In West Africa, for example, an international body which could build up a corps of experts familiar with the problems of the whole area and capable of transcending the artificial boundaries dividing the former British and French Colonies would have a real advantage. To treat West African medical, agricultural and forestry problems as a single whole would economize in man-power and serve as a useful antidote to 'Balkanization', which is one danger threatening the area after the end of Colonial rule.

It is in this context and that of the proved success of the United Nations in setting up institutes and schools of public administration in South and Central America and in helping to create similar establishments in Egypt, Ethiopia, the Sudan and Turkey, and providing skilled help and advice in this field in other countries of Asia and Africa, that Mr. Younger raises the question whether the Member States of the organization are now willing to turn technical assistance into a major force in world development or not. He thinks that new States would welcome an increase in multilateral aid, but they cannot be expected to press for it so long as it is evident that those Powers, which have both capital and skilled man-power to contribute, are unwilling to supply through international channels more than a fraction of the assistance they offer on a national basis. Nevertheless, he suggests that in the matter of trained man-power, the long-sighted policy would be deliberately to build up international services, both world-wide and regional, as the instruments best suited to future needs, and to the conditions of the post-Colonial period.

Mr. Younger's book describes a study undertaken at the request of Nuffield College, Oxford, and the Leverhulme Trust and based on a visit to Ghana and Nigeria in June and July 1959. While it is largely concerned with the public services in Nigeria and the Southern Cameroons, its clear analysis, including a detailed discussion of the movements which took place in Nigeria and Ghana, is designed to ease the transition for territories reaching independence in future, and to suggest what more might be done beforehand to that end. The difficulties and obligations of the Colonial Power are fairly discussed, but to the professional man the great interest of the book lies in its discussion of the future role of the Overseas Service, and the possible forms which such a Service could take if it is to encourage Civil servants, including scientists and other professional men, to remain in the overseas field. Even for professional and technical officers whose services are likely to be needed longer than those of their administrative colleagues, he is doubtful whether such a Service can be provided on a Commonwealth basis. Adequate career prospects, he suggests, can now be found only in an international organization.

While Mr. Younger considers that it would be sound policy for Britain to participate increasingly in the work of the United Nations and other international bodies in this field, this is not the only possibility. The launching of the British Overseas Civil Service has largely been frustrated through the anxiety as to whether the United Kingdom Government now has direct control over a sufficient range of territories to be able to guarantee a life-time of employment abroad. If, however, ways were found of encouraging men, whose careers would basically be pursued at home, to regard periods of overseas service as a normal and advantageous feature of their professional lives, this difficulty would disappear. Furthermore, it is easier for a technical man to keep abreast of modern knowledge if he retains his home base than if he spends his whole career in territories on the periphery of technical advance.

Present arrangements do no more than make it just possible for a keen man in the British public service to serve abroad for a period, albeit at some risk to his career, though a start has been made in the field of education to improve this. If, however, encouragement of overseas service were explicitly adopted as a part of government policy, a big change could probably be effected at very small cost. As Mr. Younger points out, it is primarily a change in attitude that is required, and especially in that of the Civil Service in Britain. Apart from this, he suggests the creation of an agency in Britain outside the framework of Colonial administration, which can give help to dependent and independent areas alike, and by pursuing simultaneously both these methods Britain would be making the best use of her accumulated experience and contributing at the same time to international co-operation and to the stability and development of new States.

Very clearly some fundamental thinking, as well as a change of attitude, is required, if Mr. Younger's suggestions are to be adopted and errors of the past corrected. It is not simply a matter of education policy and development in the Commonwealth, or even of the more effective training of staff proceeding overseas, either in the Oversea Civil Service or in private employment. The contribution and function of the Colonial Development Corporation must obviously be taken into account, as well as that of Barclays Bank D.C.O., Unilever, Ltd., and other firms that take great care in training staff for overseas; but besides the Government responsibility for seeing that the conditions offered for service overseas are reasonable and attract officers of the highest quality, it is also important that the quantitative demand, especially for scientific and technical officers, should receive due attention in assessing the demand for scientific and technical man-power and in determining the provision to be made to meet that demand. This was a notable omission in the last report on scientific and engineering man-power in Britain, and the omission indicates one of the failings of Government policy to which Mr. Younger directs attention. His criticism, however, is on the whole so constructive that it is to be hoped that the Government will respond swiftly to the challenge it offers, and provide alike the increased resources and the measures which the new situation demands, the critical importance of which has been underlined by all the subsequent events in the Congo.

FERRIMAGNETISM IN THEORY AND PRACTICE

Ferrites

Physical Properties of Ferromagnetic Oxides in Relation to Their Technical Applications. By J. Smit and H. P. J. Wijn. Pp. xiv+369. (Eindhoven: Philips' Technical Library, 1959.) 72*s*.

THE history of the growth of our knowledge of ferrites offers an excellent example of the conditions which are becoming increasingly necessary for success in present-day physical research. Following Néel's original theoretical conceptions of ferrimagnetism, the study of these materials was carried on mainly in an industrial organization, furnished not only with the necessary technical prowess to ensure proper sample preparation and purity control, but also endowed with a liberal policy towards basic research. Alongside this work the key to a fuller understanding emerged from government-sponsored laboratories, by means of the technique of neutron-diffraction which had grown up as a by-product of the operation of nuclear reactors. As a result of this combined attack by physical, chemical and crystallographic methods, many of the properties of ferrites are now much better understood than those of the ferromagnetic metals.

Against this background Drs. Smit and Wijn give an account of the basic magnetic properties of ferrites, emphasizing the properties which are of importance for practical applications and with particular reference to the chemical composition and crystal structure of their materials. They emphasize that they are writing at an intermediate level for readers who are actively working with ferrites, and especially in connexion with their technical uses. As a result the opening chapters, which as Part *A*, "Theory", form almost one-third of the book, concentrate on explanations given in terms of simple physical models rather than strict mathematical demonstrations. Many readers will indeed welcome this and will find that these early chapters offer a very readable account of current conceptions in magnetism, viewed in a field much wider than that of ferrites and presented in an original manner.

Succeeding sections of the book are Part *B*, "Methods of Measuring the Ferromagnetic Properties", and *C*, "Intrinsic Properties", which considers in turn the three classes of ferrite with spinel, hexagonal and garnet structures respectively, and describes their chemical composition, crystal structure, saturation magnetization and crystalline anisotropy. One can complain that the garnet class—particularly those containing rare-earth oxides—get rather scant mention compared with the hexagonal group, where the authors do justice to Braun's elegant work which unravelled the structural secrets. In the last third of the book, Part *D*, entitled "Polycrystalline Ferrites", we come to the more purely technical data for the sintered polycrystalline product as normally handled, a macroscopic product the mechanical and electrical properties of which will depend on porosity and any crystallite orientation induced during the manufacturing process. An idea of the very comprehensive discussion in this section is provided by some of the section headings. There are, for example, sections on the frequency-dependence of the conductivity, dielectric constant, permeability and magnetization curve and on the effect of mechanical stress on the magnetic spectrum and the hysteresis loop. The data here, as indeed throughout the book, are presented very clearly in graphical and tabular form.

The book is excellently produced and pleasant to read, though perhaps with more than its fair share of trivial proofing errors which have escaped detection. As a personal feeling I must admit to a dislike of the system of referencing, using forms such as *Ab* 1 and *Ze* 1 which necessitate turning to the back of the book in order to discover the year of any particular publication. Finally—as a suggestion—the less-specialized reader, who may peruse a good deal of this book with profit, might welcome a few notes on the actual employment of ferrites in electronic devices.

G. E. BACON

ENERGY FOR THE ATMOSPHERE

Turbulent Transfer in the Lower Atmosphere

By Dr. C. H. B. Priestley. Pp. vii+130. (Chicago: University of Chicago Press; London: Cambridge University Press, 1959.) 28*s*. net.

THE meteorologist is vitally concerned with the rate at which energy enters or leaves the atmosphere at the surface of the Earth because this flux ultimately provides the major control on the behaviour of the atmosphere up to quite high levels. Momentum is also drained from the atmosphere at the surface; while man, beast and plant lives (or fails to live) in the layer of air immediately affected by these fluxes. They are mainly, for momentum and latent heat wholly, effected by atmospheric turbulence, except at the very boundary, and Dr. Priestley has written a monograph describing the present position of the study of these turbulent transfers. As the leader of a notable group on the subject near Melbourne over most of the post-war period he is admirably fitted to undertake the task.

Priestley begins at the stage reached by the subject in the early post-war years, as expounded by Sutton in his "Micrometeorology". He sets out to provide a coherent body of knowledge on the relation of the vertical fluxes of heat, matter (evaporation) and momentum to the 'external' parameters—the choice of these is quite a part of the problem, particularly as they are affected by the density or thermal gradient, or, from the other end of the telescope, by the heat transfer itself. The simplest condition, that obtaining when the transfer properties of turbulence are not significantly affected by buoyancy forces (non-adiabatic lapse-rate), is now moderately well understood and described, though the flux of heat or water vapour has not yet been adequately related to the actual surface temperature or vapour pressure. For heat, a second special case obtains when the transfer properties of turbulence are dominated by buoyancy forces to the exclusion of shear-engendered forces—the regime of free convection—and here Priestley's dimensional analysis of the problem and the observations of his group provide the required relations. In the general case, however, where both the above forces are effective and all the fluxes are concerned, theory is somewhat halting, but a framework for observation has been provided and the Melbourne observations of fluxes begin to fill the frame. If Priestley is correct, this general case is not of outstanding practical importance for upward heat transfer because he argues for a quite narrow zone of conditions between the regimes on either side.

The evidence on these matters is skilfully assembled and discussed by the author. He also presents a theory of buoyant motion which is cogent and well supported by the experimental record so that mechanism begins to appear. The bridge has yet, however, to be built to the more fundamental approach adopted in recent years by W. V. R. Malkus in which disposable constants do not appear—this work is not referred to by Priestley. Not the least valuable part of the author's work is to relate the surface fluxes to the larger-scale motions of the atmosphere and to the problem of air-mass modification.

This is an excellent monograph for those with some familiarity with the subject of turbulent transfer, not necessarily in the atmosphere. It is thus to be recommended not only to meteorologists but also to practically all fluid dynamicists concerned with boundary layer problems. They will find writing which is primarily physical in approach and only so much mathematics as is needed to make the physics effective. The writer is a notably good apologist for his own cause, and the reader's enjoyment and stimulus should come in part from reacting to the writer's essence. No serious misprints have been noted and the book is nicely produced.

P. A. SHEPPARD

THE WORLD AROUND US

The World around Us

Edited by Sir Graham Sutton. (Six Essays based upon the Christmas Lectures delivered at the Royal Institution, 1958.) Pp. vi+122. (London: The English Universities Press, Ltd., 1960.) 16s. net.

THE 1958–59 Christmas Lectures at the Royal Institution were planned to mark the close of the International Geophysical Year, and this collection of essays based on the Lectures tells of the kind of work that geophysicists do, and describes some of the projects undertaken during the Year. I have never been able to understand the difference between a 'juvenile auditory' and 'teen-agers', or why it is that the former flock eagerly to hear lectures of the highest excellence by outstanding scientists, and the latter are cynically fobbed off with commercialized intellectual fare which could be described as abysmal if it were not certain that there are lower depths yet for future dredging. The answer is, I suppose, that chance is a fine thing. The regular publication of the Lectures brings them annually before a wider and equally eager audience; and as a most attractive book at about half the price of a long-playing record, this present volume should become the best-seller it deserves to be. It gives young people what they really want when they get the chance to choose it.

The first essay, by J. A. Ratcliffe, describes the exploration of the electron density in the ionosphere by radar echo-sounding, satellite transmissions, and observations of whistling atmospherics. J. M. Stagg describes the general features of the Earth's magnetic field, the complex interplay of surges in the Earth's liquid core and effects from outside, particularly the emissions from solar flares. R. L. F. Boyd writes on the information obtained about the upper atmosphere from rocket experiments and instruments carried in rockets and satellites. Sir Graham Sutton, who has edited the book, deals himself with the lower atmosphere and its weather. G. E. R. Deacon's account of oceanography presents a general picture of the scope of a science that ranges from the detailed recording of variations in mean sea-level to harbour design, tidal waves, and the tracking of deep sea currents. G. de Q. Robin describes the problems of establishing and maintaining an antarctic base, and the work done at Scott Base as part of the programme of the International Geophysical Year.

The authors and editor are to be congratulated on transmuting the Lectures into essays that reach the highest level of popular interpretation. They contain so much information that is really new to the ordinary scientist who has not followed the march of events closely, and should be widely appreciated on this account as well. The publishers also must be congratulated on the production.

G. R. NOAKES

EXPLORING VECTOR SPACE

Vector Space and Its Application in Crystal-Structure Investigation

By Prof. Martin J. Buerger. Pp. xiv+347. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 96s. net.

PROF. D. KOSAMBI, the Bernal of India, has written a collection of articles entitled "Exasperating Essays". It would make a very suitable second title for Prof. Buerger's "Vector Space and Its Application in Crystal-Structure Investigation". The book is exasperating because the subject is of vital concern to X-ray crystallographers, endeavouring to piece together the jig-saw puzzle of their experimental data, and yet one cannot help feeling that the really significant aspects could be presented in a smaller compass and made easier to assimilate.

The crystallographers' jig-saw puzzle, when the pieces are finally fitted together correctly, gives a picture of the electron-density distribution in the crystal, the peaks corresponding to atomic positions. Unfortunately the pieces will fit together in many different ways, and the key, the phase angle of the diffracted X-ray beam or the number on the back of the piece, which would enable the picture to be built up directly and systematically, has been obliterated. There is no means yet known by which the relative phases of diffracted X-ray beams can be determined directly, and it is this 'phase problem' of the structural crystallographer which is responsible for the study of 'vector space'. The concept originated in 1934 when Patterson showed that a modified jig-saw puzzle could be constructed directly from the experimental data, but that the picture so constructed was the 'vector set' derived from the actual atomic arrangement. That is, all the possible vectors between atoms are constructed and one end of each is then transferred to the origin. In general, there are n^2 peaks in the vector diagram derived from n atomic positions, and the problem resolves itself into the 'unsquaring' of this distribution of vector peaks.

Prof. Buerger has played a prominent part in the gradual development of systematic methods of tackling this problem, and the present book presents a survey of these methods, many of which the author has himself originated. It may be said that the book is too complete and insufficiently critical, but another of its exasperating aspects is that one cannot really apportion any blame for this. It is by no means yet clear which methods are going to be most fruitful in exploring vector space, and very little beyond an intuitive idea that the two methods are more or less equivalent has yet been said on the relation of vector methods to the alternative determination of phases by the statistical analysis of the raw data. In these circumstances, to have all the fundamental ideas on vector space and the various analytical methods brought together (and developed) in one book is really as much as one has a right to expect, and something for which all X-ray crystallographers owe Prof. Buerger a debt of gratitude. The criticisms that one has are largely silenced and, exasperating or not, this book will be required reading for all those concerned with Patterson analysis for a long time to come. J. W. JEFFERY

POTASH IN WET AND DRY SOILS

Japanese Potassium Symposium

Nine papers read at the First Japanese Congress, Tokyo, 1957. Pp. 137. (Berne: International Potash Institute, 1959.) n.p.

Potassium Symposium, 1958

Twelve papers read at the Fifth Congress of the International Potash Institute (4 Sessions), Madrid, 1958. Pp. 426. (Berne: International Potash Institute, 1959.) n.p.

SINCE its inception in 1952, the International Potash Institute (Berne) has rendered a valuable service to agriculture and agricultural research. As well as issuing the monthly *Potash Review* leaflets in four languages, the Institute has organized five potassium congresses in different European capitals over the years 1954–58. The Institute also instigated a Japanese potassium symposium, held in 1957; the nine papers presented in Tokyo are now reprinted in English. Four of the papers deal, not surprisingly, with potash and the rice crop. Students of rice culture will find factual articles which range from fertilizer usage to the relationships between potassium nutrition and the disorders caused by fungus and bacterium attacks on the crop. A paper on fruit trees deals specifically with the effects of fruiting on the composition of young orange tree leaves. The nutrition of tobacco is discussed in terms of deficiencies and excesses of potassium on the intake of other nutrients. Recent work on the distribution and lability of potassium in cells and the effect of different potassium-levels on respiration is also described. The reasons for the variations in the potassium-supplying power of volcanic ash soils are examined; usually the parent volcanic ash contains rather little total potassium, which is lost rapidly on weathering. The main products of weathering, allophane, halloysite and gibbsite, do little or nothing to help the potassium economy of such soils. All the papers seem to be well documented.

The volume entitled "Potassium Symposium, 1958", contains the proceedings of the fifth congress of the International Potash Institute, held in Madrid. Following an introductory paper on Spanish agriculture and the use of fertilizers, most of the contributions impinge on the general theme of "Potash and Water". Special attention is given to the potash manuring of Spanish irrigated areas and potassium problems related to the mineralogy of Spanish soils. Three articles deal with potassium, the plant and the water regime; these include treatments of the morphological and physiological conditions associated with drought resistance, the influence of potash on the water economy of plants and the effects of extracts of rotted straw on the potassium uptake and physiology of plants. Other articles deal with potassium uptake and the moisture status of soils (England), potassium in saline soils (Spain) and the importance of potassium in saline irrigation water (Israel). The papers presented towards the end of the Congress allow comparisons of the problems of potash fertilization in temperate, arid and wet-tropical climates. The development of fertilizer usage in the Hawaiian sugar industry is also described; here potash-urea pellets are now hailed on the cane from the air. Readers will find short articles on the use of potash in Portugal, chlorosis and calcium/potassium ratios and the use of potash on rubber trees.

The main articles, which are well documented, are all summarized in four languages.

Having circumscribed the globe, one's thoughts gravitate towards the numerically enormous number of the world's farmers who have yet to open their first bag of potash. The International Potash Institute will, year by year, make these fewer and so help mankind towards a happier existence by encouraging the proverbial two blades to grow where one grew before. P. W. ARNOLD

PLANT TISSUE CULTURES

La Culture des Tissus Végétaux

Techniques et Réalisations. Par Prof. R. J. Gautheret. (Ouvrage publié avec le Concours du Centre National de la Recherche Scientifique.) Pp. iv+884. (Paris: Masson et Cie., 1959.) Cartonné toile, 10,500 francs.

FOR a considerable time following the first successful culture of plant tissues in 1934, further studies of such materials were carried out mainly by a few pioneer workers. During recent years, however, there has been a great widening of interest in plant tissue cultures, which are now no longer treated merely as curiosities but are utilized in the investigation of a wide range of botanical and related problems. The scattered information obtained from these recent and earlier studies has now been collected in one comprehensive volume, and it is fitting that this task should have been carried out by Prof. Gautheret, who was not only the first worker to achieve the culture of plant tissues but by his own work and that of his pupils has also continued to make notable contributions in this field.

As the title indicates, the book deals only with tissue cultures, and the allied subject of organ culture is mentioned only incidentally. The first section, of more than 200 pages, covers the important topic of technique. The media and methods employed by various workers are described in full detail, perhaps even unnecessarily so; the reader is given several plans of the arrangement of instruments on the work table. However, such detailed instructions have the advantage of giving even the beginner in this line of work a good chance of success.

The second and largest part of the book is concerned with morphogenesis in plant tissue cultures. A detailed description is given of the behaviour of tissues when first placed in culture, and of the morphology and development of established strains. There is also an excellent treatment of the differentiation of tissues and organs in various cultures, an aspect of plant tissue culture which has probably yielded the most interesting results to date.

Other sections deal with the utilization of tissue cultures in various special studies. Thus, the use made of tissue cultures in the study of polarity and induction is described. This is followed by an extensive consideration of the nutrient requirements of plant tissues. It is pointed out that although the tissues of many plants can be grown on purely synthetic media, other tissues can only grow, or grow better, following the supply of various plant extracts such as coconut milk. This section includes a full account of the attempts at isolation of the active factor or factors, accompanied by a careful analysis of the difficulties encountered in such work. In this connexion, Prof. Gautheret emphasizes the necessity of working with a suitable tissue strain, of known behaviour, as assay material. In this type of work, as in various metabolic studies of tissue cultures, it is important to note that freshly excised tissues show marked metabolic disturbances and may differ considerably in behaviour from established stocks.

Other topics dealt with are the culture of isolated cells, which is a very recent development, and the role of tissue cultures in plant pathology. With reference to the latter section, mention may be made of the use of tissue cultures in the culture of obligate parasites, and of a particularly interesting account of plant tumours.

In sum, this book is a fine comprehensive account of all aspects of plant tissue cultures. For a work of its size it is remarkably up to date, a supplementary bibliography including most of the important literature issued during 1958. It is well illustrated, the 438 figures including photographs, diagrams and line drawings. Although bulky, the book is easy to use, a clear subdivision of the contents facilitating the location of any particular topic. There is also a useful table of the principal established strains of plant-tissue cultures, which includes a summary of any special nutrient requirements of the various tissues.

A. Allsopp

COMBATING THE DECAY OF TIMBER

Decay of Timber and its Prevention

By K. St. G. Cartwright and W. P. K. Findlay. Second edition. Pp. xv+332+57 plates. (London: H.M. Stationery Office, 1958. Published for D.S.I.R.) 27*s*. 6*d*. net.

Decay of timber must have been a perpetual problem since man first began to use wood, and a serious one as soon as wooden structures became elaborate. We know of the trouble and expense which faced the Navy as a result of the ravages of dry rot in the days of wooden ships, while in buildings decay of timber began to receive serious attention at the beginning of the nineteenth century, coincidently, no doubt, with the decline in the use of the traditional oak in favour of less-durable coniferous woods.

Nevertheless, with the exception of Marshall Ward's "Timber and some of its Diseases", which was based largely on German work, "Decay of Timber and its Prevention", by K. St. G. Cartwright and W. P. K. Findlay, of which the first edition appeared in 1946, seems to be the first comprehensive account of the subject to be published in Britain. It embodies much material based on the authors' investigations at the Forest Products Laboratory at Princes Risborough.

Following introductory chapters on decay in wood, and on the causal organisms, there are detailed accounts of the principal rots of standing trees, accompanied by useful tables concerned with macroscopic and microscopic features of the rots and the characteristic features, in culture, of the causal fungi. Felled timber and wood in outdoor use receive similar treatment, as does constructional timber in buildings and elsewhere. Preventive measures are described, particularly in reference to felled and converted timber and to timber in use. Decay in plywood, wood pulp and building boards receives consideration, and there is a valuable summary of present knowledge of stains and discoloration of timber. There are numerous illustrations, and those of the characteristic appearance of certain rots make a specially valuable supplement to the text and should greatly facilitate identification.

Although a comprehensive treatise, there are times when the information sought is scant and vague. This is no reflexion on the diligence and care of the authors, but rather on the large gaps in knowledge of these interesting and troublesome organisms and their activities. It is indicative of the enormous field of research which awaits the investigator, more particularly with reference to the rots and staining fungi of tropical areas. For any such research the book in question is certain to be a standard work of reference.

F. W. Jane

ANIMAL EXPERIMENTS IN RESEARCH

Achievement

Some Contributions of Animal Experiment to the Conquest of Disease. By Dr. Geoffrey Lapage. Pp. viii+255. (Cambridge: W. Heffer and Sons, Ltd., 1960.) 18*s*. net.

This is an unexpected, original and wholly admirable book. It could have been attempted by a journalist with a smattering of science, but it was, in fact, written by a scientist who has a considerable ability for writing. In view of the seriousness of the subject this is a piece of good fortune for the reader, while implying no derogation of the art of journalism.

Animal experimentation is not often discussed in respectable company; not often enough, and still less often without generating emotion. Dr. Lapage's book is in the direct line of descent from earlier books on the same subject by Stephen Paget and Leonard Rogers; but the treatment is entirely different. Nowhere is the word 'vivisection' mentioned, and nowhere does the author indulge in polemics or argue the moral case. He is content, and so may the reader be, to tell how animal experimentation has led, as no other method had previously led or could have led, directly to advances in human and animal medicine and their related fields of research. Among the animals used, man himself, meaning nearly always the investigator, has a prominent place in this book, which is as worthy a way of paying tribute to our great men as we could wish for. The author has drawn freely on articles appearing in *Conquest*, the journal of the Research Defence Society, over the past ten years.

A former university lecturer who has written a standard work on parasitology might be expected to have written in the style of a text-book; but Dr. Lapage has avoided this pitfall, without sacrificing accuracy and extensive documentation. The book is outstandingly readable; yet it includes nine pages of bibliography and a further nine of index.

There is so much to applaud in this dispassionate treatment of an emotive subject that even to suggest imperfections might be thought ungracious. The emphasis on infectious diseases—three chapters out of ten—is easily defended, for they represent medicine's greatest achievements to-day. Chemotherapy, hormones, nutrition and deficiency diseases are, *inter alia*, also well treated. The absence of a foreword is regretted, all the more because the preface is so short. I discovered only two misprints.

The wise refusal of the author to discuss the moral question is the best reason of all why this book should be compulsory reading for all who recognize that, in animal experimentation, a moral question exists.

The presentation conforms to the high standard one has come to expect from the publishers.

W. LANE-PETTER

SCIENCE FOR THE FAMILY

Science

Chemistry, Physics, Astronomy. Editorial Board: Dr. J. Bronowski, with Sir Gerald Barry, James Fisher, and Sir Julian Huxley. (The Macdonald Illustrated Library.) Pp. 367. (London: Macdonald and Co. (Publishers), Ltd., 1960.) 45*s*. net.

THIS is the first volume of a library of knowledge written for young readers and their parents. The book is so arranged that each double page forms a separate article. This arrangement has distinct advantages over an alphabetical one, and considerable care and thought have been taken in planning the order of the articles so that the book presents a coherent whole. There are a comprehensive glossary as well as an index. In addition, several useful references occur incidentally in the list of illustration credits; but, in a book where much of the information is of necessity superficial, a more systematic bibliography would surely have been welcomed by many readers.

The text is copiously illustrated with excellent diagrams, prints and photographs, containing information complementary to that of the text. There are also several full-page illustrations in colour by Hans Erni which, while being delightful and of high artistic merit, seem unlikely to aid the young reader in his understanding of the subject-matter.

The book unfolds the story of the advancement of the physical sciences from very early times up to the present day, including topics such as polymers, atomic power, television and satellites. A judicious and comprehensive selection has been made, and wisely no attempt has been made to introduce subjects which could not be explained adequately in elementary terms. There is a commendable lightness of touch (not always to be found in works of an encyclopædic nature) in the text, though occasional lapses do occur. For example, we are told on p. 126 that "work is done only when the force acting on a body moves that body in the direction of the force". On p. 128 the reader is apparently encouraged to use "weight" as synonymous with "mass". It is stated on p. 232 that, for a convex lens, "nearer the center . . . the rays are bent less sharply" and on p. 233, for the same lens, that "the lens bends rays that pass near its center more than rays that pass near its edge". The machine shown on p. 121 has mechanical advantage 3, and not 4 as stated. Very few misprints were detected, but the young British reader needs warning that, the book being "international in scope", an American system of spelling has, perhaps unfortunately, been adopted.

These are only minor criticisms. The distinguished editorial board, and all others concerned in its production, are to be complimented on a volume of high quality which will undoubtedly give hours of enjoyment to many readers both young and old. It would surely prove a popular addition to any school library.

D. R. DICKINSON

THE HIDDEN MIND

The Wish to Fall Ill

A Study of Psychoanalysis and Medicine. By Karin Stephen. Pp. vi+238. (Cambridge: At the University Press, 1960.) 10*s*. 6*d*. net; 1.45 dollars, paper bound.

THIS book is an excellent introduction to psychoanalytical theory. It has been based on lectures given to medical students at the University of Cambridge and so is comprehensible to those who have little or no psychiatric knowledge. The author draws on her clinical experience and the cases she quotes add interest to the theoretical descriptions.

Dr. Stephen commences with a discussion of the origin of the unconscious in disappointment, conflict and repression, and describes how this is solved by illness. She shows the obstacles in the way of investigating the unconscious and how psychoanalytical technique uses free association to penetrate this barrier.

Having shown the difficulties to investigation she passes on to describe what is found once we are able to lift the lid of the mind, as it were, and see what is underneath: the primitive sexual nature of the unconscious, infantile pleasure-seeking by mouth, excretory pleasure-seeking and phallic-pleasure seeking.

This naturally leads on to the fears of being deprived of such enjoyment—to the Oedipus complex and castration fears; the arousal of anxiety and guilt, and defence mechanisms; finally, the use of transference in treatment.

Many people, even now, have little or no idea what the analyst is trying to do or how he produces cures. Properly conducted analysis is much more scientific than is often appreciated and the process is more related to observing any other natural phenomena than to patting someone's hand and telling him all is well—which is the popular idea of the process.

CLIFFORD ALLEN

Nature and Man

By John Hillaby. (Progress of Science Series, No. 9.) Pp. 64+28 plates. (London: Phoenix House, Ltd.; New York: Roy Publishers, 1960.) 9*s.* 6*d.* net.

ANY series of books designed to help young people to keep up with the progress of science deserves encouragement. In one of this new series, John Hillaby, European science correspondent of *The New York Times* and zoological correspondent of *The Guardian*, has attempted to show the perpetual struggle between man, animals and plants and how the balance of Nature often becomes greatly disturbed from what seem trivial beginnings. From his travels in many parts of the world Hillaby has seen the awful results which sometimes follow the upsets to natural life and records these in tense and dramatic style.

Among the topics described are the blocking of the Congo River by the devil's lilac and the expenditure of £3 million on chemicals to clear it for traffic; the fearsome effect of too many lemmings, musk-rats and rabbits and other animals; soil-erosion (unfortunate, perhaps, that Hillaby had to go to Athens to witness a soil-storm when his own native Pennines are being deposited in Sheffield and other cities); and the consequences of over-shooting big game.

There is also a chapter on the ways in which young people can train for careers in the conservation of Nature. Whether the author is right to pitch a book with this approach to young people of "12 and upwards" is very questionable. In many secondary modern schools the suggestion that Elton's "Animal Ecology" could form useful further reading for children of this age would receive a not unjustified rejection.

T. H. HAWKINS

Principles of Sugar Technology

Edited by Pieter Honig. Vol. 2: Crystallization. Pp. xviii+567. (Amsterdam: Elsevier Publishing Company; London: D. Van Nostrand Company, Ltd., 1959.) 95*s.*

THIS volume was produced by a selected group of experts as with the first volume. There is a vast mass of useful material to be found in these pages and there is little to be criticized. The crystallography of sucrose might have been improved by the incorporation of some of the useful work done in the University of Bristol, namely, by N. Albon and W. J. Dunning (see *Nature*, 180, 1348; 1957). This was on growth steps of sucrose crystals. Further work was not then published, but is to be found in the thesis of N. Albon at Bristol. Also in Doremus, Roberts and Turnbull (Wiley, 1958) and in *Acta Crystallographica*, Honig directs attention to the loss by inversion on solutions above 65° Brix, as being greater than given by the Stadler tables. He also mentions that pan work actually gives an increased amount of loss of sucrose progressively from affination syrup, first crop, and second crop. The invert produced was lower progressively, showing that combination had taken place. The use of symbols is misleading; C.V. is used for crystallization velocity without explanation, whereas C.V. is already used for the coefficient of variation. A few spelling mistakes occur, including, p. 193, "fosfation". These are poor examples of an otherwise very good book. It is one that should be on the shelves in all sugar factories, refineries and head offices, and should be utilized for new work as well as for judging everyday work.

H. C. S. DE WHALLEY

Les Modèles du Noyau

Par Michel Trocheris. (Bibliothèque des Sciences et Techniques Nucléaires.) Pp. 152. (Saclay: Institut National des Sciences et Techniques Nucléaires; Paris: Presses Universitaires de France, 1959.) 26 N.F.

THE nineteen-fifties have been marked by a vigorous growth in the theory of nuclear structure and the models used to represent it. This book originated in a series of lectures delivered at Saclay in 1955, and the value of its publication nearly five years later might seem questionable. The subject-matter of this book, however, is by no means as general as its title might suggest; it is concerned with an elementary introduction to some of the techniques used in calculations based on the models considered (the Fermi gas, the shell model and the Bohr–Mottelson collective model), rather than the physics of the models themselves or their detailed application to experimental data. Such techniques are often less time-dependent than the models which suggest them, but the meagreness of physical discussion must inevitably limit the usefulness of the book. A second limitation is the almost complete omission of nuclear reaction and decay properties from the discussion. Such properties are as important to present-day nuclear models as the spectra and static moments.

Within these limits the author has written a clear, elementary account of the subject, and this book may form a useful bridge between an undergraduate course of quantum mechanics and the specialized monographs on the various nuclear models.

J. M. SOPER

Nutzenergie aus Atomkernen

Von Dr. Karl Rudolf Schmidt. (Einfuhrung in Physik und Technik von Kernreaktor und Atomkraftwerk, Band 1.) Mit Beiträgen von Hans Günter Heitmann, B. Logermann und Wolfgang Mayer. Pp. xvi+594. (Berlin: Walter de Gruyter und Co., 1959.) 106 D.M.

OF the many books currently available on reactor science and engineering, this must surely be the most ambitious in scope, dealing as it does with almost all aspects of the subject. Starting with elementary atomic and nuclear physics, it leads on to radiation and radioactivity, particle accelerators, nuclear stability and the chain reaction. This in turn leads to elementary neutron physics, reactor theory and lattice calculations.

To note that the subject of nuclear forces, for example, is dealt with in about half a page is not to criticize the book, since its aim is clearly to serve largely as an introduction to the physics side of the title, while providing a more complete analysis of the engineering and technological side. This latter, which takes up more than half the book, deals very thoroughly with such diverse aspects as chemical separation, ion exchange methods, trans-plutonium elements, thermodynamics (including turbine theory, heat transfer, heat exchangers, etc.) and a long section on the properties of materials of interest to reactor designers.

The text is very well supplemented by tables, graphs, references and even nomograms, but, surprisingly, has no index, while topics like reactor kinetics, fission-product poisoning, and shielding are apparently examined in Volume 2, rather than in the physics part of Volume 1, and reactor stability is ignored entirely.

K. R. E. SMITH

THE IAN CLUNIES ROSS ANIMAL RESEARCH LABORATORY, PROSPECT, NEW SOUTH WALES

By DR. IAN W. McDONALD
Chief, Division of Animal Physiology, Commonwealth Scientific and Industrial Research Organization, Australia

THE dominant role of the sheep industry in Australia's economy has naturally influenced the trends of agricultural research. During the early phase of research sponsored by the State and Commonwealth Governments, attention was focused primarily on the control, treatment or prevention of the numerous diseases which impaired the productivity of flocks. As effective procedures were steadily acquired, it became clear that there was scope for equally useful research on the productivity of sheep. Plans for such a development had gradually been matured by the late Sir Ian Clunies Ross (chairman of the Commonwealth Scientific and Industrial Research Organization), Dr. L. B. Bull (then chief of the Organization's Division of Animal Health and Production) and Mr. H. B. Carter (now with the Animal Breeding Research Organization of the Agricultural Research Council in Britain). The funds to initiate the project were made available by the Australian Commonwealth Government through the Wool Use Promotion Act of 1945 and the Wool Industry Fund Act of 1946. More recently, additional financial aid has been provided directly from the sheep industry by a levy on wool.

A site of 116 acres was acquired at Prospect, a village twenty miles from Sydney, where some of the earliest farms in the first Australian colony were established. The Laboratory, originally called the Sheep Biology Laboratory[1], was gradually developed over the years 1953–59, and was staffed by research groups which had been temporarily accommodated in sister laboratories. The main laboratory block, shown in Fig. 1, was completed in 1959 and officially opened on March 9 by Lord Casey, who until his recent elevation to the peerage had been the Minister-in-Charge of the Commonwealth Scientific and Industrial Research Organization.

As a tribute and a memorial to Sir Ian Clunies Ross, who had contributed so much to the sheep and wool industry through his own research as well as his official direction of the research organization, the Laboratory was renamed the "Ian Clunies Ross Animal Research Laboratory".

The Laboratory was initially directed, on a part-time basis, by Dr. C. W. Emmens, professor of veterinary physiology in the University of Sydney. In 1955, I was appointed officer-in-charge, and an assistant to the chief of the Division of Animal Health and Production, Mr. D. A. Gill. On the retirement of Mr. Gill in 1959 this Division was reorganized and I was appointed chief of the new Division of Animal Physiology, of which the Clunies Ross Laboratory plays the major part.

The present staff includes 42 graduates and 56 technical assistants. The main building contains 24 laboratories of modern design with full service facilities and air conditioning, a comprehensive library, conference room and administrative offices; the floor area is about 25,000 sq. ft., and the cost of construction was £A.240,000. Two large animal houses accommodate 300 sheep in single pens, while another 700 sheep are run out-of-doors. The usual small laboratory animals, used primarily for bio-assays, are housed in fully air-conditioned rooms. A

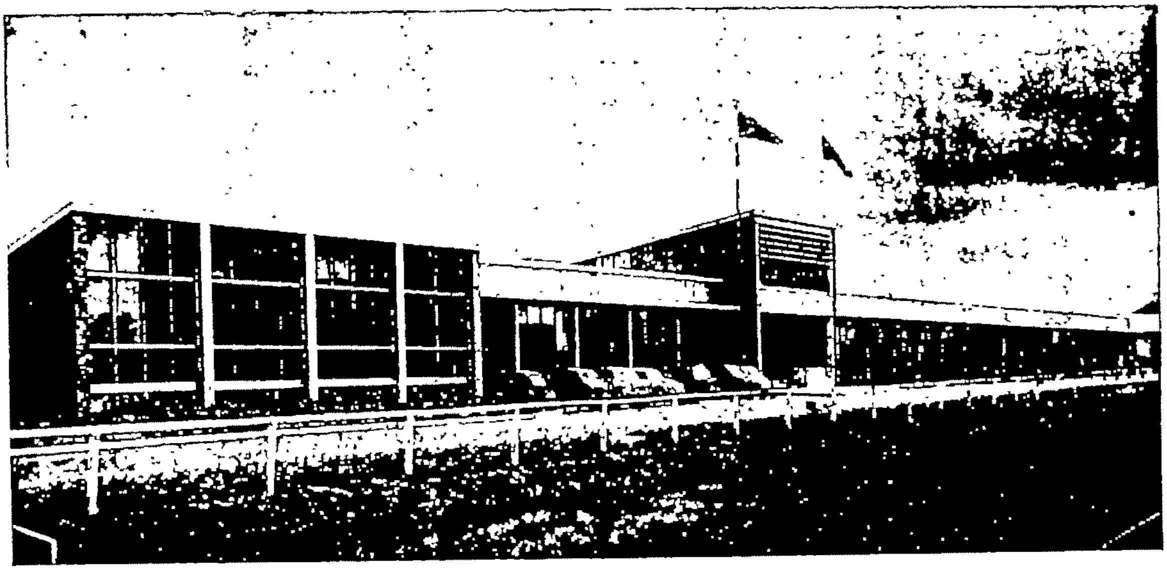


Fig. 1. The Ian Clunies Ross Animal Research Laboratory

modern operating theatre caters for experimental surgery. A number of small fields with sown pasture provide for 'pilot scale' studies on the grazing animal. A well-equipped workshop constructs and maintains much of the special equipment required.

The use of radioactive isotopes in animals as large as the sheep poses some special problems in protection of personnel and disposal of wastes. To meet these problems, an isolated block is being built with accommodation for experimental animals and specially fitted laboratories for handling highly radioactive preparations and for initial processing of biological samples. Laboratory equipment has been provided for preparative and analytical work. Amino-acids labelled with sulphur-35 have proved especially valuable in work on wool growth, and chromium-51 has found application as a marker in studies on digestion. Tritium, carbon-14, iodine-131 and phosphorus-32 have also been used in familiar biological techniques.

The work of the Laboratory falls into seven main categories: reproduction, endocrinology, intermediary metabolism, dermology (morphogenesis, structure and function of the skin), bioclimatology, nutrition, and ecology. The objective has been to expand knowledge of the special physiology of the sheep, with emphasis on those aspects which are likely to lead to more efficient productivity of healthy animals. Sheep are reared under the most diverse conditions in Australia—from the semi-arid, tropical regions of central Queensland, through the temperate grasslands of New South Wales, the tablelands of the Great Dividing Range, to the cool temperate, high-rainfall zones in Tasmania; from pastures so sparse that 10 acres may be allotted to each sheep, to rich highly developed pastures carrying several sheep per acre. With such diversity, it is difficult to generalize on the topic of animal husbandry. As a consequence, the research programme has been designed to provide a sound physiological basis on which husbandry procedures, appropriate to each of the many special regions, can gradually be developed. Some illustrations from recent work are given in the following paragraphs.

It has been known for some time that exposure of rams to high ambient temperatures may lead to seminal degeneration. The mechanisms regulating testicular temperature show very interesting features. The long, coiled, spermatic artery is in intimate contact with a venous plexus, forming a complex which greatly reduces pulse pressure in the artery, and which acts as a highly efficient heat-exchanger. The large temperature gradient between aortic blood and testicular tissue (some 5–6° C.) appears to be derived from scrotal heat loss, and the arterio–venous relations permit the afferent arterial blood to respond quickly to changes in scrotal temperature. It is probable that the efficiency of the scrotum as a heat-dissipating structure is a major factor determining the fertility of the ram in periods of high environmental temperature.

Fertility of ewes has been examined from several angles. The well-defined sexual season of breeds developed in high latitudes is not found in Merino and cross-bred sheep, many of which do not show a definite anoestrus period. The British breeds enter their breeding season in response to declining hours of daylight; but this cannot explain the activity of Merino ewes which may enter their breeding season in the spring with increasing hours of daylight. Clearly other factors, including ambient temperature, must be involved. Climate also influences the frequency of twin ovulations in the ewe. Experiments are being conducted under controlled conditions of light and temperature in the Laboratory to unravel these environmental factors and to determine the physiological pathways by which ovarian function and sexual activity are influenced.

The occurrence of oestrogens in pasture plants was first observed some years ago in Western Australia and has recently been observed in eastern States. This can lead to infertility, dystokia or neonatal deaths to a serious degree, and attempts are therefore being made to develop bioassay techniques as a preliminary to further investigation of the problem. Ovariectomized ewes and wethers appear to be promising material for this study.

Artificial insemination in bovines has been developed, in many countries, to a highly successful, routine procedure; in the sheep, however, the technique has proved less satisfactory. One achievement required for successful application is the induction of oestrus and ovulation at a pre-determined time; procedures for this are being developed; but for reasons not yet clear, fertility has remained rather low. The processes of sperm transport, fertilization and implantation are being examined to throw light on possible interference with fertility.

The metabolism of the pregnant ewe has been the subject of extended study. It has been shown that a number of factors contribute to make the ewe highly subject to nutritional and environmental stresses in late pregnancy, terminating in death of the ewe with pregnancy toxaemia or the birth of weak lambs with high neonatal mortality. The limited supplies of glucose available for absorption from the gut, the preponderance of volatile fatty acids as sources of energy, and the efficiency of the foetal lamb in withdrawing maternal blood glucose, all predispose to a physiological hypoglycaemia; this, in turn, leads to hepatic inadequacy and adrenal hypertrophy, which permits, under appropriate stress, great increases in circulating corticosteroids, the development of a diabetic state, and profound interference with the central nervous system. Only the outlines of these metabolic inter-relationships have yet been established—much remains to be learnt of the factors governing appetite, digestion in the pregnant ewe, gross energy transactions, the major metabolic pathways, the demands of the foetus for glucose and amino-acids, the capacity of sheep tissues for gluconeogenesis, the endocrine control of metabolism and the sequence of events leading to metabolic failure.

The new-born lamb arrives into an environment that is all too frequently hostile; it is perhaps scarcely credible that, even in the tropics, lambs may die from cold stress. There is a formidable list of infective diseases which account for much lamb mortality, but many controlled observations have shown unequivocally that, in Australia, most deaths in new-born lambs can be attributed to exposure and/or inadequate nutrition. This has stimulated interest in the physiological mechanisms that enable the foetal lamb to cope with its sudden change in environment, the influence of maternal nutrition on foetal development, and the initiation of lactation in the ewe.

The physiological mechanisms governing wool growth have proved to be highly complex. The wool follicles are all formed in the foetal lamb, though not all are producing fibres at the time of birth. Even during fœtal life, the development of follicles can be influenced by maternal malnutrition, with permanent detrimental effects. Maturation of follicles occurs rapidly in the lamb, and with increasing age, the follicles become progressively less susceptible to irreversible damage. The three major fields of interest regarding wool growth are endocrine control, effects of nutritional status and climatic influence. The anterior pituitary gland has the major controlling influence, but the individual hormones responsible have not yet been determined; this work has led to an intensive study of the fractionation of pituitary proteins, which has shown the multiplicity of proteins present in the most highly purified preparations at present available. The adrenal corticosteroids have a strong inhibitory effect on wool growth, while administration of thyroxine leads to enhancement of wool growth. There appears to be no specific effect of the sex hormones on wool growth.

Climatic influence on wool growth is definite, with increase during the summer months and decrease during winter. The relative contributions of day-length, ambient temperature or other environmental factors are being studied experimentally with animals maintained in artificially controlled climates. Concurrently, the seasonal variation in reproductive performance can be studied with the same experimental animals.

Wool growth-rate is very sensitive to the nutritional status of the animal. The fact that wool is essentially a protein 'secretion' led to the justified interpretation of earlier work that wool growth was a function of protein intake. More recent work has shown the curious fact that, provided the protein content of the ration is above a certain minimum level, energy intake dominates the growth-rate. The physiological mechanisms involved here remain to be elucidated. Under natural grazing conditions, the influences of nutrition and climate on wool growth are confounded, and much ecological study is needed to clarify the situation.

Biochemical work on wool growth has been greatly assisted by the use of amino-acids labelled with sulphur-35 or carbon-14. The extremely rapid incorporation of labelled cystine into the growing wool fibre (within 1 mm. after an intravenous injection) has also provided a tool for the precise measurement of rate of growth in length of fibres during short time intervals, and for critical examinations of differential changes in length and diameter within individual fibres.

Nutritional research has been aided by the construction of two respiration chambers. The closed-circuit design has been selected, with automatically controlled conditioning equipment for varying the chamber environment over a wide range and in constant or cyclic conditions. Experimental sheep are housed and trained in an air-conditioned room so that seasonal influences are reduced to a minimum.

For research in bioclimatology, two climate rooms have been constructed, each capable of accommodating fourteen sheep. In one room a wind tunnel has been built, to enable experimental animals or mechanical models to be exposed to controlled conditions of temperature, humidity, wind and simulated rainfall. Apart from studies mentioned above on wool growth and reproduction, the major projects concern the physiological mechanisms involved in cold stress and heat stress.

The Clunies Ross Laboratory is still in a formative stage; but already it is clear that the application of the biological sciences (physiology, biochemistry, histology, ecology) can throw new light on one of the most ancient of man's vocations—the husbandry of sheep.

[1] Emmens, C. W., *Nature*, 171, 597 (1953).

RECENT SCIENTIFIC ACTIVITIES AT HALLEY BAY: INTERNATIONAL GEOPHYSICAL CO-OPERATION, 1959

By M. J. BLACKWELL*

Introduction

ON January 10, 1959, a twelve-man party of the Falkland Islands Dependencies Survey arrived at Halley Bay to take over the station from the Royal Society's International Geophysical Year expedition[1]. Following the last-minute decision to continue the scientific programme during the International Geophysical Co-operation, a relief team had been hurriedly organized of personnel seconded from outside bodies, including five scientists from the British and South African meteorological services and five technicians from the Services.

The Falkland Islands party had three links with earlier teams: Lieut. G. R. Lush, R.N. (leader) and D. W. S. Limbert had been members of the 1956 advance party, while J. A. Smith remained from the 1958 party. None of the team, however, was able to spend more than a week or two in preparation for polar work; each was entirely dependent on experience gained in his normal professional occupation. An outline of the main activities of the team and a few of the significant results are described below.

Surface Meteorology

Full synoptic observations were made every three hours, and instrumental readings were taken every hour. Because of the accumulation of snow, the anemometer tower needed an extension of 15 ft. A ventilated thermocouple psychrometer, developed by D. Tribble of the International Geophysical Year party, was used throughout the period to give the first complete year of accurate humidity data at very low temperatures. It has a potential accuracy of a few hundredths of a degree in ice-bulb depression and this was more closely realized by adding extra radiation shields. Trials were carried out by D. W. S. Limbert of a phosphorus pentoxide electrolytic hygrometer[5] which is capable of giving a continuous record of absolute humidity below − 20° C. This is the limit below which the conventional hair hygrograph becomes useless[3].

---

* Seconded from the Meteorological Office, Air Ministry, as Chief Scientist, Halley Bay, during the International Geophysical Co-operation.

Upper Air Meteorology

The International Geophysical Co-operation programme provided for one ascent daily. One of the immediate problems facing the team was the maintenance of access to the balloon shed, which was already two-thirds buried by drift snow. An annexe, 16 ft. square, was built in front of the main door and covered with hinged flaps, just above the snow-level. The floor of the cavity thus created led down in easy steps to the old entrance. This arrangement, devised by G. R. Lush, made it necessary to launch the 1,250-gm. balloons out in the open. The radio-sondes and wind-finding radar targets had to be attached, on the run, before the balloons were torn to pieces in the frequent blizzards. By using unwinders with trailing aerials, quick-action clips for attaching the rigs and by dogged teamwork, ascents were achieved on all but 50 days; of these, 46 were gale days. It was surprising that balloons which had been twisted into fantastic shapes during the launches would reach heights of well over 20 km. During the winter months the balloons were dipped in a mixture of lubricating oil and kerosene to prevent premature bursts at relatively low heights. Without this treatment, heights of 10 km. would be typical, whereas 20 km. was consistently reached throughout the winter. Preheating of the balloons also contributed to the excellent performances, which are summarized in Table 1.

Table 1. Mean Heights reached in Upper Air Soundings

Month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean ht. (km.)	22·7	23·3	22·5	22·3	19·4	21·3	20·3	21·3	22·4	22·4	22·8	21·9	21·9

In addition to the work of J. A. Smith, who organized the upper air programme, it is a pleasure to record the contributions of our two South African colleagues, G. M. Artz and J. Bothma, who had not previously encountered the British radiosonde or the Decca wind-finding radar equipment.

Other Meteorological Activities

Continuous records were maintained of total and diffuse solar radiation and of total net flux. Additional measurements were made of the short-wave albedo of the ice shelf. A new hut was built for the ozone spectrophotometer. This was mounted on sledge runners to facilitate regular recovery from snow drifts. By sighting the instrument through a small hatch in the roof, observations could be made in all weathers. On one occasion, zenith sky measurements were made successfully in a wind of 55 knots with gusts to more than 70 knots. The development of sledge-based huts for similar scientific activities is one which shows considerable promise for the future. The normal summer observations were linked by Moon observations during the polar night. Six series of *umkehr* measurements were made to investigate variations in the vertical distribution of ozone. It had been observed in previous years[4] that the spring increase in total ozone content was quite sharp at Halley Bay. It is interesting to note that this increase was only gradual in 1959. The discovery of new modes of atmospheric behaviour gives some measure of reward to those responsible for urging the extension of an observational programme in a remote part of the world. Other features in which 1959 differed from previous years were noticeable in both surface and upper air climatic sequences.

Recording of surface ozone was continued using a new electrolytic detector element designed by Dr. A. W. Brewer, of the Clarendon Laboratory, Oxford. It replaced the transmogrifier system[6] previously in use. There appeared to be good continuity between the two systems, the change-over taking place in March. Monthly means reached a clear maximum in winter and minimum in summer. In 1958, a secondary decrease which occurred at mid-winter[4] is attributed to the concentration of local contaminants beneath intense surface inversions. The 1959 apparatus was installed at the new site for the spectrophotometer, well clear of smoke from the main living hut. This work was carried out by J. A. Smith.

Another meteorological project, attempted by D. W. S. Limbert, was the investigation of the significant parameters involved in the growth-rate of sea ice. Temperature profiles, in air and ice, and wind profiles were obtained together with density and salinity samples. Combined with other data on energy balance (for example, radiation fluxes) available from base records, these measurements should help to assess the rival merits of recent theoretical predictions.

Movement of the Ice Shelf

The most significant work of the year was the determination of the movement of the ice shelf, both by conventional and by less usual methods. Owing to the scatter in astronomical fixes caused by intense refraction, it has taken three years to establish the movement within reasonable limits. A provisional estimate, based on results for 1957 and 1959 only, gives a W.N.W. movement of about 600 yd. a year. Simultaneous azimuth observations made during the same period show an anti-clockwise twist of the ice shelf. The best fit of the available results gives annual rates of twist of about 18 min. of arc in 1957, diminishing gradually to 15 min. in 1959. The 1959 work was carried out by M. A. Sheret and myself in conjunction with the geomagnetic programme.

We also repeated the local magnetic survey made a year earlier by A. Blackie and J. MacDowall[7], of the International Geophysical Year party. This had shown a vertical force anomaly of several hundred gamma to the north-west of the base and close to the ice front. It was wondered whether movement of the ice shelf over such an anomaly could be detected as little as a year later. The pattern of eight stations covering an area of some 16 sq. km. was re-surveyed, again using a *B.M.Z.* magnetometer. The contours of the anomaly were fully confirmed, but it was immediately apparent that the ice shelf had moved forward, carrying the stake pattern with it, relative to the underlying anomaly. A fairly precise evaluation of the movement would require a closer spacing of the grid and a small closed loop in the magnetic contours. Nevertheless, a provisional analysis of the results (made independently of the astronomical determination) gives a W.N.W. movement of about 500 yd. a year. There is clearly a wide opportunity for the use of this simple and direct technique in areas where the magnetic topography is suitably convoluted. Though the attainable accuracy cannot compete with orthodox survey work, successive surveys could be carried out during brief summer visits.

In addition to the two methods so far described, D. W. S. Limbert fixed the position of two icebergs (which were thought to be grounded on the sea bed) by triangulation from a measured pattern of movement stakes. By repeating the survey after an interval of nine months and using the change in bearings from the icebergs, it was possible to derive a third estimate of the movement of the ice shelf. The provisional reduction of the results gives a westward movement of about 400 yd. a year. Simultaneous with the absolute translation and twist of the shelf, the pattern of movement stakes was observed to undergo deformation, with relative changes of 1 or 2 ft. in 1,000 yd. occurring within a year.

Glaciology

Measurements of snow accumulation were made against three different patterns of stakes: the standard box pattern for net monthly accumulation; a line pattern, nearer to base, for day-to-day ablation and accumulation; and two units (resembling goal posts) for studying the migration of sastrugi. It was noticeable that aggregate totals of accumulation from a given pattern of stakes would sometimes exceed and sometimes fall short of the corresponding totals from the other patterns. The differences were maintained for perhaps months at a time, and are thought to show evidence of the long-term migration of shallow, large-scale features on the ice shelf. Measurements of density and sub-surface temperature profiles were also made. The work was carried out by D. W. S. Limbert.

Other Geophysical Activities

The geomagnetic programme was maintained by M. A. Sheret and myself. Because of the continual rise of the snow surface, the fixed mark could no longer be seen from the declinometer in the magnetic hut. The problem was solved by building a new declinometer room above the north porch which could be entered from below through a small hatch. The fixed mark could then be viewed above the snow-level. To ensure continuity of reference azimuth the angular difference between the old and new sites was determined by theodolite from the mark. Settling of the foundations of the magnetographs required regular adjustments to be made to the variometers but caused no undue difficulty.

A further aspect of the movement of the ice shelf is that the annual means of the magnetic elements, which normally yield the secular variation of the Earth's field, will include an additional term due to the movement of the magnetic hut relative to the magnetic topography of the sea bed. This spurious component can be allowed for when the movement and the contours of the isomagnetics are both accurately known. In addition to the local magnetic survey, the opportunity was taken to obtain measurements of vertical force during the course of a 33-mile physiological sledging trip to the east-north-east of the base. This work was done by Dr. J. N. Norman and G. M. Artz. When combined, the two surveys show that a complex system of magnetic contours covers the whole region so far explored. We can be reasonably certain that there is a corresponding complexity in the underlying geological structure, but it now seems improbable that anything can be deduced about the physical contours of the sea bed. Soundings made from the Falkland Islands Dependency Survey relief ship, R.R.S. *John Biscoe*, indicate that the ice shelf is floating in the area of Halley Bay and that their are no significant shallows which might account for the coastal features of the ice front.

The auroral physics programme was continued with quarter-hourly visual observations, and all-sky camera records during significant displays. M. A. Sheret, who carried out the work, is also attempting to investigate auroral–geomagnetic relationships. An investigation of tidal currents off the coast, made by me, was a continuation of a programme sponsored by the National Institute of Oceanography. The potential difference created by the motion of sea water across the Earth's magnetic field was detected by a pair of silver/silver chloride electrodes suspended below the sea ice near the bay[8]. Tidal variations can be distinguished in the records during periods when geomagnetic activity is slight. Seismological records were also continued until the end of the year.

Biology

Two distinct programmes were carried out by Dr. J. N. Norman. A physiological investigation into the micro-climate of individuals was sponsored by the Medical Research Council. Integrated skin temperatures were obtained, by means of vests sensitive to temperature worn next to the skin, for four subjects going about their normal duties. Additional readings were taken during the man-haul sledging trip already referred to, and these were linked with observations on dehydration and energy balance of individuals.

A separate investigation in the field of penguin biology was carried out during the winter months. By building a small satellite base with living hut and mobile generator, planned by G. R. Lush, it was possible to observe the vast Emperor penguin rookery (3 miles to the west of base) from close quarters. As a result, J. N. Norman, helped by M. A. Sheret, was able to collect a timed series of embryos and to extend our knowledge of the breeding cycle of these primitive creatures.

An attempt has been made to describe something of the scope and variety of the work now being carried out by the Falkland Islands Dependencies Survey at Halley Bay, with particular emphasis on the less routine aspects. We are indebted to the International Geophysical Year parties of 1956–58 for the excellent start given to the station. This article is published with the permission of the Director, Falkland Islands Dependencies Survey.

[1] Fuchs, V. E., *Nature*, 184, 851 (1959).

[2] Brewer, A. W., Air Ministry, London, Met. Res. Pap. 1084.

[3] Hamilton, R. A., Air Ministry, London, Met. Res. Pap. 983.

[4] Dobson, G. M. B., Annals of the I.G.Y., 5, p. 46.

[5] Brewer, A. W., and Milford, J. R., *Proc. Roy. Soc.*, A (1960) (in the press).

[6] MacDowall, J., *Proc. Roy. Soc.*, A, 256, 145 (1960).

[7] MacDowall, J., *Polar Record*, 10, No. 64, 90 (1960).

[8] Longuet-Higgins, M. S., *Mon. Not. Roy. Astro. Soc.*, Geophys. Supp., 5, No. 8, 285 (1949).

SPECIFIC INHIBITORS OF THE ADRENAL CORTEX

By Prof. J. H. U. BROWN

Department of Physiology, Emory University, Atlanta, Georgia

THE endocrine system is composed of many glands in often inaccessible locations with a wealth of interrelationships. In order to investigate the individual hormones it is necessary to remove the gland, or to inhibit in some way its function. Removal is often difficult and in many cases impossible. For this reason, one of the aims of endocrinology has been the development of substances which specifically inhibit a single endocrine organ.

It has been possible for many years to block the action of two of the endocrine glands with specific inhibitors. The use of alloxan to destroy the beta cells of the islets of Langerhans in the pancreas and thus produce true diabetes mellitus has permitted great strides in the study of the action of insulin. The use of the various thiouracils to inhibit synthesis of thyroid hormones and permit investigation of thyroid physiology is too well known to require discussion. The search for specific inhibitors of the other endocrine glands has, in general, been disappointing.

The use of a specific inhibitor for the adrenal cortex would be of special value to the endocrinologist since in most species it is impossible to remove the cortex without simultaneously removing the medulla, and since the presence of accessory glands in all species often makes the operation complicated. Furthermore, a substance which would inhibit specific pathways of steroid synthesis would be of inestimable value in elucidating the synthesis of the various steroids.

Amphenone *B*

Great interest was aroused in 1950 when Hertz, Allen and Tullner[21] reported that a new compound, *p*-aminopropiophenone (amphenone *B*) (Fig. 1), synthesized by Allen and Corwin[1] appeared to cause enlargement of the adrenal and thyroids of rats. Two explanations were possible: the pituitary could be directly stimulated to increase output of its hormones and thus stimulate the target organ to greater function, or secondly, the target organ itself might be affected by the drug. Administration of adrenal or thyroid hormones with the amphenone completely prevented the enlargement of the glands and indicated the site of action to be at the end-organ level. The results also suggested inhibition rather than stimulation of the adrenal and thyroid and demonstrated that the enlargement was due to compensatory hypertrophy which usually occurs in the absence of the target organ hormone consequent to the increased output of trophic hormones of the pituitary[23].

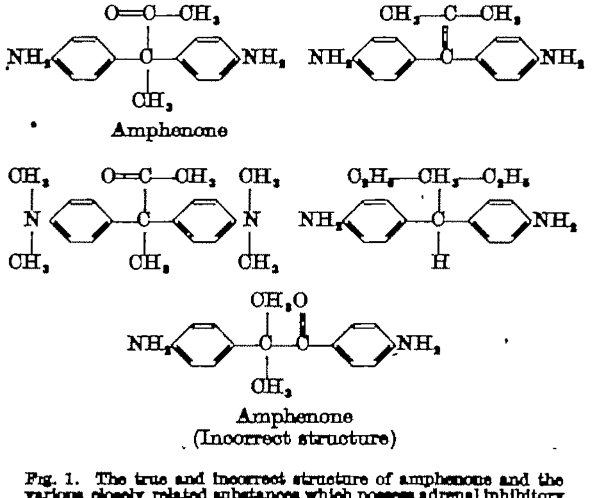


Fig. 1. The true and incorrect structure of amphenone and the various closely related substances which possess adrenal inhibitory action

The results were soon confirmed by Chappel *et al.*[12], by Coste *et al.*[15] and by Danowski[16], who reported finding increased numbers of basophils in the pituitary, increased lipid deposits in the adrenals, loss of colloid and increased epithelial cell height of the thyroid cells, and fatty infiltration of the liver of rats treated with amphenone. The results taken as a whole indicated decreased function of the thyroid and adrenal with increased output of pituitary trophic hormone.

The picture was apparently clear-cut until Hogness[24], Heming[26] and Vogt[31] presented results suggesting stimulation rather than inhibition of the thyroids and adrenals as a result of administration of amphenone. Vogt cannulated the adrenal vein and demonstrated increased steroid production when amphenone was given to rats. In the light of later experiments on both man and other animals, these results must be interpreted as due to peculiarities of dosage, to strain differences, or to unknown factors.

Despite the contradictory information, other experiments sustained the interest in amphenone *B*. For example, several workers[19,21,45] demonstrated that amphenone inhibited the production of aldosterone by the adrenal cortex at a much lower dosage than that required to suppress the output of the other adrenal steroids.

In view of the promise of amphenone as an adrenal cortical inhibitor attention was turned to the production of derivatives which might prove to be more effective or less toxic. Hertz[24] found that of some 25 derivatives only 3 had promise as inhibitors (Fig. 1). It should be emphasized that the structures reported by Allen and Corwin[1] and utilized by Hertz were not correct. In 1957, Bencze[14] found that the molecule became re-arranged (Fig. 1), so it is possible that other derivatives might prove more satisfactory theoretically than those based on the old structure.

Investigation was also proceeding on the mode of action of amphenone. Marks[29] reported that the drug appeared to inhibit pathways of steroid metabolism which did not require oxygen, that is, glands treated with amphenone to complete inhibition of steroid synthesis still utilized the same or greater amounts of oxygen. Marks also found that cholesterol accumulated in the adrenals of rats treated with amphenone and he suggested that the site of inhibition might be at the level of conversion of cholesterol to the precursors of the adrenal steroids (pregnenolone, for example). Rosenfeld and Bascom[64], in a much more elaborate study, utilized the newer methods of steroid identification and found that amphenone inhibited the 11, 17 and 21-hydroxylation of pregnenolone and probably inhibited the conversion of the 3-hydroxyl to a 3-ketone.

The demonstration of the action of amphenone in animals led to its immediate use in human patients suffering from adrenal cancer or hyperadrenalism. The drug was tried with several patients having adrenal carcinoma[25,34,38] with successful results. In these patients there was a decreased excretion of 17-ketosteroids, some evidence of tumour regression, and a depression in the excretion of 17-hydroxycorticoids. The experimental results had shown evidence of thyroid blockade as well as an adrenal action and a series of papers[34,69,73] demonstrated that iodine-uptake was depressed, organic binding of iodine was markedly decreased, and that enlargement of the thyroid occurred in man treated with amphenone. The drug was also tried in patients with hyperadrenalism[48,62,73,76] with considerable success as measured by regression of symptomatology.

However, difficulties soon arose in the use of amphenone. Patients developed thyroid blockade, toxic symptoms including blood dyscrasias, liver damage and general malaise. A major symptom was extreme drowsiness[34], which could be predicted from the anaesthetic property of the drug previously reported in rats[38]. It soon became obvious that the many disadvantages might outweigh the advantages of the drug.

DDD

At about the same time as the synthesis of amphenone, Nelson and Woodard[64] were testing the toxicity of insecticides, including the derivatives of diphenylethane. They reported that high doses of the material 1,1-dichloroethane, 2,2-*bis* parachlorophenyl (DDD) (Fig. 2) produced necrosis of the adrenal cortex in the dog. By contrast, DDT, the tri-chloroethane, was totally ineffective.

The compound was immediately taken up by Nichols and his co-workers[46–62], who found in short order that dogs fed DDD became insulin-sensitive, that the usual biphasic response of the blood sugar to alloxan did not occur in dogs treated with DDD, and that these animals did not respond to adrenocorticotrophic hormone injections with the usual increases in uric acid or allontoin excretion. Since all these responses are usually attributed to the metabolic activity of the glucocorticoids of the adrenal cortex an immediate presumption was made that DDD either suppressed the activity of the pituitary or of the adrenal cortex. Nichols[57] at first postulated that DDD blocked the effect of adrenocorticotrophic hormone on the adrenal, but was soon forced to the conclusion that DDD acted directly on the cortex.

Other evidence of the inhibition of the adrenal cortex was obtained by Little[48], who found that dogs fed DDD developed a depression of glomerular filtration-rate similar to that of adrenalectomized dogs, and by Nichols, Kaye and Larson[62], who found that DDD potentiated the action of barbiturates.

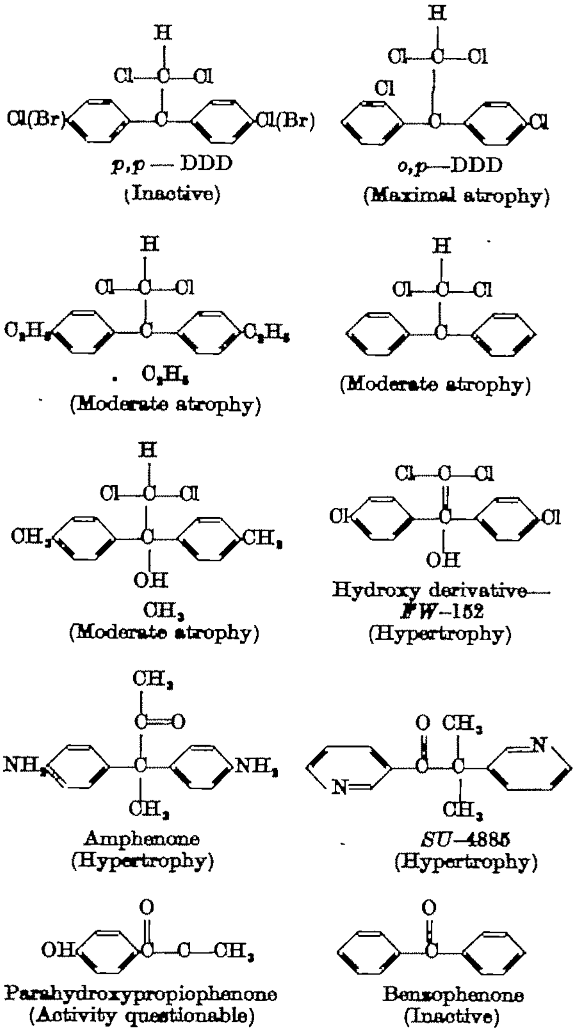


Fig. 2. Structures related to DDD with some indication of the activity as adrenal cortical inhibitors

The first direct proof of the adrenal suppressing activity of the substance was obtained by Brown *et al.*[9,10], who found that the excretion of 17-hydroxycorticoids was markedly depressed in dogs given DDD. They also reported that the effect could not be reversed by the administration of adrenocorticotrophic hormone, indicating the adrenal site of action, but that the effect could be completely reversed by the administration of cortisone. The results were soon confirmed by Kuchmeister *et al.*[45] and by Vilar and Tullner[79].

The action of DDD in the dog was clear. Identical results were obtained in cattle[56] and in the domestic fowl[55]. Unfortunately, the results were not so clear in the rat. Brown[6,7] found that DDD had some influence (decrease) on the eosinophil response of the rat to adrenocorticotrophic hormone and that it may have alleviated the course of alloxan diabetes in the same animal. Verne and Wegmann[77,78] claimed that DDD produced adrenal cortical atrophy in the rat. This was in direct contradiction to Brown[6] and others, who reported hyperplasia of the adrenal in DDD treated rats. Stoner[71], Haag *et al.*[37] and D'Arcy[19] failed to find evidence of any effect of DDD on this animal. It would appear that the situation is unresolved, and that further work is necessary. Perhaps the isomers to be discussed below will provide a compound active on the rat adrenal. This is a problem which must be attacked since the rat is the most commonly used laboratory animal in the investigation of adrenal function. It may be an interesting coincidence that DDD appears to be most active in those species which secrete hydrocortisone as the major metabolic steroid and is inactive in the one animal tested to date (the rat) which does not secrete this steroid.

Because of the possible use of DDD as an adrenal blocking agent, many derivatives have been investigated (Fig. 2). The most active of these is 'Perthane', the di-ethyl derivative of DDD. The drug is an active adrenocorticolytic agent, but appears to be active only at about three times the dose required for DDD[3,4,14]. The relationship between structure and function is somewhat obscure. Many derivatives have some activity and result in atrophy of the cortex, but there are several in the series which appear to produce hyperplasia of the adrenal[14,44]. It is not known if these later compounds act in a manner similar to that of amphenone, which they closely resemble in structure.

It is known that the action of DDD and amphenone on the adrenal cortex are not similar. Nichols and Hennigar[46] fed amphenone to animals previously treated with DDD, and DDD to animals previously treated with amphenone. They found that amphenone could not prevent the atrophy from DDD, but that the usual hypertrophy due to amphenone could be entirely prevented by DDD.

In addition to the more direct measurements of adrenal function under the influence of DDD (steroid excretion, etc.) there are more subtle indications that the gluco-corticoids are either not being produced or not active at the tissue-level. Candela and Candela[11], for example, found that the diaphragms of DDD-treated rats were insulin-sensitive when compared to normal diaphragms, while Nichols, Davis and Green[54] found that the adrenal cortices of dogs treated with DDD did not respond to adrenocorticotrophic hormone with the usual increase in oxygen consumption found with normal glands. Naidoff *et al.*[58] found that DDD lowered the blood-sugar of diabetic rabbits, and Tornblom[74] reported that DDD lowered the serum polysaccharides of the same species. All these observations suggest responses of the peripheral tissues similar to those obtained in adrenalectomy.

In course of investigations on DDD, many workers had noted that the dosage required to produce a given response appeared to vary from batch to batch of the technical material[8]. Conflicting reports were obtained from laboratories using different batches of DDD. These difficulties were resolved in 1958 when Cueto and Brown[16,17] reported the isolation from the technical material of an active agent which gave consistent responses at much lower dose-levels than that reported for the crude DDD. Characterization of the pure substance led to the conclusion that it was present to the extent of about 10 per cent in the technical products and was the *o,p*-isomer of DDD. The remainder of the technical material was largely *p,p*-isomer.

It was soon demonstrated that the *p,p*-isomer was inactive and that the *o,p*-isomer contained all the activity attributed to DDD. This explained many inconsistencies. Several groups had recrystallized DDD before using it and this effectively removed the active component. Others had used the technical material, and as the active isomer varied from batch to batch, inconsistencies were reported. At about the same time as the isolation of the active agent, Nichols[61] found that an oil isolated from the technical material was active in producing atrophy of the adrenals, but he failed to characterize the material. It was probably the *o,p*-isomer. Vilar and Tulner[79], however, used crystalline *o,p*-DDD and confirmed the results completely.

With the availability of a pure product, it became possible to test the material in man. 'Perthane' had been previously tested[64,78], but large doses were required and some toxicity developed. Sheehan and Nichols had previously tested DDD in man with negative results[70], but they had used the technical material with unknown amounts of *o,p*-isomer. Zimmerman[82], on the other hand, also used technical material and found some tumour regression occurred in cancer patients and that a modest decrease in blood corticosteroids could be elicited with the drug. Brown *et al.*[9] found a definite decrease in blood corticoids in three cancer patients treated with the *o,p*-isomer and Bergenstal, Lipsett, Moy and Hertz[3] found definite suppression of adrenal function in twelve patients with adrenal carcinoma with regression of tumours and objective improvement of the cancer. Some toxicity was reported. Tornblom[75] found that DDD decreased the incidence of hyaline vascular disease in diabetic man and noted that diabetics given the drug required a smaller insulin maintenance dose than before treatment.

To the present very little attempt has been made to determine the site of action of DDD on the adrenal cortex. Large doses of the drug cause necrosis with a complete disappearance of cell structure, but it is known that small doses will inhibit steroid production before signs of necrosis develops. Nichols was able to demonstrate an effect of DDD on the oxygen consumption of adrenals treated with adrenocorticotrophic hormone[54], but he did not attempt to determine the site at which the inhibition occurred. Because of its value as an adrenocorticolytic agent, further work should be done on this phase of the problem. It is also possible that use of the *o,p*-isomer or of some other derivative might make the compound effective in the rat and increase its value immensely.

SU-4885

In 1958, Chart *et al.*[13] reported that a new analogue of amphenone, designated as *SU*-4885 (Fig. 2), was effective in suppressing the adrenal function of dogs, rats and guinea pigs. The drug produced an increase in adrenal-weight, increased insulin sensitivity of experimental animals, had no effect on the thyroid, and was effective in suppressing steroid synthesis in adrenal slices.

Jenkins, Meakin, Nelson and Thorn[40] tried *SU*-4885 in man and obtained a decrease of 90 per cent in steroid excretion. The precursors of the 11-hydroxylated steroids appeared in the urine, indicating blockade of this step. The blockade was confirmed by the finding of large amounts of tetrahydro *E* and *F*. Similar results were reported almost at once by Liddle *et al.*[47]. In a later paper, Jenkins *et al.*[41] again reported almost total suppression of glucosteroid production by the adrenal under *SU*-4885 treatment and suggested that the major difference between *SU*-4885 and amphenone was that amphenone was less selective in action.

The drug has not yet been investigated to the extent which will allow prediction of future use in clinical medicine.

Other Substances

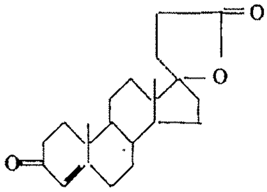
Several other materials have been reported to exert an inhibitory or lytic effect on the adrenal cortex. Dimethylaminoantipyrine and some of its analogues have been reported by Borth[5] to inhibit steroid output of the cortex. The effect is slight and the large doses required do not permit routine use.

Edgren *et al.*[20] found that 6-methyl-17-acetoxy-progesterone decreased adrenal size and function as measured by the 'cold' test. This is inconclusive evidence and no further work has been reported.

Inhibition of aldosterone secretion upon administration of delta-4-cholesterone has been reported by Frederickson[23] and Golden and Overman[26] reported necrosis of the adrenal cortex following infection with *C. diphtheria* in monkeys. The compound para-hydroxypropiophenone (PHP), which is essentially half the amphenone molecule (Fig. 2), has been tested by several groups. Foglia[22] reported that PHP caused a decrease in adrenal weights in rats, Sachsse[67] found improvement of diabetes upon treatment with PHP which might be attributed to decreased adrenal function and a consequent decrease in gluconeogenesis, while Danowski[18] found that the drug decreased adrenal size. In all cases, the effects were not marked and high doses were required.

Steroidal Lactones

A good deal of attention has been directed to a class of drugs which antagonize aldosterone and deoxycorticosterone (Fig. 3). The drug has been extensively investigated by Kagawa[33,34]. The effects are not mediated through the adrenal, and so this drug cannot be classed with those which have a direct adrenal action.



Spiralactone

Fig. 3. The structure of a steroidal lactone with effects on steroid excretion

Structure-function Relationships

All the compounds which are potent adrenal inhibitors appear to possess two six-membered rings linked together by one or two carbon chains. In the case of amphenone and of DDD phenyl groups are attached to the same carbon atom, while in the case of *SU*-4885, they are attached to adjacent carbon atoms.

The effect of substitution on function is not clear. The presence of substitutions on the phenyl rings is not necessary for activity (Fig. 2)[44], but substitution appears to enhance the activity in some cases. The addition of ethyl, methyl, chlorine and bromine to the phenyl group produces a more active compound. The use of nitro, methoxy, or aldehyde substitutions produces a completely inactive compound[4]. The effect of location of the substitution has not been extensively investigated. It is known that the *p,p*-chloro derivative is completely inactive while the *o,p*-chloro derivative is active in a high degree. Compounds are now being synthesized with various steric configurations to investigate this problem.

The substitution on the carbon adjacent to the phenyl attachments is important. A tri-chloro substitution (DDT) is completely ineffective, as is the mono-chloro compound[44]. Removal of the chlorines from the adjacent carbon, substitution of a hydroxyl group on the phenyl carbon, and apparently the presence of a ketone on one of the chain carbons results in hypertrophy rather than atrophy, although a greater or lesser inhibition of action may occur. Apparently more than one carbon must be present in the chain since benzophenone is inactive[73]. In this connexion it is interesting to note that a compound of related structure (3,5-dioxo-1,2-diphenyl, 4-*n*-butyl pyrazolidine) has been reported to have slight adrenal inhibitory activity[5].

It is interesting to note that all the compounds which have inhibiting properties appear to have a six-membered ring, but there appears to be no requirement that it be benzenoid in character. The nitrogen-containing ring of *SU*-4885 appears to be quite effective. Although the active amphenones mentioned by Hertz[30] all contained *p,p*-amino groups on the benzene rings, it is not known whether these are essential to activity. Reasoning from the information available on DDD one could conclude that other substitutions might be equally or more effective.

This work was supported by grants from the National Institutes of Health, National Cancer Institute (*Cy*-3150).

BIBLIOGRAPHY

[1] Allen, M. J., and Corwin, A. H., *J. Amer. Chem. Soc.*, **72**, 117 (1950).

[1a] Bencze, W. L., and Allen, M. J., *J. Org. Chem.*, **22**, 352 (1957).

[2] Bergenstal, D. M., Lipsett, M. B., Moy, R. H., and Hertz, R. (personal communication submitted for publication).

[3] Bleiberg, M. J., Ph.D. thesis, University of Virginia (1958).

[4] Bleiberg, M. J., and Larson, P. S., *J. Pharm. Exp. Therap.*, **121**, 421 (1957).

[5] Borth, R., and Musso, E., *Acta Endoc.*, 11, 245 (1952).

[6] Brown, J. H. U., *Proc. Soc. Exp. Biol. Med.*, **83**, 59 (1953).

[7] Brown, J. H. U., *Endocrinol.*, **53**, 116 (1953).

[8] Brown, J. H. U., Griffin, J. B., Smith, R. B., and Anason, A., *Metabolism*, **5**, 594 (1956).

[9] Brown, J. H. U., Preddy, J. R. K., Brown, C. H., and Hallman, B., *Lancet*, i, 1208 (1959).

[10] Brown, J. H. U., Smith, R. B., and Griffin, J. B., *Metabolism*, **4**, 452 (1955).

[11] Candela, J. L., and Candela, R. R., *Arch. Med. Exp.* (Madrid), 17, 57 (1954).

[12] Chappel, C. L., Cahill, J., Roma, G., and Grant, G. A., *Endocrinol.*, **63**, 30 (1958).

[13] Chart, J. J., Sheppard, J., Allen, M. J., Bencze, W. L., and Gaunt, R., *Experientia*, 14, 151 (1958).

[14] Cobey, F. A., Taliaferro, I., and Haag, H. B., *Science*, **123**, 140 (1956).

[15] Coste, F., Delbarre, F., and Lacroblque, F., *C.R. Soc. Biol.* (Paris), **150**, 959, 963 (1956).

[16] Cueto, C., and Brown, J. H. U., *Endocrinol.*, **62**, 334 (1958).

[17] Cueto, C., and Brown, J. H. U., *Endocrinol.*, **62**, 326 (1958).

[18] Danowski, T. F., Wirth, P., Brown, M., Hill, G. C., and Fetterman, G. H., *J. Clin. Endoc.*, **12**, 1454 (1952).

[19] D'Arcy, P. F., *J. Pharm. Pharmacol.*, 6, 625 (1954).

[20] Edgren, R. A., Hambourger, W. E., and Calhoun, D. C., *Endocrinol.*, **65**, 505 (1959).

[21] Finnegan, J. K., Haag, H. B., and Larson, P. S., *Proc. Soc. Exp. Biol. Med.*, **72**, 357 (1949).

[22] Foglia, V. G., Di Paola, D., and Hutz, A., *Rev. Soc. Arg. Biol.*, **27**, 76 (1951).

[23] Fredrickson, D. S., Peterson, R. E., and Steinberg, D., *Science*, **127**, 704 (1958).

[24] Gallagher, T. F., *J. Clin. Endoc.*, 18, 937 (1958).

[25] Gallagher, T. F., Kappas, A., Spencer, H., and Laszlo, D., *Science*, **124**, 487 (1956).

[26] Golden, A., and Overman, R. R., *Amer. J. Path.*, 19, 899 (1949).

[27] Haag, H. B., Finnegan, J. K., Larson, P. S., Dreyfuss, M. L., Main, R. J., and Riese, W., *Indust. Med.*, 17, 477 (1948).

[28] Harada, M., Nakagawa, M., and Osaki, S., *Wakayama Med. Report*, **3**, 187 (1957).

[29] Hayano, M., Saba, N., Dorfman, R. I., and Hechter, O., *Rec. Prog. Hormone Res.*, **12**, 79 (1956).

[30] Heming, A. E., Holtkamp, D. E., Kerwin, F., Mansor, L. F., and Dacanay, J. G., *Proc. Soc. Exp. Biol. Med.*, **80**, 154 (1952).

[31] Hertz, R., Allen, M. J., and Tullner, W. W., *Proc. Soc. Exp. Biol. Med.*, **75**, 627 (1950).

[32] Hertz, R., Allen, M. J., Tullner, W. W., and Westfall, B. B., *Proc. Soc. Exp. Biol. Med.*, **79**, 42 (1952).

[33] Hertz, R., Bergenstal, D. M., Lubs, H. A., and Jackson, J. J., *Cancer*, 10, 765 (1957).

[34] Hertz, R., Pittman, J. A., and Graff, M. M., *J. Clin. Endocrinol. and Med.*, 16, 705 (1956).

[35] Hertz, R., Tullner, W. W., and Allen, M. J., *Proc. Soc. Exp. Biol. Med.*, *77*, 480 (1951).

[36] Hertz, R., Tullner, W. W., Schricker, J. A., Dhyse, F. G., and Hallman, L. H., *Rec. Prog. in Hormone Res.*, 11, 119 (1956).

[37] Hogness, J. R., Lee, N. D., and Williams, R. H., *Endocrinol.*, **52**, 378 (1953).

[38] Hogness, J. R., Williams, R. H., and Lance, M., *Proc. Soc. Exp. Biol. Med.*, **79**, 43 (1952).

[39] Holzbauer, M., *J. Endoc.*, 14, 26 (1956).

[40] Jenkins, J. S., Meakin, J. W., Nelson, D. H., and Thorn, G. W., *Science*, **128**, 478 (1958).

[41] Jenkins, J. S., Meakin, J. W., and Nelson, D. H., *Endocrinol.*, **64**, 572 (1959).

[42] Johnson, J. R., Remmers, A. R., Gregory, R., and Clayton, G. W., *J. Lab. Clin. Med.*, **48**, 822 (1956).

[43] Knohmeister, H., Pleiss, G., and Wilhelm, W., *Acta Endoc.*, **20**, 39 (1955).

[44] Larson, P. S., Hennigar, G. R., Finnegan, J. K., Smith, R. B., and Haag, H. B., *J. Pharm. Exp. Therap.*, **115**, 408 (1955).

[45] Leone, L. A., Hahn, H., and Mellette, S. J., *Virginia J. Science*, 7, 334 (1956).

[46] Lewis, L. A., and Page, I. H., *Amer. J. Physiol.*, 173, 359 (1953).

[47] Liddle, G. W., Island, D., Lance, E. M., and Harris, A. G., *J. Clin. Endoc. Med.*, 18, 906 (1958).

[48] Little, M. J., Kelsey, W. M., and Yount, E. H., *Amer. J. Physiol.*, **186**, 159 (1956).

[49] Mach, R. S., and Muller, A. F., *Schweiz. Med. Wschr.*, Supp., 60, 406 (1957).

[50] Marks, B. H., Alpert, M., and Kruger, F. A., *Endoc.*, **63**, 75 (1958).

[51] Max, B., Muller, S., and Muller, A., *Schweiz. Med. Wschr.*, **87**, 406 (1957).

[52] McCullagh, E. P., and Tretbar, H. A., *J. Clin. Endoc.*, 18, 134 (1958).

[53] Naidoff, D., Pincus, I. J., Town, A. E., and Scott, M. E., *Amer. J. Ophthal.*, **39**, 510 (1955).

[54] Nelson, A. A., and Woodard, G., *Arch. Path.*, **48**, 387 (1949).

[55] Newcomer, W. S., *Amer. J. Physiol.*, **196**, 276 (1959).

[56] Nichols, J., Davis, C., and Green, H. D., *Endocrinol.*, **53**, 541 (1953).

[57] Nichols, J., and Gardner, L. I., *J. Lab. Clin. Med.*, **37**, 229 (1951).

[58] Nichols, J., and Green, H. D., *Amer. J. Physiol.*, 176, 374 (1954).

[59] Nichols, J., and Hennigar, G., *J. Clin. Endoc. Med.*, 16, 956 (1956).

[60] Nichols, J., and Hennigar, G., *Endocrinol.*, **61**, 226 (1957).

[61] Nichols, J., and Hennigar, G., *Exp. Med. Surg.*, **15**, 310 (1957).

[62] Nichols, J., Kaye, S., and Larson, P. S., *Proc. Soc. Exp. Biol. Med.*, **98**, 239 (1958).

[63] Nichols, J., and Sheehan, H. L., *Endocrinol.*, **51**, 362 (1952).

[64] *Canad. Med. Assoc. J.*, **78**, 357 (1958).

[65] Renold, A. E., Crabbe, J., Hernando-Avendano, J., Nelson, D. H., Ross, E. J., Emerson, K., and Thorn, G. W., *New Eng. J. Med.*, **256**, 16 (1957).

[66] Rosenfeld, G., and Bascom, W. D., *J. Biol. Chem.*, **222**, 565 (1956).

[67] Sachsse, B., *Med. Klin.*, **49**, 1254 (1954).

[68] Schricker, J. A., Farber, G. R., Tullner, W. W., and Hertz, R., *Endocrinol.*, **51**, 394 (1952).

[69] Selenkow, H., Rivera, W. A., and Thorn, G. W., *J. Clin. Endoc. Med.*, 17, 1131 (1957).

[70] Sheehan, H., Summers, V. K., and Nichols, J., *Lancet*, i, 312 (1953).

[71] Stoner, H. B., *Nature*, **172**, 1044 (1953).

[72] Taliaferro, L., and Leone, L., *New Eng. J. Med.*, **257**, 855 (1957).

[73] Thorn, G. W., Renold, A. E., Goldfein, A., Nelson, D. H., Reddy, W. J., and Hertz, R., *New Eng. J. Med.*, **254**, 547 (1956).

[74] Tornblom, N., *Acta Med. Scand.*, **152**, 149 (1955).

[75] Tornblom, N., *Acta Med. Scand.*, **164**, 23 (1959).

[76] Tullner, W. W., Graaf, M. M., and Hertz, R., *Endocrinol.*, **58**, 802 (1956).

[77] Verne, J., and Wegmann, R., *C.R. Soc. Biol.* (Paris), **146**, 1044 (1952).

[78] Verne, J., and Wegmann, R., Cong. Assoc. Francaise Adv. des Sciences (1954).

[79] Vilar, O., and Tullner, W. W., *Endocrinol.*, **65**, 80 (1959).

[80] Weber, A. F., Bell, J. T., and Seller, A. F., *Amer. J. Vet. Med.*, 19, 51 (1958).

[81] Vogt, M., *J. Endoc.*, **14**, **25** (1956).

[82] Zimmerman, B., Bloch, H. S., Williams, W. L., Hitchcock, C. R., and Hoelscher, B., *Cancer*, **9**, 940 (1956).

[83] Kagawa, C. M., Sturtevant, F. M., and Van Arman, C. G., *J. Pharm. Exp. Therap.*, **126**, 123 (1959).

[84] Cella, J. A., and Kagawa, C. M., *J. Amer. Chem. Soc.*, **79**, 4808 (1957).

OBITUARIES

Dr. W. Lawrence Balls, C.M.G., C.B.E., F.R.S.

Dr. Lawrence Balls, who died on July 18, was the foremost of many workers who have been engaged on the development of Egyptian cotton during the present century. His personal investigations have been of great practical importance as well as of outstanding scientific interest. In addition to providing scientific knowledge, he markedly influenced the administrative procedures in Egypt for making that knowledge effective.

William Lawrence Balls was born in 1882. After being educated at King Edward VI School, Norwich, and St. John's College, Cambridge (of which he was a Fellow from 1909 until 1913), he became botanist to the Khedivial Agricultural Society in 1904 and served that body and (later) the Egyptian Department (later Ministry) of Agriculture until his retirement in 1947, except for a period 1915–26, when he was designer and head of the Experimental Department of the (then) Fine Cotton Spinners' Association, Ltd., at Bollington, Cheshire.

During the first phase of his career in Egypt, Balls made detailed physiological studies of the growth of the cotton plant and of the mode of development of the fibres produced from the seeds—the raw cotton of commerce. Many of the results of these fundamental investigations are summarized in his now classical works "The Cotton Plant in Egypt" (1912) and "The Development and Properties of Raw Cotton" (1915). He also made some of the earliest critical genetical studies of plant characteristics and features of fibre quality, and rapidly formed the conclusion that mediocrity and degeneration in both yield and quality were inevitable under Egyptian conditions unless genetic variability was minimized and controlled. From this arose his concept of 'pure line' strains. This work led to the development of methods for making available pure-line seed supplies. During his later career in Egypt, as chairman of the Cotton Research Board of the Ministry of Agriculture, Balls gave continuous encouragement to the policy of crossing and re-crossing of the various strains to exploit to the full the latent characteristics inherent in Egyptian cotton and persisting from the original historical medley of impure cottons.

From the start of his career, Balls was actively interested in the physiological requirements of the cotton plant, and this led him to study the water and drainage requirements for optimum yield under Egyptian irrigated conditions, with the results described in "The Yield of a Crop" (1953). In this work he arrived at the valuable, though possibly depressing, conclusion that the improvements in crop yield made over the years, by himself and his co-workers through better pest control, improved manuring, the development of more prolific strains, etc., had only made it possible to counterbalance approximately the progressive losses caused by the water-logging of the soil associated with the increase in the water-table following the change from the basin type of irrigation to perennial irrigation.

In considering fibre quality, Balls took as his end-point the quality of the spun yarn, and this interest, together with the circumstances of his career, led him into spinning technology. His "Handbook of Spinning Tests for Cotton Growers" (1920) was a pioneer work that needs little amendment to-day. His "Studies of Quality in Cotton" (1928), based on research work done at Bollington and describing notably the 'drafting wave' and the 'Rule' spinning frame, has influenced much of later technological research and development.

Balls was active to the end, and it was a pleasure to delegates at the Jubilee Conference of the Textile Institute (which had awarded him an honorary fellowship in 1943) in May of this year, to hear from the master himself a paper on the "Beginnings of Botany on a Cotton Crop".

Dr. Lawrence Balls was a great man, in the true sense of the words, who made for himself a career and won by his ability international recognition in a little-known and, at that time, little-regarded field of investigation.

D. W. HILL

Prof. J. Bronte Gatenby

PROF. JAMES BRONTË GATENBY, the eminent cytologist, died on July 20 while on holiday at Galway, Ireland. Born in 1892 in New Zealand, he developed a keen interest in entomology and this led him to correspond with Prof. E. B. Poulton in Oxford, where he later went as a student and studied under Prof. E. S. Goodrich. His interest in entomology was reflected in many of his later papers. He graduated in 1916 with first-class honours and was appointed lecturer in histology in Prof. (later Sir Charles) Sherrington's Physiology Laboratory. He soon became interested in cytology, particularly in the inclusions of the germ cells of a wide variety of animals, and he published a long series of papers on this subject. In 1918 he was appointed to a senior demyship at Magdalen College, Oxford, and in 1919 lecturer in cytology in the University of London, where he worked with Prof. J. P. Hill. During these years he produced a considerable number of papers on the embryology, oogenesis and spermatogenesis of both invertebrates and vertebrates. His D.Phil. he obtained from Oxford and his D.Sc. from London.

In 1921 he was appointed to the chair of zoology and comparative anatomy in Trinity College, Dublin, a post which he held until 1959, when he was appointed to a research chair of cytology in the same University. During this period in Dublin he attracted students from all over the world, and he was involved in several fierce controversies relating to the Golgi apparatus—the cell inclusion which he studied in considerable detail. These controversies were mainly concerned with Parat's vacuome hypothesis and also with the question of whether or not the Golgi bodies in many cells were staining artefacts.

Since the Second World War, Gatenby took an increasing interest in electron microscopy. He became firmly convinced of the great potentialities of this technique two years ago when he worked for a while at the Argonne National Laboratory in the United States. He was, however, always insistent on linking this work with light microscope studies. This was his second visit to the United States—in 1930 he spent a year at Yale University as a Seessel Fellow. In 1933 he was appointed visiting lecturer to the University of Louvain.

He had a very extensive knowledge of microscopical techniques, and for many years was a joint editor of "The Microtomist's Vade Mecum". He was on the editorial board of the *Journal of the Royal Microscopical Society* and other learned journals, and was made an honorary member of a number of scientific societies.

To his students Gatenby appeared rather fearsome at times, but to keen and interested ones he gave every encouragement and showed much kindness. He would stand for no sham or bluff. He was in many ways an outstanding representative of the old school of classical zoologists. His teaching and published work reflected his respect and affection for some of the great names of British zoology whom he knew well—Goodrich and Lankester in particular. By his death the world of cytology and zoology has lost an eminent man. He is survived by his second wife and four children by his first marriage.

J. N. R. GRAINGER

Prof. F. A. Jenkins

PROF. FRANCIS A. JENKINS, professor of physics in the University of California, died at his home in Berkeley on August 3, after an illness of two months. He was a graduate of the Universities of Chicago and Toulouse and had been a faculty member at Berkeley for thirty-one years. He had held Guggenheim fellowships at Utrecht, Uppsala and most recently at Oxford, where his presence and activity in the autumn of 1958 are warmly remembered at the Clarendon Laboratory, at Brasenose College, which made him a member, and by many friends and colleagues.

Jenkins's name is perhaps most widely known through the excellent text-book on optics, by Jenkins and White; but it is his research work, covering a wide field of optics and especially spectroscopy, which has established his reputation among physicists, chemists and astronomers everywhere. His chief contributions were in the field of molecular spectroscopy; of the numerous topics only some of the most important can be mentioned here: his thorough study of the CN bands and of perturbation effects in their rotational structure, the investigation of isotope effects and the determination of isotopic mass ratios (Li_2, BO), his work on the intensity distribution in the rotational structure of bands and on the changes of coupling conditions as the result of increasing rate of rotation (NO), the determination of nuclear spins and nuclear statistics from alternating intensities (Se, C^{14}) and the study of Rydberg series in band spectra.

In the field of atomic spectroscopy, his work on the quadratic Zeeman effect in sodium and potassium, of Zeeman effects in forbidden lines and on hyperfine structure and isotope shift is outstanding. He also made valuable contributions to spectroscopic methods, especially in the field of dielectric multi-layers, studying the performance of broad-band interference filters, the dispersion of the phase change in such filters and the ultra-violet reflectivity of multi-layers containing antimonous oxide and lead chloride. It was especially his knowledge and experience in this field from which the spectroscopy group in the Clarendon Laboratory derived great benefit during his stay there.

His most recent interests were exciton absorption spectra and methods of applying electronic computers to the analysis of band spectra. In the latter field he worked in close collaboration with the Departments of Chemistry and of Astronomy in Berkeley.

A feature common to all Prof. Jenkins's publications is their thoroughness and completeness, both in the measurements themselves and in their theoretical evaluation; there was no room for false claims, either in his work or in his personality.

Those who knew personally 'Pan', as he was called, will have lively memories of his warm personality, his human understanding and friendliness, his sense of humour and the breadth of his interests and concerns. Many will also recall his happy home and family, that meant so much to him. He was strongly attached to California, where he had spent most of his life, and he liked the camping holidays for which that State offers so many opportunities. But he also had strong ties with the Old World and felt very much at home in England and other European countries. His presence and contributions will be sadly missed at many spectroscopic conferences.

H. G. Kuhn

Prof. Tadeusz Miłobedzki

Prof. Tadeusz Miłobedzki, formerly of the Warsaw Polytechnic, died on July 13, 1959. He led a simple, quiet life and worked successfully until old age. He was a man of great intellectual power, a skilful research worker and an excellent teacher.

Miłobedzki was born at Koło upon Warta on June 16, 1873, and graduated at the University of Warsaw in 1897. He took a special interest in organic chemistry, and was a student of Prof. Wagner, a specialist in terpenes. He also worked in Berlin, Leipzig and Graz, and obtained his Ph.D. at the Jagellonian University in Cracow in 1918.

In 1906, when the Russian authorities had allowed the opening of the Polish Technical College, Miłobedzki was appointed a lecturer in inorganic and analytic chemistry there. In 1915 he took an active part in the organization of Polish university education. He was a co-organizer of the Warsaw Polytechnic and the first dean of its Faculty of Chemistry. In 1917 he was appointed an extraordinary professor at the Central School of Agriculture in Warsaw, where he became the first rector. In 1922 he was called to the chair of inorganic chemistry in the University of Poznań, and in 1929, after the death of Prof. J. Zawidzki, he succeeded to the chair of inorganic chemistry at the Warsaw Polytechnic.

For his outstanding work as a scientist, organizer and teacher, he was made an honorary professor of the Central School of Agriculture at Warsaw and of the Jagellonian University.

In 1922 Prof. T. Miłobedzki became an ordinary member of the Poznań Society of the Friends of Sciences, and in 1932 he was elected to the Warsaw Scientific Society. During 1937–39 he took part in the work of the Polish Committee of the International Union of Pure and Applied Chemistry. In 1945 he became a member of the Polish Academy of Science and Arts and, on its foundation, of the Polish Academy of Science.

Prof. Miłobedzki played a prominent part in the development of the Polish Chemical Society. In 1920 he was one of its founders and in 1928 he was elected president. During 1916–17 he was the editor of *Chemik Polski* and during 1935–39 he was the editor of *Roczniki Chemii* (*Annales Societatis Chimicae Polonorum*).

Prof. Miłobedzki and his pupils carried out important investigations on titration analysis. He also worked on phosphorus compounds, using not only the methods of classical inorganic chemistry but also those of physical chemistry, including the Raman spectra and absorption spectrometry. Prof. Miłobedzki also worked out a commonly applied new method for the detection of acid radicals. His books on analytical chemistry, "Szkoła analizy jakościowej" (School of Qualitative Analysis) and "Szkoła analizy ilościowej" (School of Quantitative Analysis), were much used.

Wiktor Wawrzyczek

NEWS and VIEWS

National Institute of Medical Research: Prof. P. B. Medawar, C.B.E., F.R.S.

Prof. P. B. Medawar, professor of zoology at University College, London, who is to succeed Sir Charles Harington in 1962 as director of the National Institute of Medical Research at Mill Hill, brings to the post an outstanding record in medical research and an exceptionally broad background of relevant biology. A product of the Oxford Department of Zoology and Comparative Anatomy, he began research in Sir Howard Florey's department with a study of growth and movement in cell populations. When the Second World War came, he turned to nerve regeneration with Prof. J. Z. Young's group, and the problems of nerve grafting soon led him to skin grafting. Ever since, though there have been many interesting by-products of his active mind concerning human growth, wound-healing, ageing and cell transformation, he has pursued the problems of the homograft reaction, tenaciously and resourcefully. He has immensely clarified this field, and has been the leading figure in an international movement which is contributing fundamentally to knowledge of immune mechanisms. His success in research has been due to an unusual range of gifts: skill and speed in the laboratory, a flair for the design of crucial experiments, and a powerfully analytical mind. He was elected to the Royal Society at an unusually early age in 1949, and received a Royal Medal in 1959. His work is communicated in an irresistibly brilliant style, and his powers of exposition have often been used effectively to a wider public, most recently in the Reith Lectures. Somehow he has combined his activity in creative science with a great amount of work in scientific policy-making, notably on the University Grants Committee (1955–60) and the Agricultural Research Council (since 1952). His ability to combine productive research with heavy administration assures the success of his new appointment.

The London Research Station of the Gas Council: Dr. R. H. Griffith

DR. R. H. GRIFFITH, director of research at the London Research Station of the Gas Council, has retired. Dr. Griffith went to Magdalen College, Oxford, and obtained a D.Phil. in 1925. In the same year he joined the research laboratory of the Gas Light and Coke Company. During the ensuing thirty-five years, Dr. Griffith has built up a world-wide reputation in the intricate field of catalysis, and has contributed a number of important papers on various aspects of this subject, notably in the *Proceedings* of the Royal Society. He is the author of a standard text-book on "Contact Catalysis" and also of "The Practice of Research", which describes in detail the functions, structure and organization of a chemical research department attached to industry. In 1945 he was appointed senior research chemist to the Gas Light and Coke Company, a position he continued to hold with the North Thames Gas Board after nationalization. On the retirement of Dr. Hollings in 1952, Dr. Griffith was appointed controller of research of the Board and director of the London Research Station of the Gas Council. Dr. Griffith has been awarded the H. E. Jones Medal of the Institution of Gas Engineers on two occasions. The Gas Council is now to review its research activities, and for the time being Mr. G. U. Hopton, senior research chemist, will be responsible for research at the Fulham Laboratories of the London Research Station.

Hector: a New Research Reactor

THE United Kingdom Atomic Energy Authority has now issued the contracts for the construction of a new zero-energy oscillator reactor which is to be built at the Atomic Energy Establishment, Winfrith. The reactor, which will be called *Hector* (heated experimental carbon (graphite) thermal oscillator reactor), has been designed expressly to facilitate the use of the pile oscillator technique for evaluating the nuclear behaviour of fuels, moderators, and structural materials in reactors. This technique, which utilizes small samples, has been devised by the Authority to further the reactor physics aspects of power reactor development. It is expected that *Hector* will go critical during 1962. The reactor possesses a unique feature, in that it is possible to reproduce closely the conditions appropriate to many different designs of power reactors. The reactor core is an annulus of graphite and highly enriched uranium/aluminium alloy within which various assemblies of fuel and moderator may be constructed around a central tube. The sample under investigation will be cycled through this tube, producing oscillations in reactor power-level from which the nuclear behaviour of the sample, under the conditions reproduced by the assembly, can be determined. Since the fuel material in the assembly may be natural or enriched uranium-235, plutonium, thorium, uranium-233 or irradiated elements from power stations, and since the assembly can be heated to 450° C., it is possible to investigate samples under the conditions to be found throughout the life of many different designs of power reactors. Successful measurements are possible only if the temperature of the heated assembly is extremely stable. It is desirable that the moderator temperature should not change by more than 3×10^{-3} degree C. per minute. The design of the reactor to achieve this has involved the use of novel techniques, specialized materials and the highest standard of control and instrumentation.

Special Assistance for Effluent Liaison

A THREE-YEAR project to assist tanners and dressers with effluent problems has just been started by the British Leather Manufacturers' Research Association. The project has been made possible by the agreement of the leather industry, through the United Tanners' Federation and the British Leather Federation, to contribute 'new' industrial income for 'effluent liaison'. To this the Department of Scientific and Industrial Research will add £2 for every £1 of 'new' income up to a maximum of two-thirds of the total cost (estimated to be about £20,000 for the three-year period). The terms on which the grant has been awarded are that the industrial income must be additional to any other income which the British Leather Manufacturers' Research Association receives, and that it must be used for liaison purposes only. It was decided that under this scheme, two new liaison officers, one a specialist in vegetable tanning, the other a specialist in chrome tanning, should be appointed to recommend and demonstrate to supporting firms modifications in leather-making processes designed to reduce effluent problems. A mobile laboratory will be equipped to undertake the analytical tests required in this work.

British National Lending Library for Science and Technology

CHANGES in the book-buying policy of the National Central Library recently adopted by the Trustees, partly in consequence of the creation of a new National Lending Library for Science and Technology, are described by Mr. S. P. L. Filon, librarian and secretary to the Trustees, in an article contributed to the *Library Association Record* for August. More attention will be devoted to earlier British books (before 1958), particularly those published since 1800, when they are actually required and not available. Many foreign books not available in Britain will in future be bought, rather than depend on foreign loans. Books in English, published in other countries and in the Commonwealth, will remain a substantial proportion of those purchased by the Library, and generally the same conditions as for British books will be applied. Consideration of the purchase of medical books has been deferred until the policy of the National Lending Library for Science and Technology in this respect is clarified, and acquisition of research material, both books and periodicals, in the field of science and technology has been mostly left to the future National Lending Library. The Library will acquire foreign university theses if these are not available in Britain. In future, the Library will acquire all current British Government publications as well as useful older publications and certain publications of international bodies obtainable through H.M. Stationery Office. In future, priority will be given to the acquisition of publications of learned societies, both British and foreign. As regards periodicals, it is expected that virtually every periodical in science and technology will be taken by the National Lending Library for Science and Technology, or by some library in association with it. The position in the humanities will be very different, and while the Trustees envisage that the National Committee on Library Co-operation may wish to organize a scheme for coverage of British periodicals, they have authorized the librarian to acquire foreign periodicals where these are not available and where they are not more suitably taken and made available by another library. The policy regarding acquisition of periodicals for loan will be closely related to that for the purchase of learned society publications. It is also intended to build up a collection of specimen copies of new periodicals. Mr. Filon stresses that these changes imply no changes in the rules for the inter-lending work of the Library or in its work for adult classes.

Index Chemicus

A NEW journal entitled *Index Chemicus* has been published by the Institute for Scientific Information, 1122 Spring Garden Street, Philadelphia (annual subscription rates: educational foundations, 250 dollars; industrial and Government agencies, etc., 500 dollars). The publication is a monthly index of new compounds reported in the literature and claims to give information within thirty days of its first appearance. The first number reports more than 3,700 newly synthesized organic compounds. The production is in the hands of a staff of experienced organic chemists, and the preparation uses both manual and machine methods for handling chemical information. A system of checking to ensure accuracy is in use. The text lists chemical names, structural diagrams and molecular formulæ, as well as complete bibliographical information including article title, authors' institutions, addresses, and original journal references for each compound. Indexes will be issued quarterly and annually. Each entry is numbered and there is an inserted author index referring to these numbers. It is noticed that Japanese and Russian literature is extensively covered.

There is no doubt that this new publication will greatly facilitate the work of research chemists in the field of organic chemistry. In other abstract journals there is a serious time lag between the publication of the material and the appearance of the abstract, and particularly in the publication of indexes. The amount of information which can be extracted from the *Index* is, however, very limited, but enough is probably given to enable a chemist to know if the publication listed is likely to be of interest to him. Particulars of prices, etc., also a booklet and specimen pages, can be obtained from the Institute.

Nuclear Engineering Abstracts

THE appearance of yet another abstracting journal is an event which it is natural to regard with some suspicion. However, the practice of nuclear engineering involves the drawing together of so many different sciences that there has been a growing need for a journal which attempts to cover the whole field. *Nuclear Engineering Abstracts* sets out to provide informative abstracts of all the important publications which are relevant to the theory or practice of nuclear engineering; the coverage is wider than that of many abstracting journals, since newspapers and house journals are included, when appropriate, in addition to the usual periodicals, patents and reports. The standard set by the first issue of the new journal is high; the layout is good, so also are the indexing and cross-referencing. If this standard can be maintained in succeeding issues, *Nuclear Engineering Abstracts* will be essential reading for anyone taking a real interest in the field (*Nuclear Engineering Abstracts*, 1, No. 1; July 1960. Pp. 100. London: Silver End Documentary Publications, Ltd., 1960. Annual subscription covering four issues, post paid, £6 6*s.*; 18.50 dollars. Single copies, if available, post paid, £1 12*s.* 6*d.*; 4.75 dollars).

Scientific Papers of the Meteorological Office

"Airborne Measurements of Latitudinal Variation of Frost-point Temperature and Wind" is the subject of the first number of a new series entitled "Scientific Papers" to be published by the Meteorological Office (Air Ministry: Meteorological Office. Scientific Paper No. 1. Pp. ii+30. (M.O. 664.) (London: H.M. Stationery Office, 1960.) 3*s.* 6*d.* net). This series replaces the former "Professional Notes" and "Meteorological Reports", and like them each number will contain one paper. It will give accounts of research work carried out in the Office. It is printed on paper more than an inch wider than its predecessors in order to allow more space for the diagrams which are an important feature of most meteorological papers. Accounts of the most important investigations will, however, continue to appear in the "Geophysical Memoirs" series. This first issue, by N. C. Helliwell, summarizes and discusses observations of the elements quoted made by the Meteorological Research Flight in the lower stratosphere on six days in the summer of 1956 and three in March 1957 between Minorca and the Norwegian Sea near the Arctic Circle. The frost-point, giving a measure of the humidity, showed little variation with latitude. Jet streams were traversed on some flights, and the horizontal wind-shear in them was measured. Clear-air turbulence was, as expected, encountered in association with some jet streams, but it was also encountered at places where no explanation for it could be found. The temperature observations on two flights were such as to suggest that tropospheric fronts were continued into the stratosphere.

Environment and Culture in Southern Rhodesia

ROGER SUMMERS, curator of the Museum at Bulawayo, Southern Rhodesia, has published an interesting paper on the relationships of environment to past cultures in that country (*Proc. Amer. Phil. Soc.*, 104, No. 3; June 15, 1960). In arguing from the present to the past, changes in climate naturally have to be remembered, but the physical map and the geology of the region have remained constant. No less than twenty-three distribution maps are given, showing such things as the modern vegetation pattern and what it would be with various percentages of the present rainfall. Other maps show the distribution of the prehistoric cultures, as well as of the rock-shelter art and the ancient mine workings. Why did some early cultures shun areas where Mopane forests would be growing? The answer is probably because the tsetse fly *Glossina morsitans* would have made cattle breeding impossible in those districts. The various possible invasion routes depend to a large extent on the 'lay-out' of the country, and peoples coming in from outside have, of course, greatly influenced past history. Actually, Southern Rhodesia can be shown to have been both a cradle and a corridor. Again and again not enough attention has been paid to the relationship of various culture groups to their environment, both climatic and geological, when the past history of a country is being studied. Roger Summers is to be congratulated in having so successfully followed in the footsteps of Sir Cyril Fox in producing for Southern Rhodesia what Sir Cyril did in his "Personality of Britain".

Strontium-90 and Natural Strontium in Human Bone

A RECENT report, "Radioactive and Natural Strontium in Human Bone", from the Chemistry Division of the Atomic Energy Research Establishment, Harwell, is the latest in the series in which results of the analyses of human bones in the United Kingdom for strontium-90 and natural strontium are listed (A.E.R.E. *R*23246. By J. W. Arden, F. J. Bryant, E. H. Henderson, G. D. Lloyd and A. G. Morton. Pp. 8. London: H.M. Stationery Office, 1960. 1*s*. 9*d*. net). The results given are for samples received during 1959 and analysed by the end of the year. Many of the samples were from subjects who died during 1957 and 1958. For the determination of strontium-90 the separation and counting of the yttrium-90 daughter is the preferred method, but when the activity is too low the determination has to depend on counting of the strontium source. Emission spectroscopy was used for the determination of the natural strontium sources. The results show that between the latter part of 1958 and the first half of 1959 there was a rise, compared with previous periods, in the number of strontium units absorbed for all the various age groups except the 'over 20 years' group. The contamination of diet in the United Kingdom is largely dependent on the rate of fall-out and the higher bone burdens thus reflect the increased rate of deposition which has occurred since early 1958.

Low-temperature Fuel Cell

THE successful development of a low-temperature fuel cell that can generate 3–5 times more power per unit volume than other similar cells has been announced by the Shell Research Centre at Thornton, Cheshire. The high output has been achieved as a result of fundamental studies on fuel cell electrodes. This work has led to the development of inexpensive, highly active electrodes. The cell can operate with either alkaline or acid electrolytes. When run on hydrogen and oxygen at a pressure of 3 lb. per sq. in., current densities of 70 amp. per sq. ft. can readily be obtained with both types of electrolyte at room temperature. If air is substituted for oxygen there is little loss in performance. As the cell warms up to 60° C., the output is doubled and a power output of 3–5 kW. per cu. ft. is achieved. Multiple fuel cells with up to six cells per inch have been constructed, and it is considered that units with a power-to-weight ratio of 50 W. per pound could be made. The work at Thornton is continuing and will include a study of fuels other than hydrogen. During the past decade, much of the effort on fuel cells has been devoted to the development of high-temperature cells since, in these cells, the electrode reactions are rapid and high efficiencies can be more easily achieved. Recently, however, more attention has been given to low-temperature cells and it would appear that this is a fruitful field for further research and development.

Travelling Fellowships in Medicine

APPLICATIONS are invited for Rockefeller travelling fellowships, Sir Henry Wellcome travelling fellowships, U.S. Public Health fellowships and the French exchange scholarships. These awards are open to graduates in science who are resident in the United Kingdom and have some training in research in medical science and who intend to return to Britain to resume or take up new appointments in university, hospital or academic research. Fellowships held in the United States provide annual maintenance allowance at rates varying from 3,000 dollars according to individual circumstances (500–700 new francs monthly with additional sterling marriage allowance in the case of French exchange scholarships) and travelling expenses are also provided. Further information and application forms may be obtained from the Secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1, and the closing date for applications is October 31.

Announcements

MR. A. R. O. WILLIAMS, a managing director of Consolidated Gold Fields, Ltd., and of New Consolidated Gold Fields, Ltd., has been elected president of the Institution of Mining and Metallurgy for 1961–62. He has served on the council of the Institute for fifteen years, and held the office of vice-president during the period 1951–54.

DR. W. J. KROLL, of Corvallis, Oregon, will deliver the sixth Castner Memorial Lecture, "The Fusion Electrolysis of Titanium", on October 7 at the Royal College of Science and Technology, Glasgow, C.1. Further information can be obtained from the Society of Chemical Industry, 14 Belgrave Square, London, S.W.1.

THE Research Laboratories of the Timber Development Association at St. John's Road, Tylers Green, Penn, Buckinghamshire, are holding two open days on October 12 and 13. Further information can be obtained from the Association's headquarters, 21 College Hill, London, E.C.4.

THERE will be open days at the National Chemical Laboratory, Teddington, Middlesex, on October 19 and 20. Applications for invitations should be sent to the Director not later than September 24. Those already on the mailing list for invitations need not re-apply.

THE next meeting of the Biochemical Society will be held in the Department of Biochemistry, the University of Glasgow, during September 29–30, and will include a colloquium entitled "The Biosynthesis of Nucleic Acids". Further information can be obtained from Dr. F. A. Robinson, c/o Allen and Hanburys Ltd., Bethnal Green, London, E.2.

JOINT Conferences are to be held on "Analytical Chemistry in Nuclear Reactor Technology" and "Nuclear Reactor Chemistry" at the Civic Auditorium, Gatlinburg, Tennessee, during October 12–14. The Conferences are sponsored by the Analytical and Reactor Chemistry Divisions of the Oak Ridge National Laboratory. Further information can be obtained from C. D. Susano, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tennessee.

THE Aero Space Medical Panel of the NATO Advisory Group for Aeronautical Research and Development (AGARD) will hold its sixteenth meeting in Istanbul, Turkey, during October 3–8. Technical papers on clinical aviation and space medicine will be presented. Further information can be obtained from the Advisory Group for Aeronautical Research and Development, Organisation du Traité de l'Atlantique Nord, 64 rue de Varenne, Paris 7ème.

ERRATUM. In the article entitled "Blue Hazes in the Atmosphere" by Dr. F. W. Went, in *Nature* of August 20, p. 641, the sizes of particles mentioned are incorrectly given in 'mμ'; they should be 'microns'.

WEATHER PROBLEMS IN AGRICULTURE

FOUR papers were presented during the second morning (July 1) of the summer meeting of the Royal Meteorological Society at Queen's College, Dundee.

Introducing the session before presenting the first paper, Dr. H. L. Penman, of Rothamsted Experimental Station, stated that two of the main objectives of crop-weather studies are, first, to achieve better growth of healthy plants, and secondly, to exercise control of pests and diseases the activity of which is dependent on weather. It is essential for the agricultural meteorologist to know something of the principles of plant-growth, though two of his problems can be derived from the simple equation for photosynthesis of carbohydrate. The need for short-wave radiation made a study of solar radiation income imperative, both as physics and as climatology. The latter topic was taken up later by Mr. G. J. Day. The supply of carbon dioxide to the crop can now be treated as a meteorological phenomenon similar to heat and vapour transfer (see second paper, by Dr. J. L. Monteith), and out of it there arises a third problem. The physiological state of the plant that permits easiest uptake of carbon dioxide also provides the most favourable conditions for transpiration, and this transfer of water from soil to atmosphere presents the meteorologist with another flux problem, and with a problem in energy balance. To the micro-meteorologist it brings problems concerned with the source of the water, and the effects that it has on the immediate environment of the plant, that is, on the 'weather' experienced by the plant, its pests and its pathogens.

In the hope that the information would some day be biologically useful, Dr. Penman and Mr. I. F. Long have been collecting detailed physical measurements in various farm crops. "Weather in Wheat"[1] is a condensation of the results for three summers of temperature, humidity and wind-speed, all continuously recorded over and within the crop on a site on which many other auxiliary measurements were made. Selecting a few topics, primarily of meteorological interest, a demonstration of variability across the site at constant height provides one of the reasons for using long-period averages in the analysis of profiles. Hot spots and damp spots can persist for several hours. By plotting wind-speed against temperature, and against vapour pressure, at the four observation heights above the crop, straight lines were obtained, from which it was inferred that the aerodynamic transport constants were effectively equal for transfer of momentum, sensible heat and latent heat. Computation of the transfer of latent heat for the forty-eight 4-hr. periods in eight days of fine weather gave very good agreement with the measured values from a large transpiration gauge, continuously weighed, in phase, amplitude and in mean daily total. Both estimated and measured values showed that transpiration is a daylight phenomenon. Calculations were presented for two periods to show how the transpiration stream was built up, layer by layer, between the soil surface and the top of the crop. It seemed that all layers contributed about equally (in this particular crop). Some time in the future it may be possible to tackle the carbon dioxide problem in the same way and find out the vertical distribution of efficiency of assimilation.

Dr. J. L. Monteith, also from Rothamsted, then summarized what he and Mr. G. Szeicz had done in measuring "The Carbon Dioxide Flux over a Field of Sugar Beet"[2], work first made possible by a grant from the Rockefeller Foundation and later by the skill of the Infra-Red Development Co. in building an instrument capable of measuring to 0·1 p.p.m. of carbon dioxide. From differences of concentration at two heights 25 cm. apart above the crop, and contemporary wind data, fluxes were computed. For a period of a few weeks from August onward the flux was always downward in daylight (assimilation > respiration), the main changes following very closely behind those of solar radiation intensity. The night flux was upward, at a fairly constant rate representing plant respiration and biological action in the soil. Net growth over the period calculated from these physical measurements agreed well with direct measures by crop sampling. Later, in October, biological activity in the soil appeared to provide more than enough carbon dioxide for plant growth—the day-time flux was upward except during short sunny intervals around noon, and the crop was still growing. Though this latter behaviour raised some important problems in soil microbiology, Dr. Monteith confined his discussion to the meteorological aspects of the earlier period, giving a hint that he had since made progress in the interpretation of the interactions of radiation intensity, mixing parameters and carbon dioxide uptake, and that there was a possibility of a link-up between the field-work he and Szeicz were doing, and laboratory work on single leaves being done elsewhere. As a purely meteorological point, he suggested that the uniform upward flux at night might be exploited in the study of transfer processes in very stable conditions. In discussion, the somewhat optimistic suggestion was made that this physical technique might replace periodic sampling, to give a non-destructive method of measuring the rate of plant growth.

Although there are many stations with long records of duration of bright sunshine (n), it is only within the last few years that there has been any attempt to measure incoming solar radiation (Q) at stations in Britain other than in south-east England. There has been much use of an empirical equation $Q/Q_A = a + bn/N$, in which Q_A is the radiation that would reach the site in the absence of an atmosphere, and N is the maximum possible duration of sunshine. Under the title "Radiation Climatology", Mr. G. J. Day (Meteorological Office, Eskdalemuir) first gave the values of a and b he has derived from monthly mean values of Q/day and n/day obtained at twelve stations having records of Q for at least three years. The geographical distribution of stations was very irregular, with large gaps in northern Scotland, eastern Scotland, eastern England, the Welsh border and along the south coast. Mr. Day made reservations about the accuracy of some of the radiation records, but by giving equal weight to all observations he found that a has a range from 0·08 to 0·19; and b varies from 0·63 to 0·95. Neither constant shows any systematic geographical variation. Having got local values of a and b from short-period records, he applied them to large neighbouring areas with long-term records of n, to derive expected mean monthly average values of Q. These were plotted together with the corresponding values given by Black[3] for twenty-eight stations in the area bounded by lat. 50–60° N., long. 5–30° E., and isopleths of mean monthly radiation drawn for north-west Europe using the two sets of estimates. The value of the twelve maps lies in their detail, and this may be modified after a re-check of some of the basic data. When published, they will be a very useful supplement to the corresponding maps of rainfall, temperature and sunshine.

During recent years there has grown a demand for more information about the effects of shelter on plants and on animals. Much of the resulting field work has the active co-operation of the Meteorological Office in Edinburgh, and in a paper entitled "Wind-breaks—Some Physical Effects", Dr. R. W. Gloyne of that Office considered some purely aerodynamic aspects of air flow over a barrier. Summarizing world experience, he listed the three distinct flow regions that arise: (1) the up-wind boundary layer; (2) the down-wind disturbed region; and (3), overlying these, the undisturbed flow. The disturbed region can be subdivided into: (2*a*) a space, immediately behind the obstacle where there may be strong eddies—it is here where it is most difficult to reconcile field and wind-tunnel studies; (2*b*) a region, farther down-wind, of turbulent motion, approximately conforming to a logarithmic profile, which, with distance, becomes in fact the logarithmic profile of the original undisturbed flow. The sizes of the regions (as multiples of the barrier height h) vary with the permeability (φ) of the barrier. In brief (with winds of normal incidence): for dense barriers ($\varphi < 40$ per cent) the original profile is re-established at about $30h$, though a logarithmic profile may re-appear at $20h$, and the original mean direction is re-established at about $15h$. For open barriers ($\varphi > 60$ per cent) the re-establishment of speed profiles is much as for dense barriers, but that of mean direction occurs much nearer the barrier, perhaps as close as $2\frac{1}{2}h$ behind a very open mesh. The width of the affected area depends on the length (L) of the barrier. When $L > 20h$, the system behaves almost as a portion of an infinite barrier; a shorter barrier has relatively larger edge effects so that the affected area varies roughly as L^2, approximating to a parabola with its vertex perhaps $1\frac{1}{4}L$ down-wind.

Dr. Gloyne concluded with a brief reminder that there is a pressure excess up-wind and a pressure deficiency down-wind of an obstacle placed in an air stream, and he suggested that pressure measurements, similar to those made in wind tunnels, might be useful in wind-break studies.

H. L. PENMAN

---

[1] Penman, H. L., and Long, I. F., *Quart. J. Roy. Met. Soc.*, 86, 16 (1960).

[2] Monteith, J. L., and Szeicz, G., *Quart. J. Roy. Met. Soc.*, 86, 205 (1960).

[3] Black, J. N., *Archiv. fur Met., Geophys. und Biokl.*, B10, 2 (1960).

TUBERCULOSIS IN ANIMALS

TUBERCULOSIS in animals was the subject of the fourth symposium of the Zoological Society of London, held on May 24. Mr. J. N. Ritchie, who organized the meeting, presided at the evening session. Dr. R. E. Glover was chairman at the morning session, and in the afternoon Dr. J. M. Ross filled this position.

Dr. Glover explained that the subject was appropriate for discussion at this particular time because of the progress that had been made in the eradication of tuberculosis from the cattle in Great Britain. With this advance, it was useful to review the position among other animals.

The first paper was by Dr. J. T. Stamp, who dealt with the comparative pathology. In calves, the incidence of tuberculosis is low, and infection enters mainly by inhalation or is congenital. Hæmatogenous dissemination is frequent. The fact that the incidence of tuberculosis increases considerably with age shows conclusively that tuberculosis of the adult is not merely a slow progression of lesions acquired in calfhood. In the older animals, the site of the primary complex is predominantly pulmonary and it is very obvious that advanced pulmonary tuberculosis develops as a result of bronchial dissemination following cavitation of the primary lung focus. The pathology of tuberculosis of the udder shows that there is always extensive involvement of the milk ducts.

In the pig, the chief route of infection is by the alimentary tract, and this gives rise to an incomplete primary complex in the regional lymph glands. In bovine-type infection in this species, hæmatogenous dissemination is common, but chronic pulmonary tuberculosis occurs only infrequently.

Horses have a high resistance to tuberculosis. Primary infection is almost entirely by ingestion. Hæmatogenous dissemination is frequent and gives rise either to miliary tuberculosis or to large tumour-like swellings, not unlike those of sarcoma.

The tuberculin test and the laboratory diagnosis of tuberculosis were discussed by I. W. Lesslie, who gave a brief history of the methods of preparation of tuberculin and the ways in which it had been used.

The general objective of research on tuberculin is to obtain a preparation which will give a maximum response in the infected animal at all stages of sensitization and a minimum response in the non-infected or non-specifically sensitized animal. He described the procedure necessary for the characterization of tuberculins.

The intradermal comparative tuberculin test has been developed for use in cattle. It consists in the injection of 0·1 ml. of avian and mammalian tuberculins in selected sites in the neck. The reaction at each site is measured, and the test is interpreted on each animal with reference to the results recorded in the whole herd and having regard to the herd history and clinical findings. *P.P.D.* tuberculin is used (mammalian 2·5 mgm./ml., avian 0·5 mgm./ml.). The relative strength of the *P.P.D.* tuberculins resulted from somewhat empirical decisions based on the strength of the tuberculins formerly used in this test.

A laboratory service is of great value in confirming field diagnosis and, particularly, for typing the organisms concerned. Frequently, when re-infection in a herd of cattle is being investigated, the knowledge of the type of organism involved is helpful in tracing the source of infection, both in animals and in man.

Mr. J. D. Blaxland, in describing tuberculosis in poultry, said that it is no longer of great importance as a cause of serious loss in our flocks. This relates generally to the lower age of birds being kept and the better conditions of husbandry. Nevertheless, tuberculosis still accounts for a fairly high proportion of condemnations of poultry carcasses. The disease affects domestic and wild birds. There is no good evidence that wild birds play any large part in infecting domestic species, but apparently wild birds do acquire infection from poultry. Wild birds may, however, be responsible for infecting farm animals.

Organisms of the avian type may cause progressive disease in pigs, and account for about one-third of the reports of tuberculosis in British pigs. Avian-type infection in cattle is important because it sensitizes the animal to tuberculin and, unless some form of comparative tuberculin test is used, may lead to errors in diagnosis.

Mr. I. M. Lauder, discussing tuberculosis in dogs and cats, mentioned that the incidence is much reduced. Bovine-type infection is now rare among cats, but a few cases of human-type infection occur. Tuberculosis was found in 1–2 per cent of autopsies of dogs in veterinary schools in Great Britain in the last five years. Infection in dogs is mainly of human-type and a source in man has been found in 77 per cent of cases, usually within the household. Symptoms in dogs are readily recognizable, and in these animals diagnosis may be made by X-ray examination. The tuberculin test is not reliable but a test using B.C.G. vaccine intradermally is of some value. Many of the comparatively few cases of tuberculosis found in dogs are 'open' and humans might therefore be infected from this source.

In a paper on the disease in zoo animals, Mr. Oliver Graham-Jones emphasized that the primates are very susceptible, and it is common in all vertebrate species. All three main types of the organism are involved. Many carnivores, which might be expected to acquire bovine tuberculosis from eating infected meat, instead are found to be infected with a human strain apparently from close contact with the general public.

Bovine infection has been recorded in monkeys, although one would expect the infection to be with the human strain entirely.

There is considerable difficulty in diagnosis because the usual signs of loss of condition leading to emaciation are not so apparent in animals in captivity. The use of laboratory techniques in diagnosis is becoming more important; but it is recognized that a suitable diagnostic test is needed. The only test available at present is the intradermal tuberculin test, as developed for cattle. There is some promise, however, from the use of B.C.G. vaccine which was developed by the author as a diagnostic aid in primates and has since been used in dogs.

Treatment is, of course, possible; but it was stressed that eradication of the disease by destruction of the affected animal, and prevention of recurrence by strict measures of disinfection was the best practical course. Precautions have, of course, to be taken by testing incoming animals with tuberculin. So far as possible, this should be done before the animals leave their country of origin; but this is sometimes quite impracticable. Whatever the practical difficulties of carrying out tuberculin tests and eradicating the disease from zoo animals, it was most important to appreciate that in the light of the current successful eradication programme for tuberculosis in cattle, it is most undesirable that zoological gardens should remain a reservoir of infection which might overspill into rural areas.

Mr. R. V. Blamire, dealing with tuberculosis and food inspection, pointed out that although tuberculosis has, in the past, been regarded by food inspectors as the most important animal disease, its significance has rapidly declined in recent years in Great Britain. More than 97 per cent of milk consumed is now either heat-treated or comes from attested herds.

The techniques of meat inspection are exacting, and the judgment of tuberculous carcases is often difficult.

In 1957, approximately 7·3 per cent cattle, 0·1 per cent calves, 3·6 per cent pigs, and 0·0006 per cent sheep were found to be affected with tuberculosis when inspected in abattoirs in England and Wales. In 1950, it is estimated that the value of meat rejected because of tuberculosis was about £1,000,000; in 1955, although the price of meat had doubled, £800,000, and in 1957 it was £500,000. Soon, the loss should be negligible.

The risk to public health from the consumption of under-cooked tuberculous meat has never been clearly established; but it should not be under-estimated. The detection of tuberculosis by meat inspectors will in future have more animal health than public health significance. Differential diagnosis will then become very important.

The disease in man was dealt with by Prof. J. W. Crofton.

With the greater control of malaria, tuberculosis has become the world's most important public health problem. The World Health Organization calculates that 0·5–1 per cent of the entire population of the world is coughing up tubercle bacilli at any one time. Since the introduction of modern chemotherapy in 1947, there has been a dramatic fall in mortality from tuberculosis, at least in the economically developed countries; but the fall in notifications has been very much slower. Human infection by bovine tubercle bacilli can be measured directly only by typing bacilli isolated from patients. Indirect estimates can be made by following trends of tuberculosis in young children, who are likely to be infected from milk, or of such forms as abdominal tuberculosis which are likely also to be associated with milk infection. Figures quoted demonstrated such falls, greater in urban areas, where milk infection was first well controlled, than in rural areas, and much greater than the falls in respiratory tuberculosis.

The control of infection with human bacilli depends on efficient case-finding, mainly by mass miniature radiography, on efficient treatment to render patients permanently non-infectious, on efficient prophylactic vaccination with B.C.G. and on the general improvement in environmental conditions. Figures for Edinburgh were quoted to show the dramatic effect relatively thorough re-organization and good teamwork can have not only on the mortality but also on the morbidity of tuberculosis. It is suggested that, with sufficient energy and enthusiasm, the elimination of tuberculosis could be proceeding much more rapidly than it is in most areas at the present time.

Mr. W. D. Macrae traced the story of the eradication of tuberculosis from cattle from its beginning with the introduction of the Tuberculosis Attested Herds Schemes in 1935. It proved relatively easy to reduce an incidence of 20 per cent to 0·3 per cent; but there is real difficulty in reducing this figure any further for various reasons, such as re-infection from other animal sources, including man; loss of tuberculin reactivity at certain stages of the disease; and residual infection on farms, particularly in old, dilapidated buildings.

The overall current incidence of infection is 0·16 per cent of the animals tested but in some areas it is now as low as 0·05 per cent. Whether it will ever be reduced beyond this figure is a matter for conjecture.

Among the reactors disclosed, some 70 per cent show evidence of disease at postmortem examination in abattoirs. This figure of confirmation was higher at one stage but has fallen somewhat as a result of difficulties in carrying out adequate postmortem examinations and the apparent increase in the number of reactors showing no visible lesions.

In the course of dealing with bovine tuberculosis, the incidence in pigs of the bovine type infection has been markedly reduced and may well disappear in this species.

A great deal of effort is still required to maintain the disease under strict control. There must be regular organized tuberculin testing at appropriate intervals and tracing of animals which have been in contact with infection, so that the herds to which they have moved may be tested. Every source of information of the presence of tuberculosis in cattle must be used, including abattoirs and knackeries.

Tuberculosis in cattle, although not eradicated in a literal sense, is at least under satisfactory control, and there is every promise that it will be maintained at an extremely low incidence in future. Coincidentally, the amount of infection among other animals has been reduced in parallel, but certain precautions are still necessary to prevent re-infection of herds of cattle. Man may remain a source of infection, and while bovine-type tuberculosis in man is probably not sufficiently common among people who are in close contact with animals to make this a serious hazard, it has to be appreciated that as the interval between tests of herds is extended any source of re-infection is very important.

THE BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

THE nineteenth meeting of the Research Panel of the British Gelatine and Glue Research Association was held on May 19, with the chairman of the Association, Mr. S. G. Hudson (Richard Hodgson and Sons, Ltd.), in the chair.

Dr. G. R. Tristram (Department of Physiology and Biochemistry, University of St. Andrews) presented "A Preliminary Study of the Thermal Conversion of Acid-soluble Calf-skin Collagen into Gelatin". The collagen was obtained by extraction of calf-skin with cold aqueous acetic acid. The release of end-groups on heating with water at *p*H 6 was investigated, using Sanger's method. Changes in optical rotation and viscosity caused by heating at *p*H 3·3 in 0·1 *M* aqueous acetic acid solution were recorded. At *p*H 6, most of the collagen dissolved after 1 hr. at 50° C. and all of it after 1 hr. at 60° C. Solubilization was accompanied by a large increase in ε-amino groups reactive towards Sanger's reagent and by the appearance of terminal amino-groups of a similar pattern to those found in eucollagen by Courts[1]. End-groups were also estimated after keeping the collagen in strong aqueous urea at 15° C. so as to obtain a comparison with the effect of heating in water. On heating at *p*H 3·3 the optical rotation and viscosity rose to a maximum at about 28° C. and then fell. Dr. Tristram drew some tentative conclusions about the unmasking of N-terminal residues during the treatments applied and discussed the question of there being one or more chains in the collagen structure.

The second paper, "The Swelling of Gelatine Films", by Miss E. M. Simms and Mr. J. N. Blake (Richard Hodgson and Sons, Ltd.), was presented by Mr. Blake. A variety of gelatine gels and sols were dried on a solid supporting base at various temperatures in the range 5–60° C. The resultant thin films were detached and allowed to swell freely in water at 10° C.; previous workers in this field have studied attached films. The weights and dimensions of the swollen films were measured. By far the most important factor controlling swelling was the temperature at which the films were dried; for example, a 210*g*. Bloom acid-process pigskin gelatine film, imbibed twenty-three times its weight of water if dried at 5–10° C. but only six times if dried at 30–35° C. The imbibition was largely evidenced by an increase in thickness rather than in linear dimensions, whereas films dried from the sol state exhibited the opposite behaviour. Swelling in water at 20° C. was considerably greater than at 10° C. and swelling was more pronounced in films dried from weak (5 per cent) solution than from strong (20 per cent) solution. Films dried unrestrained on liquid surfaces from both sols and gels exhibited subsequent swelling of the sol form type. The extensive results were discussed in terms of the molecular orientation of the systems during drying.

Mr. A. M. Kragh (British Gelatine and Glue Research Association) gave the final paper, entitled "The Flocculation of Suspensions with Gelatine". Gelatines and animal glues have a flocculating action on a wide variety of suspended solids of which quartz has been most studied, and this property has been evaluated in comparison with that of other flocculating agents both polyionic (for example, synthetic polyamides) and non-ionic (for example, dextran). Gelatine flocculates best where almost all of it is adsorbed on to the particle surfaces and where the amount so adsorbed is about one-third of the maximum adsorbable. It is exceptional among flocculating agents in its ability to be strongly adsorbed on a wide range of different surfaces and in that its flocculating action is strongly dependent on *p*H. The lively discussion centred around the mechanism by which flocculation is induced in these systems.

[1] Courts, A., *Biochem. J.*, 74, 238 (1960).

DOMESTIC HEATING AND THERMAL INSULATION

DIGEST 133 of the Building Research Station, entitled "Domestic Heating and Thermal Insulation" (Pp. 7. London: H.M. Stationery Office, 1960. 4*d*.), brings together the essentials needed to guide the choice of the standard and methods of heating from among the many systems that are available. In choosing a domestic heating system the decisive questions are: What standard of heating is required? How much will it cost to run? Convenience in operation and the form of heat distribution preferred are also important.

Broadly, the systems of domestic heating can be divided into three main categories: (1) Full house warming. (2) Partial heating, that is, the full heating of two or three rooms from a central heat-source, with the remainder of the house heated as required by gas or electric fires: or the background warming of the whole house to a uniform temperature lower than that obtained by category (1) together with 'topping up' in individual rooms as required. (3) Heating limited to individual appliances in one or two of the main living rooms.

The main differences in the three standards of heating are in the scope of the heating service. In the full house-warming systems and background heating systems, for example, comfort is enhanced by the fact that the house is uniformly warm; such systems are essential for the open-house plan. By contrast, systems using separate appliances, for example, open fires, in a limited number of rooms give a less-uniform standard of comfort.

The standards covered by these three categories can be characterized broadly in terms of difference between the average outdoor temperature over the whole heating season and the average indoor temperatures they provide.

Assuming an average seasonal outdoor temperature of 43° F., a temperature difference of 18° F., averaged over 24 hr., can be taken as representative of full house warming, 13° F. for partial central heating systems and 11° F. or less for the third category. The smaller temperature difference between the medium and low standards of heating may be explained by the fact that even in dwellings where the bedrooms are unheated some stray heat is received from the heated part of the house. These average temperature differences can help in estimating seasonal fuel requirements and, therefore, running costs. They are not, however, appropriate for estimating maximum heat demands and hence the size of the heating plant; these have to be calculated from a maximum temperature difference between indoors and outdoors.

For a fair comparison of capital costs of various domestic heating systems, account should be taken of any building costs incidental to the heating installation, such as those of brick flues and fuel stores, or, conversely, the saving effected if these items are not required. For example, in a system comprising one open fire with back boiler, electric immersion heater for summer use and two electric fires, the cost of a chimney breast and flue and a fuel store for the open fire is about 25 per cent of the total cost of the installations. Broadly, the capital costs of the three categories of heating are in the same order as the standard of heating attained, but there may be some overlapping.

The seasonal heat loss for a particular dwelling will depend to some extent on the overall floor area, on the grade of insulation, the standard of heating, the ventilation-rate and the length of the heating season.

To estimate the seasonal fuel requirements the seasonal loss of heat should be divided by the calorific value of the fuel multiplied by the 'house efficiency' of the heating system.

Other points affecting the choice of a heating system are convenience in operation and the form of heat distribution. The size and number of heating appliances required for a particular heat service depend mainly on the maximum heat demand during a cold spell.

POPULATION TRENDS AMONG HAWKS AND OWLS IN ILLINOIS

DATA on hawks and owls in Illinois, as reported in the Christmas counts sponsored by the National Audubon Society and its parent organizations, have been analysed by Richard R. Graber and Jack S. Golden to determine population trends for the years 1903–55 (Biological Notes, No. 41. Dept. Registration and Education, State of Illinois).

Even though most of northern and central Illinois offered a fairly uniform habitat of cultivated farm land with relatively little forest, the distribution of raptors was not uniform, and raptor populations varied considerably even within relatively small areas. Highest concentration of raptors was in the southern part of the State. Through the years a given locality, in relation to other localities, has tended to show a consistent rank with regard to the density of its raptor populations.

Analysis of frequency of occurrence for all species of raptors in the period 1903–55 was based on 527 censuses—103 in southern, 123 in central, and 301 in northern Illinois. This analysis shows the expected higher frequency of prairie-inhabiting species of raptors in central and northern Illinois and of woodland species in southern Illinois. Regardless of habitat, certain species, such as the sparrow hawk and the marsh hawk, were seen with increasing frequency from north to south, as though responsive to a temperature cline.

The combined data for all raptor species show that there has been a marked and consistent decline in winter raptor populations during the period 1903–55. Peaks representing years of high populations are lower in later years. Trends in raptor populations were deduced from birds per observer-hour, birds per party-hour, and birds per mile.

The records of individual species show that the rough-legged hawk has suffered the severest decline in numbers; the red-tailed hawk, the sparrow hawk and the barred owl also decreased. Marsh hawk and the red-shouldered hawk populations have not changed appreciably. The bald eagle has been increasing in numbers since the early 1940's; but this is the only species for which a notable increase was shown. The records for many species are too incomplete to evaluate.

Because the decline in raptor populations is shown particularly among the less-wary species and those species that are most likely to be encountered by man, it is suggested that man may be directly responsible for the decline. This view is corroborated by the fact that many raptor band returns are from birds that were trapped or shot and also by the indication that a notably lethargic species, the rough-legged hawk, has suffered the severest decline.

The species of raptors, namely, *Buteo* spp., *Circus* spp. and *Falco sparverius*, which have been protected by law since 1919, were seen at least seven times as frequently as the previously unprotected accipiters and the great horned owl.

SINGAPORE BOTANIC GARDENS

A SPECIAL issue of the *Gardens' Bulletin* (17, Pt. 2; 1959. 12.50 dollars. Obtainable from the Botanic Gardens, Singapore) has been issued to commemorate the hundredth anniversary of the founding of these well-known gardens. In fact, a botanic garden was established in Singapore soon after its founding in 1819 by Sir Stamford Raffles, nutmegs, cloves and cocoa being among the early introductions. This garden was closed after some years in a retrenchment of expenditure, but new gardens, the present ones, were established on a new 60-acre site towards the end of 1859 (see also *Nature*, 184, 1602; 1959).

Since then the gardens have been extended and amplified and for many years have been recognized as being among the most important tropical institutions of this kind, the more so as they are set in a region of very considerable agricultural importance and quite exceptional floristic interest. Virtually from the outset, the staff have paid attention to the needs of practical agriculture and horticulture as well as to systematic and other aspects of scientific botany usually associated with botanic gardens. This was exemplified in a remarkable degree by the work of Dr. H. N. Ridley, director of the Gardens during 1888–1912, who has not only been rightly named "the father of Malaya's rubber industry" but was also responsible, as an indefatigable field botanist, for vast accessions of new plants to the gardens and its herbarium. After his retirement, he produced his five-volume work on the "Flora of the Malay Peninsula" (1922–25).

As several distinguished botanists have worked on the staff of the Singapore Botanic Gardens over the years, the output of work, often on plants of unusual scientific interest, has been both extensive and impressive. In the present commemorative volume (pp. 125–340) the reader will find much that is pertinent, informative and interesting. J. W. Purseglove has contributed a paper on the history, functions and contemporary work of the gardens; T. A. Russell has described the relationships between them and the Royal Botanic Gardens, Kew; while H. J. Lam has written of Singapore and Leyden. Other authors deal with the contribution which work in the gardens has made to agriculture in the Malaysian region, and there are several papers of both general and special interest by well-known botanists; for example, R. E. Holttum has written on his work on orchids, gingers and bamboos carried out in the gardens, and E. J. H. Corner has discussed the importance of the taxonomy of tropical plants in contemporary botany; and so on.

Perhaps the best way of indicating briefly the value of the present volume is simply to say that, for the general botanical reader, it affords an unusually interesting introduction to the many facets and fascinations of tropical botany.

ROAD ACCIDENTS DURING CHRISTMAS 1959

TWO factors stand out in the Road Research Laboratory report of the investigation of the 150 fatal road accidents in England and Wales during the Christmas period (December 24–27, 1959)—the bad weather conditions and the unusually high proportion of people involved in the accidents who had taken alcohol (Road Research Technical Paper. No. 49. Pp. iv + 20. Published for the Department of Scientific and Industrial Research by H.M. Stationery Office, 1960. 1*s*. 9*d*. net).

The investigation was carried out at the request of the Minister of Transport and shows that the number of fatalities per mile travelled by motor-vehicles was high on each of the four days of the Christmas period when compared with the other days in December or with the year as a whole.

The factors usually associated with road accidents (such as vehicle defects, cross-roads, and skidding on wet roads) were present in the normal proportion.

The weather conditions were bad. Roads were dry for only 10 per cent of the accidents; in 73 per cent it was dark and wet; in 12 per cent it was daylight and wet; and in 5 per cent it was icy. The report states: "this weather would be expected to result in increased accident frequency but not to the extent that occurred".

In at least 56 per cent of the accidents one or more of the people involved had taken alcohol not long before the accident. The corresponding figure in a normal period is 18 per cent. The report concludes: "the bad weather of the Christmas period made travelling conditions difficult. The fact that many of the people involved in the accidents had been drinking beverages containing alcohol would be expected—in the light of previous research—to have made many of them less able than usual to deal adequately with the difficult conditions. Although other factors may have been involved, the combination of these two alone might account for the high accident-rate over the period".

UPPER-ATMOSPHERE WIND STUDIES BY *SKYLARK* ROCKET SODIUM EXPERIMENT

By Dr. G. V. GROVES

Physics Department, University College, London

IN the sodium experiment, sodium vapour is ejected from a high-altitude rocket along its flight path. If the experiment is performed at twilight, when the sky has darkened yet the trail itself is still in sunlight, the trail glows conspicuously yellow by re-radiating the *D*-line emission from the Sun. This experiment, originally proposed by Prof. D. R. Bates, was first performed in 1955 at White Sands, and is now being carried out with the *Skylark* rocket at the Woomera Rocket Range.

The first *Skylark* experiment was carried out on December 3, 1958, the rocket being fired within 2 min. of a specified time, when the Sun was at a depression of 6° below the horizon. The sodium trail was laid continuously from 67 km. altitude over the trajectory vertex at 126 km., and down to a height of 93 km. Photocells on the rocket recorded sunlight from 60 km. altitude on the upward path to 69 km. on the downward path.

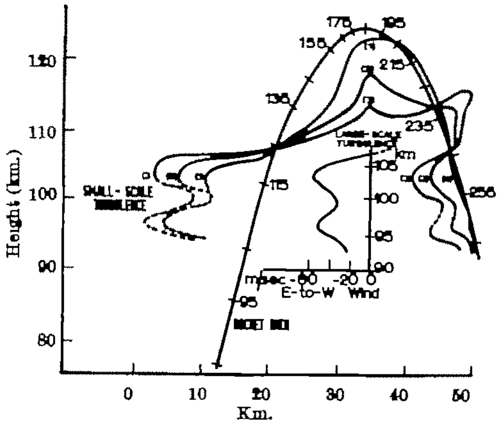


Fig. 1. East-to-west displacement of sodium trail. *Skylark* 11. Woomera, South Australia, December 3, 1958, 19.43 hr. Numbers on rocket path give time in sec. after launching. Sodium trail at (1) + 270 sec., (2) + 330 sec., (3) + 390 sec.

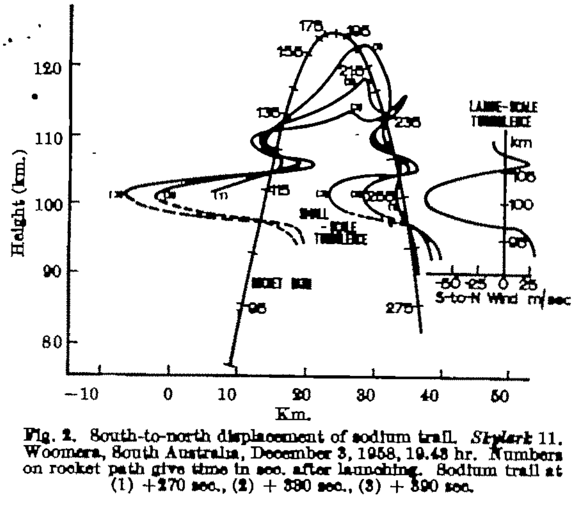


Fig. 2. South-to-north displacement of sodium trail. *Skylark* 11. Woomera, South Australia, December 3, 1958, 19.43 hr. Numbers on rocket path give time in sec. after launching. Sodium trail at (1) +270 sec., (2) + 330 sec., (3) + 390 sec.

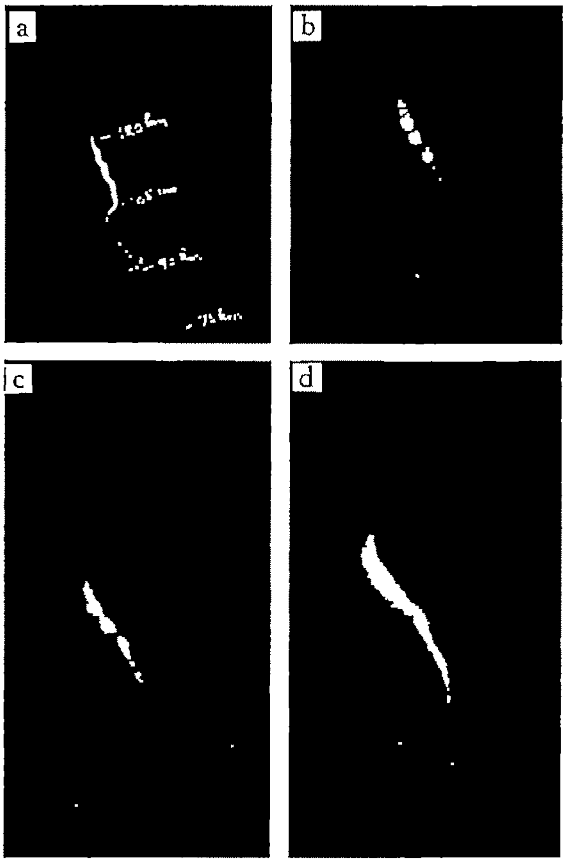


Fig. 3. *a*–*d*, Exposures of sodium trail made at 2½, 3½, 4½ and 5½ min. after launching

Photography of the trail was undertaken by twelve cameras of either moving-film or fixed-plate design, distributed between three roughly symmetrically placed observation posts. All cameras carried orange filters and were orientated in slightly different directions to increase sky coverage. Exposures were of 5-sec. duration, synchronized to within ¼ sec., and were made at intervals of either 1 or 5 min. The trail was bright enough to be recorded photographically for about 10 min., and persisted visually for about 20 min.

The series of photographs reproduced here were taken at 1-min. intervals from + 2½ to + 5½ min. from the time of launch, and the rocket is still in the field of view of the first three. The width of the sodium trail reaches a maximum near the vertex of the trajectory on account of the slower speed of the rocket and the lower ambient air density into which the vapour expands. The short waviness of the trail near the vertex is thought to arise from the rotation of the rocket as the wave-length corresponds closely to the measured spin. The main distortions of the trail arise from the wind structure, as the sodium atoms very quickly pick up the mean motion of the atmosphere at these heights.

The method of triangulating the trail depends on identifying corresponding features on various photographs taken from different camera posts. The identified points are then measured up in a plate-measuring machine, together with a number of star images as reference points. The processing of the data was carried out at the Admiralty Research Laboratory, Teddington, using the *Pegasus* computer. The accuracy of the triangulation depended on the width of the trail and on the presence of readily identifiable features. The width of the trail increased from about 1 km. at the lower heights to 3 km. at the vertex, and the standard deviation in the triangulation was usually less than half the width of the trail.

Fig. 1 shows the rocket trajectory and the sodium trail projected on the east–west vertical plane. The complete trail is plotted at + 4¼, + 5¼ and + 6¼ min. Fig. 2 shows the corresponding results for the south–north direction. The rocket trajectory was obtained optically using contraves, the data being supplied by W.R.E., Salisbury.

Figs. 1 and 2 show several interesting features. Small-scale turbulence appears to be present to a height of 102 km., while above this level, the trail remained unbroken. At the lower heights the trail broke up increasingly rapidly, and at 94 km. had disappeared within 2 min. Fig. 3*a* shows this part of the trail at about 1 min. after formation. From 94 to 102 km. the trail took some 8 min. to break up.

Below 107 km., the air motion is horizontal, and portions of the trail on both the upward and downward legs of the flight path are correspondingly displaced. The variation of wind speed with height is shown in Figs. 1 and 2 from 93 to 107 km. Above 107 km., the air appears to be moving in large cells with vertical motions of 50 and more m./sec. The cell size is difficult to estimate on the evidence of a single firing, as the trajectory intersects only a small part of the wind structure. The horizontal extent appears from Figs. 1 and 2 to amount to several tens of kilometres.

Acknowledgments are gratefully made to the Royal Aircraft Establishment for provision of the rocket and arranging its firing (particularly Dr. E. B. Dorling); to the Weapons Research Establishment, Australia, which carried out the firing and operated the cameras (particularly Mr. P. Moran and Mr. J. S. Colville); to Dr. E. B. Armstrong and Dr. J. Mazur, The Queen's University, Belfast, who prepared the first trial burners and carried out tests on them; and to the Mathematics Department, Admiralty Research Laboratory, Teddington (Miss M. Thorpe, Mrs. L. Blake) for triangulation computations on the sodium trail.

This work formed part of the programme of the British National Committee for the International Geophysical Year.

FATE OF TRANSFORMING DEOXYRIBONUCLEATE FOLLOWING FIXATION BY TRANSFORMABLE BACTERIA

I

By DR. MAURICE S. FOX and DR. ROLLIN D. HOTCHKISS

The Rockefeller Institute, New York

An analysis of the kinetics of the reaction between transforming deoxyribonucleate and transformable pneumococci has shown first a reversible adsorption of the deoxyribonucleate by the bacteria, followed by an irreversible fixation of the deoxyribonucleate[1]. Fixed deoxyribonucleate is defined as that which cannot be removed either by exhaustive washing or treatment with deoxyribonuclease. The quantity of such deoxyribonucleate fixed by the transformed population of bacteria is proportional to the number of bacteria transformed; and the efficiency with which such fixed deoxyribonucleate may yield a transformed bacterium is very high[2-4]. For preparations of the most active deoxyribonucleates less than two and perhaps one bacterial equivalent of donor deoxyribonucleate fixed by the recipient population yields a bacterium transformed with respect to a particular genetic property observed.

The experiments to be described represent an attempt to examine the growth of the transforming deoxyribonucleate following its fixation by transformable bacteria. Transforming deoxyribonucleate carrying both a biological label and a phosphorus-32 label has been introduced into transformable bacteria. After various times of incubation following the fixation of the labelled deoxyribonucleate, the total bacterial deoxyribonucleate from aliquots of the transformed population is isolated. This newly isolated deoxyribonucleate is used to transform a second bacterial population and the ratio of its biological activity to the amount of phosphorus-32 fixed by this new population is determined. An increase in the absolute quantity of the deoxyribonucleate capable of conferring the chosen property, as a consequence of synthesis of new deoxyribonucleate by the original transformed bacteria, results in a dilution of the phosphorus-32 label and therefore an increase in this ratio.

Transformable bacteria sensitive to streptomycin are incubated for 15–40 min. at 30° with the deoxyribonucleate labelled with phosphorus-32 isolated from bacteria resistant to streptomycin. Pancreatic deoxyribonuclease (20 μgm./ml.) is added and the mixture transferred to 37° C. The first sample is removed after 5 min., placed in an ice-bath, and further samples are removed at various times as the culture grows. An aliquot is removed to measure the quantity of phosphorus-32 incorporated and the culture is assayed after 2-hr. incubation for the total number of cells transformed, in this case from streptomycin-sensitivity to streptomycin-resistance.

After sampling for a bacterial count (viable and Petroff–Hausser), the iced aliquots are filtered, thoroughly washed and re-suspended in 0·15 *M* sodium chloride, containing 0·05 *M* sodium citrate and 4 mgm./ml. bovine serum albumin fraction V.

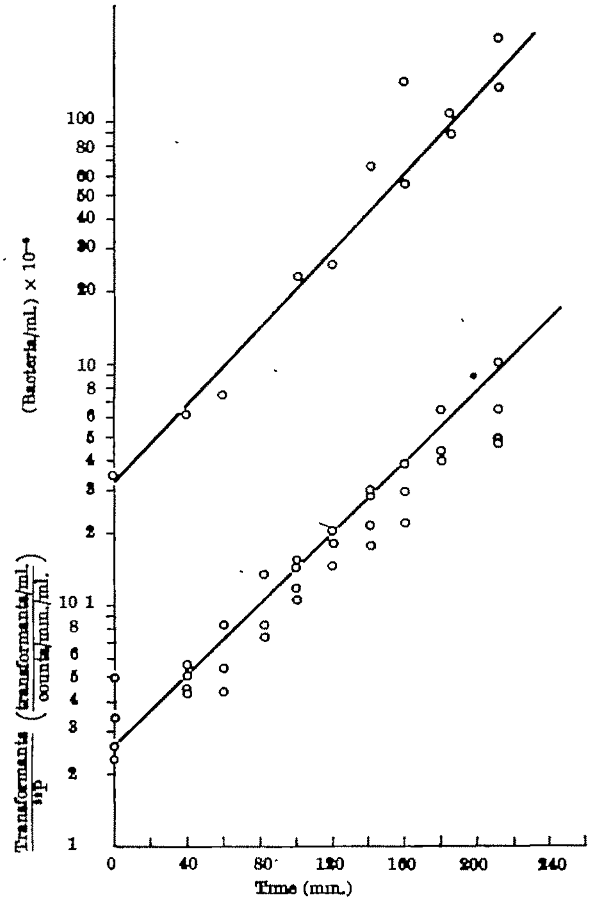


Fig. 1. Growth of bacteria, and dilution of phosphorus-32 of transforming deoxyribonucleate. Transformable bacteria were allowed 25 min. exposure to deoxyribonucleate at 30°. Deoxyribonuclease was added and bacteria were incubated at 37° C. for 5 min. prior to time zero

The re-suspended cells are lysed with sodium deoxycholate at 37° C. (5 min.), precipitated with 1·3 vol. of alcohol, centrifuged, and the crude deoxyribonucleate pellet dissolved in saline buffered with 0·01 *M* phosphate *p*H 7·8. Such solutions are used for transformation of a new culture of streptomycin-sensitive bacteria, measuring number of cells transformed and quantity of phosphorus-32 fixed.

The activity of this re-isolated deoxyribonucleate, when measured in terms of the yield of transformants per unit of phosphorus-32 fixed, is not changed significantly by passage through the bacteria if the deoxyribonucleate is re-isolated 5 min. after fixation (Table 1). In Table 1 are indicated the values of these activities before and after passage through transformable bacteria for a number of deoxyribonucleate preparations labelled with phosphorus-32 of various specific radioactivities. For deoxyribonucleate re-isolated after longer incubation and growth of the transformed bacteria, this activity increases as a function of time (Fig. 1). Also shown in Fig. 1 are the counts made in a Petroff–Hausser chamber of the number of bacteria per ml. The similarity of these two curves suggests that the transforming deoxyribonucleate, or material resembling the transforming deoxyribonucleate, increases at the same rate as do the bacteria in the total culture.

Table 1. RECOVERY OF PHOSPHORUS-32 LABELLED DEOXYRIBONUCLEATE (DNA) ACTIVITY FOLLOWING PASSAGE THROUGH TRANSFORMABLE BACTERIA

Duration of exposure to ^{32}P-labelled DNA	Transformants per unit of ^{32}P fixed for original DNA	Transformants per unit of ^{32}P fixed for DNA re-isolated after 5 min. incubation at 37° with DNase
36 min.	8	15
40 min.	6	5 4
25 min.	2·8	3 4
15 min.	100	104
15 min.	28	30

These data are insufficient to indicate whether or not it is possible to superimpose these two curves. In order to determine more precisely the relationship between these two growth-curves, the biological activity of the newly fixed deoxyribonucleate was directly compared with the biological activity of deoxyribonucleate resident in the recipient bacteria.

In a manner similar to that described above, transformable bacteria sensitive to streptomycin and resistant to *p*-nitrobenzoic acid (that is, 'wild type', see ref. 5) were exposed to deoxyribonucleate isolated from bacteria resistant to streptomycin and sensitive to *p*-nitrobenzoic acid. Thus, the deoxyribonucleate responsible for streptomycin-resistance was introduced into bacteria carrying resident deoxyribonucleate responsible for resistance to *p*-nitrobenzoic acid. The process of deoxyribonucleate fixation was terminated after 15 min. at 30° C. by the addition of deoxyribonuclease. The transformed population was transferred to 37° C., 5 min. allowed for action of deoxyribonuclease, and samples, were removed at various times thereafter. Deoxyribonucleate was isolated from the bacteria in these samples and the relative biological activities of the incoming versus the resident deoxyribonucleate were measured. This ratio shown in Table 2 is established at the earliest time of observation, 5 min. after the termination of exposure to deoxyribonucleate, and does not change with the growth of the transformed culture. In addition, the ratio assumes a value approximately equal to the absolute frequency of transformants observed in the first transformation.

Table 2. RELATIVE BIOLOGICAL ACTIVITY OF NEWLY INTRODUCED PROPERTY TO THAT OF A RESIDENT PROPERTY FOLLOWING GROWTH OF THE TRANSFORMED CULTURE

Ratio of number of cells transformed to total number of cells in transformed culture	Relative increase in turbidity of transformed culture at time of DNA re-isolation	Ratio of biological activities of newly introduced DNA to resident DNA
$6 \cdot 7 \times 10^{-3}$	(1·0)	$5 \cdot 2 \times 10^{-3}$
	1·5	$6 \cdot 7 \times 10^{-3}$
	2·2	$5 \cdot 4 \times 10^{-3}$
	3·1	$6 \cdot 1 \times 10^{-3}$
	3·5	$5 \cdot 4 \times 10^{-3}$
	4·5	$6 \cdot 0 \times 10^{-3}$
	6·1	$5 \cdot 5 \times 10^{-3}$
	25 0	$5 \cdot 5 \times 10^{-3}$

These observations give further evidence of the high efficiency with which fixed transforming deoxyribonucleate may give rise to transformed bacteria. It would appear that transforming deoxyribonucleate re-isolated a short time after fixation has suffered neither physical nor biological dilution, though it is admixed with deoxyribonucleate of the transformable host bacteria. Furthermore, it has been shown that during the growth which follows the fixation of the transforming deoxyribonucleate, this deoxyribonucleate increases at precisely the same rate as does the resident deoxyribonucleate of the transformed bacteria. This synchronization is already established at the earliest times that have been examined in these experiments.

II

By DR. MAURICE S. FOX

AN examination of re-isolated deoxyribonucleate from transformed populations of pneumococci, following moderately long exposures to transforming deoxyribonucleate, has indicated that the new deoxyribonucleate is fully synchronized with the resident deoxyribonucleate of the transformed bacteria from the earliest times that had been observed. In addition, it has been shown that passage of transforming deoxyribonucleate through transformable bacteria does not appreciably alter its biological activity (previous communication).

Further investigation of such re-isolated deoxyribonucleate immediately following short exposures to the transforming deoxyribonucleate has demontrated an intermediate state of the transforming deoxyribonucleate between its fixation by the bacteria and that state in which the production of transforming deoxyribonucleate is fully synchronized with that of the resident deoxyribonucleate of the transformed population. The deoxyribonucleate in this intermediate state is biologically inactive in transferring in a second transformation the property which it carries. In addition, in line with the segregation investigation being carried out in this laboratory by Hotchkiss, it has been possible to examine the appearance of genetic linkage occurring as the result of an interaction between entities present in the donor deoxyribonucleate and those present in the recipient bacteria, following fixation of such deoxyribonucleate.

The genetic properties that were studied are streptomycin resistance *S*, two readily distinguishable levels of sulphonamide resistance, *a* (fully resistant to 10 μgm. sulphonamide/ml.), and *d* (resistant to 40 μgm. sulphonamide/ml.), and the combined property, *ad* (resistant to 200 μgm. sulphonamide/ml.). Conditions for selection and quantitative measurement of transformed bacteria carrying these properties have been described[8]. The properties *a* and *d* have been shown to be closely linked[8]. Deoxyribonucleate isolated from bacteria carrying both properties yields on transformation, under the conditions used, about as many transformed cells with only the properties *a* or *d* as those carrying the combined property *ad*.

The general procedure followed is similar to that described in the previous communication. After a high-density suspension of transformable bacteria is exposed to deoxyribonucleate for a given time at 30° C., a high concentration of deoxyribonuclease (20 μgm./ml. Worthington, pancreatic) is added to stop any further fixation, and samples are chilled at 0° C. after various incubation times.

After thorough washing, deoxyribonucleate is re-isolated from the bacteria. More than 50 per cent of the newly introduced deoxyribonucleate phosphorus-32 is recovered. Its biological activity is determined by using this deoxyribonucleate to transform a new strain of pneumococcus with respect to one of the properties carried by the original donor deoxyribonucleate and one or more of the properties resident in the recipient bacteria used in the first transformation.

It has been shown in the previous communication that after moderately long exposure to deoxyribonucleate, the ratio of these two activities (newly introduced deoxyribonucleate)/(resident deoxyribonucleate), assumes a value equal to the frequency of transformants in the first transformation, and that this ratio remains constant during the further growth of the transformed population.

It is now found that after very short exposure times to deoxyribonucleate and immediate re-isolation, this ratio is only a very small fraction of the ultimate ratio observed after longer incubation. This ratio rises and becomes a larger and larger fraction of the ultimate ratio with increasing exposure times to deoxyribonucleate (Table 3). Thus, the fractional recovery of the newly introduced deoxyribonucleate increases with increasing exposure times in the first transformation.

Table 3. RECOVERY OF NEWLY INTRODUCED DNA AFTER VARIOUS EXPOSURE TIMES TO DEOXYRIBONUCLEATE (DNA) AT 30°

Time of exposure to DNA (min.)	Frequency of transformants	Ratio of input activity to resident activity for DNA isolated after 1 min. incubation at 37° C. with DNase	Fraction of input activity recovered	Ratio of input activity to resident activity after 2 hr. growth at 37° C.
3	2×10^{-4}	7×10^{-6}	5 per cent	$1 \cdot 5 \times 10^{-4}$
7	5×10^{-4}	10^{-4}	20 per cent	5×10^{-4}
15	$1 \cdot 2 \times 10^{-3}$	$3 \cdot 4 \times 10^{-4}$	31 per cent	$1 \cdot 1 \times 10^{-3}$

The time course of the recovery of the biological activity of the newly fixed deoxyribonucleate has been examined. After very short exposure (5 min.) to the transforming deoxyribonucleate, and re-isolation of deoxyribonucleate from samples of the transformed population that have been allowed increasing incubation times, measurement of the biological activity of such preparations of deoxyribonucleate shows increasing fractional recoveries of the newly introduced deoxyribonucleate. The ratio of the biological activity of the newly introduced deoxyribonucleate to that of the resident material rises to a constant value determined by the frequency of transformants obtained as a consequence of the original 5-min. exposure to the deoxyribonucleate (Fig. 2). This level is identical with that observed after long exposures to deoxyribonucleate (previous communication).

The rates of recovery of the lost biological activity are the same when the newly introduced deoxyribonucleate comes from an organism carrying the properties *S*, *d* or *ad*. In addition, the rates show a dependence on temperature such that at 30° the half-time for recovery is about twice as long as at 37°.

Making use of the possibility of building up the linkage group *ad*[8] from its component parts, a transformable strain of pneumococcus carrying the properties *S* and *a* has been transformed with deoxyribonucleate isolated from a strain carrying the property *d*. The biological activity of the re-isolated deoxyribonucleate is then tested on bacteria carrying none of these properties. The recovery of deoxyribonucleate carrying the newly introduced *d* property follows the time course already described. It is also possible to observe the appearance of a new biological entity that is capable of introducing simultaneously both properties *a* and *d*. The appearance of this new entity, a product of the interaction between the newly introduced and the resident deoxyribonucleates, follows a time course roughly similar, with a half-time about twice as long as that observed for the recovery

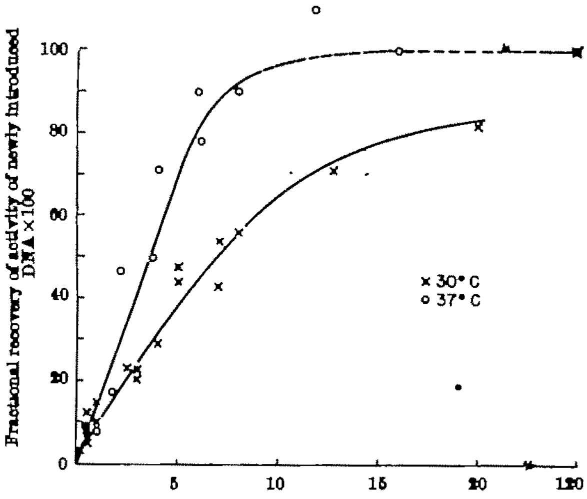


Fig. 2. Fractional recovery in re-isolated deoxyribonucleate of biological activity of newly introduced deoxyribonucleate as a function of time following termination of a 5-min. exposure to transforming deoxyribonucleate with deoxyribonuclease

of the *d* marker that has been introduced (Fig. 3). Thus, the biological activity of the newly introduced deoxyribonucleate recovers with a half-time of about 3–4 min. and the linking of this new deoxyribonucleate with that present in the genome of the recipient cell occurs with a half-time of about 6 min. at 37° C.

The fractional recoveries shown in Figs. 2 and 3 are measured as the ratio of the biological activity of the newly introduced deoxyribonucleate to that of the resident deoxyribonucleate. They are expressed relative to the ultimate ratio observed for deoxyribonucleate isolated after 2-hr. incubation at 37° C. of a dilution of the transformed culture. This incubation is sufficient to allow about a ten-fold increase in the number of bacteria. The ultimate ratio agrees within experimental error with the absolute frequency of bacteria transformed for a single property. For the cases in which the linkage group *ad* is observed, the ultimate ratio assumes a value equal to one-half the frequency of *ad* transformants in the first transformation. This factor of two difference between the frequency of transformants and the recoverability of the linkage group is to be expected since deoxyribonucleate carrying the *ad* property regularly gives equal numbers of *d* and *ad* transformants.

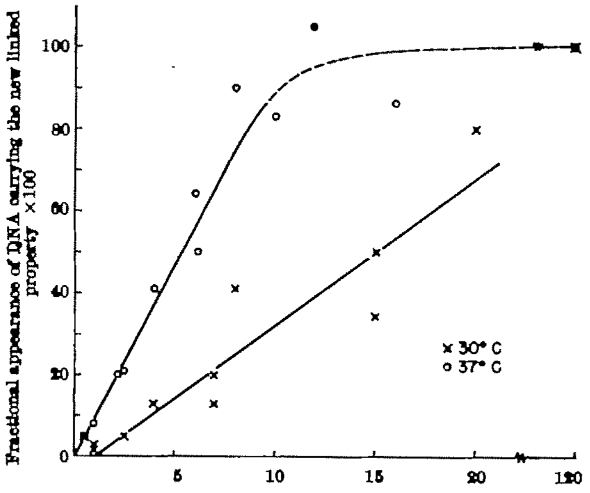


Fig. 3. Fractional appearance, in re-isolated deoxyribonucleate, of biological activity manifesting linkage between the newly introduced and resident deoxyribonucleate. A 5-min. exposure to transforming deoxyribonucleate is terminated with deoxyribonuclease and deoxyribonucleate is re-isolated from bacteria allowed the indicated additional incubation time

Thus, there exist at least two processes that transforming deoxyribonucleate may undergo following its fixation by bacteria. One has as its consequence the recovery of the biological activity in re-isolated deoxyribonucleate and the second results in the specific coupling of this newly introduced deoxyribonucleate with that resident in the recipient bacteria. The difference between those two processes may be further examined by a consideration of the relative transforming activities of a given deoxyribonucleate re-isolate with regard to the newly introduced property and the linked property.

Since deoxyribonucleate from bacteria carrying the linkage group *ad* yields on transformation about twice as many transformants bearing *d* (including *ad*) as *ad*, deoxyribonucleate isolated from a transformed population in which about a half of the transformed cells are *d* only and half are *ad* would be expected to yield four times as many *d* (including *ad*) as *ad* transformants. When deoxyribonucleate is re-isolated from a transformed population in which deoxyribonucleate from bacteria carrying the linkage group *ad* is introduced into sulphonamide-sensitive bacteria, the ratio:

$$\frac{\text{yield of } d\text{, including } ad\text{,}}{\text{yield of } ad}$$

(*d*/*ad*) assumes a value of close to four from very early times (Table 4).

Table 4. RELATIVE ACTIVITY OF A SINGLE PROPERTY, NEWLY INTRODUCED, COMPARED WITH A LINKED PAIR OF PROPERTIES (*a*) BOTH MEMBERS OF THE LINKAGE GROUP, (*b*) ONE MEMBER OF THE LINKAGE GROUP, NEWLY INTRODUCED, AND ONE MEMBER RESIDENT IN THE RECIPIENT BACTERIA

(*a*) DNA from strain *ad* into sulphonamide-sensitive strain

Time at 30° before re-isolation of DNA (min.)	½	3	7	14	20	120 (at 37° C.)
d / *ad*	3·6	3·4	4·8	4·0	3·9	4·2
Per cent *d* recoverable	4	21	54	70	100	100

(*b*) DNA from strain *d* introduced into strain *Sa*

Time at 30° before re-isolation of DNA (min.)	½	2½	7	20	20 (at 37° C.)
d / *ad*	13	10	9	6	4
Per cent *d* recoverable	6	14	40	100	100

In the experiment described in Table 4, in which deoxyribonucleate from bacteria carrying the property *d* is introduced into bacteria carrying the property *a*, the ratio *d* : *ad* assumes a high value at early times and approaches an equilibrium value of four at longer incubation times. The fact that the ratio *d* : *ad* is independent of the frequency of bacteria transformed either to *d* or *a* excludes the possibility that any appreciable fraction of the *ad* transformants observed are the consequence of a random double event.

The difference in the behaviour of the *d* : *ad* ratio as a function of time between the two experiments described shows that the recovery of *ad* activity from newly introduced deoxyribonucleate carrying *ad* is a different process from that in which *ad* activity appears as a consequence of an interaction between the newly introduced deoxyribonucleate and that of the recipient bacteria. It is impossible as yet to distinguish with certainty between a sequential process, recovery of *d*, followed by linking *a* and *d*, and two independent simultaneous processes occurring at different rates.

It is also not as yet possible to say whether or not synthesis of deoxyribonucleate is an obligatory requirement for either the recovery or the integration of the new deoxyribonucleate. Both processes are complete within a period during which there has been little overall growth; the increase in turbidity of the total culture may be less than 10 per cent. Earlier observations have demonstrated that transforming deoxyribonucleate re-isolated after prolonged exposures to deoxyribonucleate, followed by incubation for 5 min. at 37° with deoxyribonuclease, has suffered neither physical nor biological dilution. These times are long enough for both these processes to have approached completion. Furthermore, concentrations of 5-fluorodeoxyuridine thirty times higher than that necessary completely to inhibit bacterial growth fail to inhibit either reaction. Preliminary measurements of incorporation of phosphorus-32 into deoxyribonucleate during this period suggest that the net new synthesis of deoxyribonucleate by such transformed bacteria is less than 5 per cent.

Thus, it may be concluded that transforming deoxyribonucleate becomes integrated into the genome of the recipient bacteria during the first few minutes following the fixation of the deoxyribonucleate. Transforming deoxyribonucleate re-isolated immediately after its fixation has suffered a loss of function, and this function is rapidly recovered on incubation of the transformed bacteria. In addition to a recovery of function, the newly fixed deoxyribonucleate may become genetically linked to deoxyribonucleate resident in transformed bacteria during this period. Preliminary observations suggest that little or perhaps no new deoxyribonucleate synthesis is required for either the recovery of function or the appearance of genetic linkage.

The technical assistance of Miss I. Miller is gratefully acknowledged.

[1] Fox, M. S., and Hotchkiss, R. D., *Nature*, 179, 1322 (1957).
[2] Fox, M. S., *Biochim. Biophys. Acta*, 26, 83 (1957).
[3] Lerman, L. S., and Tolmach, D. J., *Biochim. Biophys. Acta*, 26, 68 (1957).
[4] Goodgal, S. H., and Herriott, R. M., *Fed. Proc.*, 15, 590 (1956).
[5] Hotchkiss, R. D., and Evans, A. H., *Cold Spring Harbor Symp. Quant. Biol.*, 23, 85 (1958).

EFFECT OF ACRIDINE ORANGE ON LIVING BULL SPERMATOZOA

By C. VAN DUIJN, JUN.

Biophysics Department, 'Schoonoord' Research Institute for Animal Husbandry, Hoogt 10, Utrecht

SINCE the introduction of the acridine orange vital fluorochroming technique in 1940[1-3] vital fluorochroming of spermatozoa with this substance was performed for the first time by Strugger and Rosenberger in 1944[4]. Goat spermatozoa showed different resistance to varying concentrations of acridine orange. Using a dilution of 1:80,000 in a glucose-phosphate buffer after Milovanov, 100 per cent motility could be maintained for two days in complete darkness at 8° C. In artificial insemination experiments with fluorochromed semen, fertilization was accomplished in 21 goats out of 27 and this was followed by normal development and birth of young.

Although most living cells do not suffer toxic effects from acridine orange if this is used in very low concentration[3,5,6,7] some cells may be more susceptible. Personally, I found that mouse lymphoblasts are killed by acridine orange in a concentration of 1:5000; even in concentrations as low as 1:50,000 reproduction was impaired[8]. With human spermatozoa, susceptibility was found to be rather high, 1:10,000 being about the highest concentration that may be used without killing them instantaneously, and even then great care has to be taken as to the method of application[9]. Susceptibility also seemed to depend on the activity of the specimens; the more active the spermatozoa, the quicker they were killed.

In recent years Vandemark *et al.*[10,11] have applied acridine orange for evaluating the motility of bull spermatozoa. They did not observe toxic reactions with concentrations of 1:40,000 up to 1:10,000 during 15 min. incubation at 37° C. and they observed only a slight reduction in motility after storage at 5° C. for 24 hr. These estimations, however, were based on visual observations only and not on exact measurements.

Contrary to these observations, I have found a definite adverse effect of acridine orange on living bull spermatozoa, both with respect to the number of normally moving sperms and their mean velocity, measured with high accuracy with the photoelectric method developed by Rikmenspoel[12,13].

Freshly ejaculated semen was allowed to cool to 25° C. and then diluted 10 times with an ultramicroscopically clear egg-yolk—citrate buffer[14] (pH 6·75 ± 0·05 at 22–23° C., corresponding to pH 6·80 ± 0·05 at 37° C.) of 30° C. After this first dilution the samples were slowly cooled to ~ 4° C. by placing the tubes in a larger glass beaker which in its turn was placed in a Dewar vessel with ice. Further four-fold dilutions were made with portions of the same buffer to which varying amounts of acridine orange had been added to get a range of concentrations of 1:200,000–1:5000. The fluorochrome-containing buffer was poured gently on top of the fluid to avoid mixing, and the sample was allowed to stand in the Dewar vessel for 20 min. before mixing was accomplished by gentle turning; this cautious procedure is required to avoid shocking the specimens when semen is diluted. After mixing, drops (13·5 ± 0·3 μl.) of the diluted semen were brought into a micro-chamber by means of a leukocyte pipette and warmed up for 5 min. to 37° C. Then the dark-field image of individual swimming spermatozoa was projected on to a small aperture 'viewed' by a photomultiplier through an auxiliary lens. Every time a sperm passes by the area 'seen' by the photomultiplier the latter receives light impulses and emits a corresponding number of photo-electrons. The resulting fluctuating photocurrent is amplified and recorded. From the recordings the velocities of individual spermatozoa can be measured, discrimination between normal and abnormal movements is possible and the method also allows one to determine the total number of normally moving sperms.

The mean velocity of the spermatozoa with normal movement was found to decrease proportionally with the square root of the fluorochrome concentration, according to the equation:

$$\bar{v}_c = \bar{v}_0 - 3900\sqrt{c} \quad \mu/\text{sec.}$$

where $\bar{v}_c$ is mean velocity at fluorochrome concentration c; $\bar{v}_0$ is mean velocity without fluorochrome addition; and c is concentration of acridine orange expressed in weight ratios, for example, $c = 2 \times 10^{-4}$ is equivalent to the expression 1:5,000.

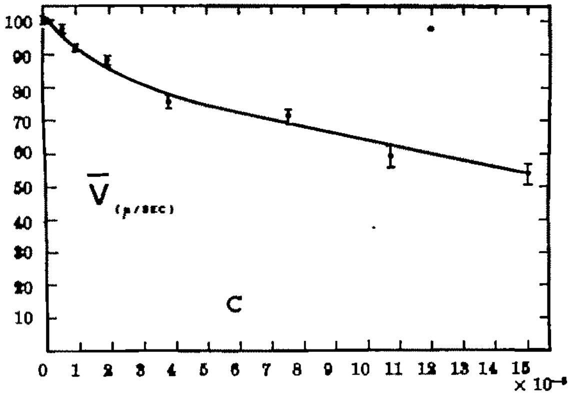


Fig. 1. Mean velocity of normal bull spermatozoa as a function of the concentration of acridine orange. The plotted results have been obtained by pooling all v values of the individual spermatozoa from five ejaculates from four different bulls at each concentration

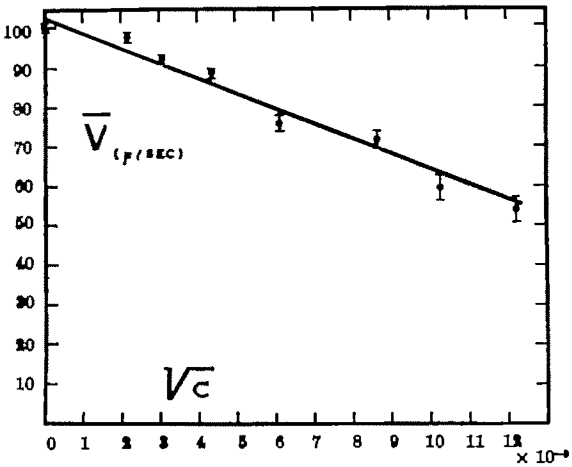


Fig. 2. Mean velocity of normal bull spermatozoa as a function of the square root of the concentration of acridine orange. Same results as depicted in Fig. 1

This relationship is shown by Figs. 1 and 2 representing the data obtained in a series of measurements of 5 ejaculates from 4 different bulls of Dutch-Friesian and red-and-white Meuse-Rhine-Yssel breed. It is shown that the mean velocity at an acridine orange concentration of 1:10,000 has decreased to 62 per cent of that measured in the control without fluorochrome addition under the conditions of the experiment, which include 7 min. irradiation with white light obtained from a 6 V., 5 amp. incandescent microscope bulb, operated at 6 amp. The mean irradiation period is only half this, since the period covers the total time required for recording.

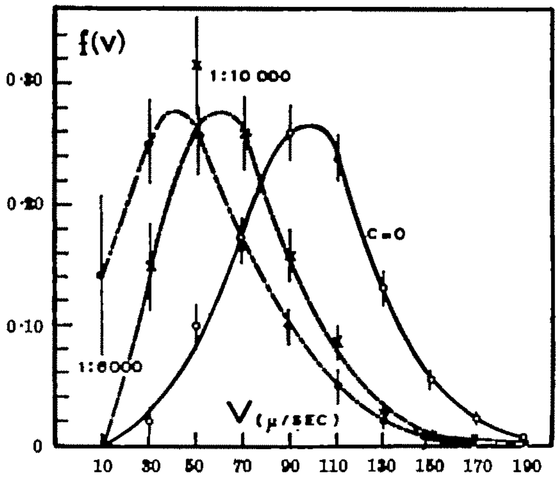


Fig. 3. Normalized velocity frequency distributions of normal bull spermatozoa with acridine orange 1:6,000 and 1:10,000 compared with control ($c = 0$) without fluorochrome

The velocity frequency distributions not only shift to lower values, but their shape is altered, too, as shown in Fig. 3. Whereas at low concentrations the curves do not differ much from that obtained for the control, the distributions become definitely skew at concentrations of 1:10,000 and higher.

The number of normally moving specimens also decreases with increasing fluorochrome addition (Figs. 4 and 5). The effect is not bull-specific, the slopes of the regression lines being identical within the experimental errors for all experiments. Although there

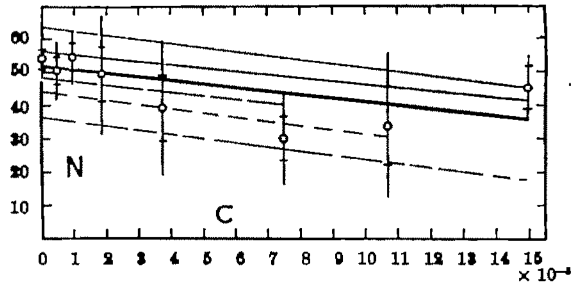


Fig. 4. Number of normally moving bull spermatozoa (arbitrary units) as a function of the concentration of acridine orange. Dotted lines: regression lines of the individual experiments; full line: regression line of all data, with indications of the standard deviations and the standard errors of the means of the individual figures

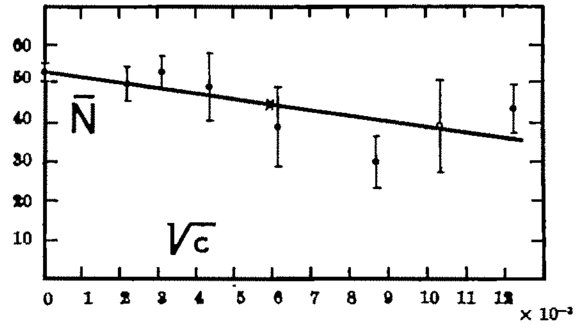


Fig. 5. Number of normally moving bull spermatozoa (arbitrary units) as a function of the square root of the acridine orange concentration. The mean values $\bar{N}$ obtained by averaging the data obtained for the individual ejaculates have been plotted with the standard errors of the means. Comparison with Fig. 4 shows that there is no significant difference in fitting the data to proportionality with either c or $\sqrt{c}$

might be reason to assume that this relationship would also be proportional to the square root of the concentration, the curves show that in this case the data can equally well be fitted by an equation of the type $N_c = N_0 - k.c$ as by one where $N_c = N_0 - k\sqrt{c}$ (N_c and N_0 being the numbers of normally moving sperms, expressed in arbitrary units, at concentration c and 0, respectively). At an acridine orange concentration 1:10,000 the number of spermatozoa showing normal movements is shown to have fallen to approximately 80 per cent of that of the control without fluorochrome addition.

Acridine orange exerts a powerful photodynamic action[5] like all fluorescent dyes[15–17], and in preliminary experiments I have found a great difference in the rates of decrease of velocity with time in illuminated samples of semen to which acridine orange had been added and the controls, consisting of a similar fluorochromed sample kept in the dark and samples without fluorochrome addition kept in darkness and under illumination. Even native bull spermatozoa are highly susceptible to light; Norman and Goldberg[18] found a progressive decline in metabolic activity, followed by the premature death of the cells, showing all characteristics of a photodynamic action, due to the effect of a photosensitizer which is an intrinsic component of the cell. That the adsorption of acridine orange can add to its effect will not be surprising.

Since the technique employed by Vandemark *et al.*[11] implies the use of pure ultra-violet irradiation it seems unlikely that the discrepancy between their results and mine would be due to differences in photosensitizing effects, although this might require additional information on the dependence on wave-length of this effect of acridine orange with respect to spermatozoa. At present it seems more likely that the discrepancy can be accounted for by the low reliability of visual motility estimations in general as compared with exact measurements of velocity.

In recent years it has repeatedly been asserted that acridine orange should be adsorbed preferentially to nucleic acids[6,7,19–25]. Whereas it may be that this applies to certain types of material and special conditions of application[4,20,26] it would lead to serious mistakes if one should take excessive adsorption of acridine orange in itself as a test for nucleic acids. The original investigations by Strugger[5] point to the great diversity of substances that may heavily adsorb this fluorochrome, whereas I demonstrated that in human spermatozoa strong red fluorescence can be obtained after total removal of nucleic acids by extraction with hot trichloroacetic acid[9,27]. Neither in bull nor in human spermatozoa has differentiation between nucleic acid-containing parts (nucleus, mitochondria in the midpiece, and the axial filament of the tail[27]) and the cytoplasmic components been observed in the living state. In bull spermatozoa the entire head appears fluorochromed rather homogeneously, both in the living and the dead state, allowing the fluorochrome method to be used as most reliable for determining biometrical data of the external head shape and its area[28].

Although it would not seem unreasonable to assume that at least part of the adverse effect of acridine orange might be due to adsorption to nucleic acids, this would require experimental corroboration. The mathematical expression of the effect with respect to the swimming velocity is in agreement with a simple adsorptive process following the Freundlich adsorption isotherm, but this is insufficient for further deductions.

A further account of the investigations, which are being continued, will be published elsewhere.

[1] Bukatsch, F., and Haitinger, M., *Protoplasma*, 34, 515 (1940)
[2] Strugger, S., *Jenaische Z. Naturwiss.*, 73, 97 (1940).
[3] Strugger, S., *Deutsch. tierärztl. Wschr.*, 48, 645 (1940).
[4] Strugger, S., and Rosenberger, G., *Deutsch. tierärztl. Wschr. u. Deutsch. tierärztl. Rundschau*, 357, No. 39/40, 52/50 (1944).
[5] Strugger, S., "Fluoreszenzmikroskopie und Mikrobiologie" (M. and H. Schaper, Hanover, 1949).
[6] Austin, C. R., and Bishop, M. W. H., *Exp. Cell Res.*, 17, 35 (1959).
[7] Hill, jun., R. B., Bensch, K. G., and King, D. W., *Nature*, 184, 1429 (1959).
[8] Duijn, jun., C. van, *The Microscope*, 10, 57 (1954).
[9] Duijn, jun., C. van, *Mikroskopie*, 9, 324 (1954).
[10] Vandemark, N. L., Schorr, R., and Estergreen, V. L., *J. Animal Sci.*, 17, 1216 (1958).
[11] Vandemark, N. L., Estergreen, V. L., Jun., Schorr, R., and Kuhlman, D. E., *J. Dairy Sci.*, 42, 1314 (1959).
[12] Rikmenspoel, R., and Van Herpen, G., *Physics in Medicine and Biol.*, 2, 54 (1957)
[13] Rikmenspoel, R., "Photoelectric and Cinematographic Measurements of the 'Motility' of Bull Sperm Cells", Thesis, Utrecht (1957).
[14] Rikmenspoel, R., *Experientia*, 13, 124 (1957).
[15] Tappeiner, F. H. von, and Jodlbauer, A., *Deutsch. Arch. klin. Med.*, 80, 427 (1904)
[16] Metzner, P., *Biochem. Z.*, 101, 33 (1919).
[17] Metzner, P., *Biochem. Z.*, 148, 498 (1924)
[18] Norman, Ch., and Goldberg, E., *Science*, 130, 624 (1959).
[19] Krieg, A., *Klin. Wschr.*, 31, 350 (1953)
[20] Armstrong, J. A., *Exp. Cell Res.*, 11, 640 (1956).
[21] Bertalanffy, L. von, and Bickis, I., *J. Histochem. Cytochem.*, 4, 481 (1956).
[22] Bishop, M. W. H., and Austin, C. R., *Endeavour*, 16, 137 (1957).
[23] Bishop, M. W. H., and Smiles, J., *Nature*, 179, 307 (1957).
[24] Schümmelfeder, N., Ebschner, K. J., and Krogh, E., *Naturwiss.*, 44, 467 (1957).
[25] Smiles, J., and Taylor, A. E. R., *Nature*, 179, 306 (1957)
[26] Armstrong, J. A., and Hopper, P. K., *Exp. Cell Res.*, 16, 584 (1959).
[27] Duijn, C. van, Jun., *J. Roy. Micro. Soc.*, 74, 69 (1954).
[28] Duijn, C. van, Jun., *Mikroskopie*, 14, 265 (1960).

EFFECT OF GLYCERINE ON THE X-RAY SENSITIVITY OF *SERRATIA MARCESCENS*

By DR. D. L. DEWEY

British Empire Cancer Campaign Research Unit in Radiobiology,
Mount Vernon Hospital, Northwood, Middlesex

IN 1951 Burnett *et al.*[1] reported that many alcohols and glycols, at concentrations in the 0·1–1 *M* range, protected *Escherichia coli B/r* against the lethal effects of irradiation at 2° C. Later Marcovich[2], using *Escherichia coli K*12 (λ), observed similar protection against aerobic irradiation by glycerine and four other similar compounds. Maximally protected organisms had about the sensitivity of anaerobic organisms, and no protection was observed against phage induction which he had reported previously to

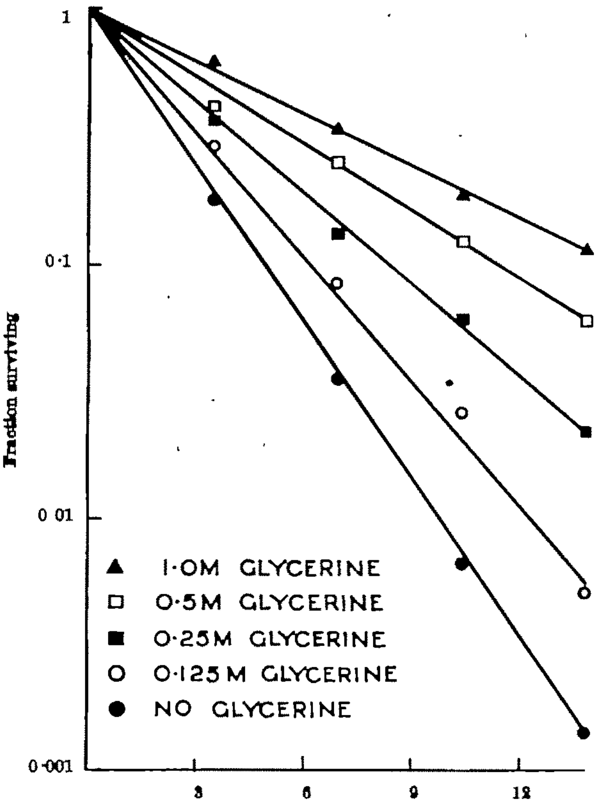


Fig. 1. Logarithmic survival of *Serratia marcescens* suspended in various glycerine concentrations and equilibrated with oxygen during X-irradiation

be independent of the presence of oxygen at the time of irradiation. This phenomenon of radiation protection by glycerine has been re-examined using the small red pigmented bacterium, *Serratia marcescens*, and the observations indicate that protection of aerobic organisms is brought about by some mechanism other than oxygen scavenging or competition with oxygen for radiation-induced radicals, and that organisms which are anaerobic when irradiated can also be substantially protected by the presence of glycerine.

Overnight cultures grown at 25° in unaerated nutrient broth were diluted in 0·015 *M* phosphate buffer at *p*H 7 shortly before irradiation by 200-kV. X-rays (1·6 mm. aluminium filter) at 1,000 r./min. in a 'Perspex' vessel which provided for continuous bubbling and thermostatic control. In the present experiments, the bacteria were diluted and suspended in the glycerine solution a few minutes before irradiation. A control sample was taken just before irradiation, and an experimental sample was taken immediately after irradiation. Both samples were then appropriately diluted in 0·015 *M* buffer containing no glycerine, and plated out in nutrient agar. Visible colony counts were made after 48 hr. incubation at 25°. The fraction of cells surviving to form a visible colony was used as a measure of the X-ray damage.

For anaerobic experiments, nitrogen was bubbled through the bacterial suspension for 20 min. before taking a control sample. Gassing was then continued for a further 5 min. before irradiation in case any atmospheric oxygen had entered the apparatus during sampling. The exit gas was passed through a Hersch cell[3] and any trace of oxygen impurity continuously monitored. Any anaerobic experiments in which the oxygen concentration rose above 20 parts per million have been excluded.

The effect of glycerine on survival of bacteria gassed with 100 per cent oxygen during irradiation is shown in Fig. 1. When plotted as the logarithm of the surviving fraction against linear dose, the points lie on straight lines through the origin at all glycerine concentrations. The slope of the regression line through each set of points has been determined by mean square analysis. The effect of glycerine on the radiosensitivity of bacteria appears to follow the second-order kinetics type of equation used by Michaelis and Menten[4] for enzymes, and Alper and Howard-Flanders[5] for the effect of oxygen on the radiosensitivity of bacteria. If this is so, the effect of glycerine on the sensitivity of bacteria to X-rays can be expressed in the form:

$$\frac{D}{D_0} = \frac{mG + K}{G + K}$$

where D is the 37 per cent dose for the bacteria suspended in a glycerine solution of concentration G, D_0 is the 37 per cent dose in the absence of glycerine. m and k are constants. By plotting D_0/D against $D_0 - D/D \times G$, a straight line should be obtained. By extrapolating this line to cut the axis, values of m and k can be determined. The best line determined by the points from Fig. 1 plotted in this way gives a value for m of 5·25, this being the ratio of the sensitivity of the bacteria in the absence of glycerine to their sensitivity in infinite glycerine concentration. The concentration of glycerine required to give half the theoretical maximum is equal to $K = 0·9$ molar. In Fig. 2 the 37 per cent dose has been plotted against glycerine concentration. The solid line is the theoretical curve using the above values of m and k. If glycerine is competing with oxygen for active sites, or preventing oxygen from reaching these active sites then the concentrations of glycerine required to produce a given amount of protection should depend on the concentration of oxygen. The experiment was repeated using a mixture of 1 per cent oxygen in nitrogen in the gas phase. The results shown in Fig. 2 demonstrate that the protective effect of glycerine is independent of a change

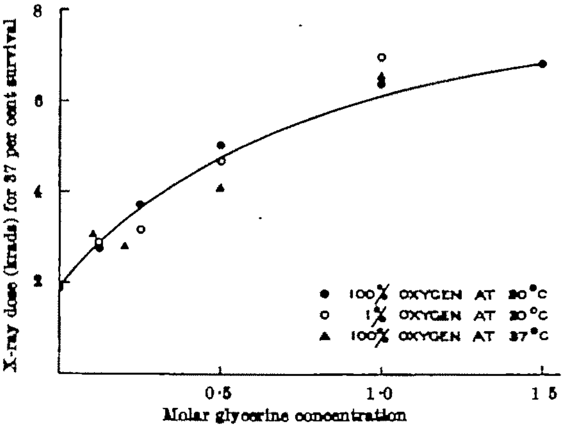


Fig. 2. The effect of glycerine on the aerobic X-ray sensitivity of *Serratia marcescens*

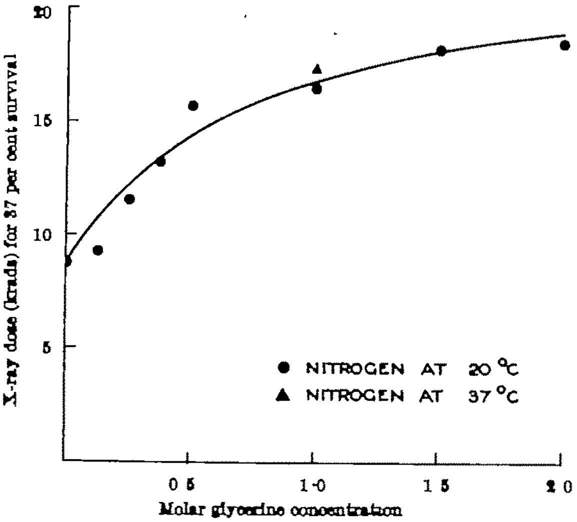


Fig. 3. The effect of glycerine on the anaerobic X-ray sensitivity of *Serratia marcescens*

in oxygen concentration by a factor of 100. Another experiment, using 100 per cent oxygen but at 37°, demonstrates that protection by glycerine has little or no temperature effect. Control bacteria which were suspended in 1·5 *M* glycerine within a minute after they were irradiated, and then kept in glycerine for the same length of time as the experimental bacteria, were not protected against the full X-ray damage.

Glycerine also protected cells from the effect of X-rays when the bacterial suspension was gassed with nitrogen or with 10 per cent nitric oxide in nitrogen anoxia. The kinetics of the effect in the presence of nitric oxide has not yet been worked out. The effect of various glycerine concentrations combined with pure nitrogen is shown in Fig. 3. Using the same procedure as above, the value of m was 2·66 and k was 0·8 molar.

Wood[6] has protected yeast cells against X-ray damage by high concentrations of glycerine. He has interpreted the results as a dehydration of the cells. The overall effects of glycerine on *Serratia marcescens* is very similar to the radioprotection of cysteine on *E. coli* reported by Kohn and Gunter[7]. The effective concentrations of the two chemicals are also very similar. Kohn and Gunter mention the trapping of free radicals or the formation of mixed disulphides as possible protective mechanisms. Burns[8] has been able partially to protect diploid but not haploid yeast against anoxic radiation damage with p-chloromercuribenzoate and suggested a masking of sulphydryl groups. No final answer to the mechanism of glycerine protection can yet be given. But, assuming that it protects against the indirect effects of radiation, and extrapolating to infinite glycerine concentration, the dose reduction factor of 2·66 would mean that only 37 per cent of the damage in the anaerobic system was due to direct effects.

I wish to thank Dr. L. H. Gray and Dr. J. W. Boag for helpful discussions, and Mr. J. Steadman and Miss J. Liddon for technical assistance.

[1] Burnett, W. T., Stapleton, G. E., Morse, M. L., and Hollaender, A., *Proc. Soc. Exp. Biol. Med.*, 77, 636 (1951).

[2] Marcovich, M., "Organic Peroxides in Radiobiology", 117 (Pergamon Press, 1958).

[3] Hersch, P., "Instrument Practice", 937 (1957).

[4] Michaelis, L., and Menten, M. L., *Biochem. Z.*, 49, 333 (1913).

[5] Alper, T., and Howard-Flanders, P., *Nature*, 178, 978 (1956).

[6] Wood, T. H., *Radiation Res.*, Supp., 1, 332 (1959).

[7] Kohn, H. I., and Gunter, S. E., *Radiation Res.*, 11, 732 (1959).

[8] Burns, V. W., U.S. Atomic Energy Commission, Report *UCRL*-2812 (1954).

BIOSYNTHESIS OF CELLULOSE BY *ACETOBACTER ACETIGENUM*

By Dr. A. M. BROWN and Dr. J. A. GASCOIGNE

British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester, 22

Morphology of *Acetobacter acetigenum* and Cellulose Synthesis

In the course of a systematic study of cellulose biosynthesis by the bacterium *Acetobacter acetigenum* our attention has turned to the possible function of the cell wall and capsule (that is, a distinct envelope of polysaccharide material) in the production of cellulose. Methods of preparing cell-free extracts of *Acetobacter xylinum* capable of promoting cellulose synthesis have been reported recently. In the Colvin method[1] the extract is prepared from unbroken cells; in other methods[2-4] the extract is prepared from cells which have been disrupted by mechanical or ultrasonic disintegration. An important difference in the behaviour of broken and unbroken cell extracts lies in the ability of the former to incorporate into cellulose the glucose molecule from uridine diphosphate glucose. This observation suggested that it would be advantageous to examine systematically the function of the various cell components in cellulose synthesis. In this article we report that, although *A. acetigenum* is not capsulated, its cell wall plays an important part in cellulose biosynthesis.

Cells of *A. acetigenum* (N.C.I.B. 8132) were grown on standard malt wort[5], and were then inoculated into a sterile medium (*G.M.S.*) of the composition: D-glucose monohydrate, 1 per cent; yeast extract (Oxoid), 0·2 per cent; potassium dihydrogen phosphate, 0·3 per cent; ammonium sulphate, 0·3 per cent; crystalline magnesium sulphate, 0·2 per cent, all by weight in water adjusted to pH 6·0. After growth for 40 hr. at 28°, the cells were harvested by the method of Hestrin and Schramm[6]. Microscopic examination of the cells at this stage revealed adherent, ill-defined material surrounding some cells. The cells were then washed three times by suspension in water and centrifugation, and were finally passed through a sintered glass filter (porosity 3). After centrifugation, the precipitated cells were examined by ordinary and phase contrast microscopy in preparations stained by the wet indian ink method[7], dry-film indian ink method[8], and a mordanting procedure[9]; capsules could not be observed surrounding any of the cells. Washed, filtered cells, when reinoculated into standard malt wort, rapidly produced cellulose. Repetition of these experiments with *A. acetigenum* cells after growth for 72 hr., 7 and 14 days failed to reveal any capsulation. As a control experiment, well-capsulated cells of *Klebsiella pneumoniae* were submitted to the same washing and filtration procedures, and distinct capsules were observed under the microscope.

The partial removal of cell walls has been accomplished by the growth of Gram-negative bacteria in the presence of antibiotics[10], or by the partial hydrolysis of cells in the presence of lysozyme and a chelating agent[11]. *A. acetigenum* cells were grown at 28° in the *G.M.S.* medium, to which was added benzyl penicillin (sodium salt) at concentrations of 100, 500 and 1,000 units per ml. For 48 hr. little growth occurred in any of the cultures, and microscopic examination showed many spherical large bodies in addition to normal rod-shaped cells. After this time, slow cellulose formation occurred at the two lower penicillin concentrations, but in no case was synthesis so rapid as in the absence of penicillin. The swelling of cells could not be halted by the addition of polyethylene glycol or sucrose as stabilizers, so that protoplasts could not be isolated.

It was found that cells harvested from 48-hr. *G.M.S.* cultures (without penicillin), and allowed to rest in sterile water at 2° for 2 hr., could be lysed in the following mixture[12]: crystalline egg lysozyme 13·3 μgm./ml.; ethylenediamine tetraacetic acid (sodium salt), 1·4 μmoles/ml.; sucrose, 0·06 m.moles/ml.; 2-amino-2-hydroxymethylpropane-1:3-diol buffer (*p*H 8·5), 33·3 μmoles/ml.; and wet compacted cells, 0·2 ml./ml. After 30 min. at 28°, many protoplasts could be seen under the microscope; more prolonged lysis disrupted the protoplasts giving rise to almost transparent 'ghost' membranes. At all times a few normal, rod-shaped cells remained in the solutions, but differential centrifugation enabled a partial separation to be made. The protoplast-rich fraction, containing very few normal cells, on inoculation into either *G.M.S.* medium or a sucrose solution (*M*) containing mineral salts and yeast extract, did not produce any cellulose for more than 48 hr. at 28°; with normal cells cellulose becomes visible after growth for 3 hr. at 28°. The resumed synthesis with protoplast-containing media may have been due to the recovery of the few normal cells in the inoculum from metabolic upset. However, this partial removal of the cell wall certainly interfered with cellulose synthesis.

We have observed that the growth of *A. acetigenum* in *G.M.S.* medium in both shaken and aerated cultures at 28° produced very little cellulose, and examination showed the presence of large cells in such cultures, similar to the large bodies produced by lysozyme action in the absence of stabilizers. These results have interesting bearings on the findings of Walker and his co-workers[13,14], who observed changes in colonial morphology, and described the cells as 'cellulose-less mutants'. Some doubt has been cast on the purity of such cultures, and it has been suggested that Walker's observations could have arisen from culture contaminants[15]. The formation of protoplasts or even large bodies retards and possibly completely halts cellulose synthesis by such cells, and thus such altered cells could be regarded as cellulose-less mutants. From these observations, it is suggested that the bacterial cell wall plays some part in cellulose biosynthesis.

Extracellular Synthesis of Cellulose by *Acetobacter acetigenum*

THE formation of cellulose by *Acetobacter xylinum* from ultrafiltered ethanol extracts of glucose metabolizing cells has been recorded by Colvin[1]. Similar findings are now reported with *Acetobacter acetigenum*, together with some modifications of the Colvin procedure.

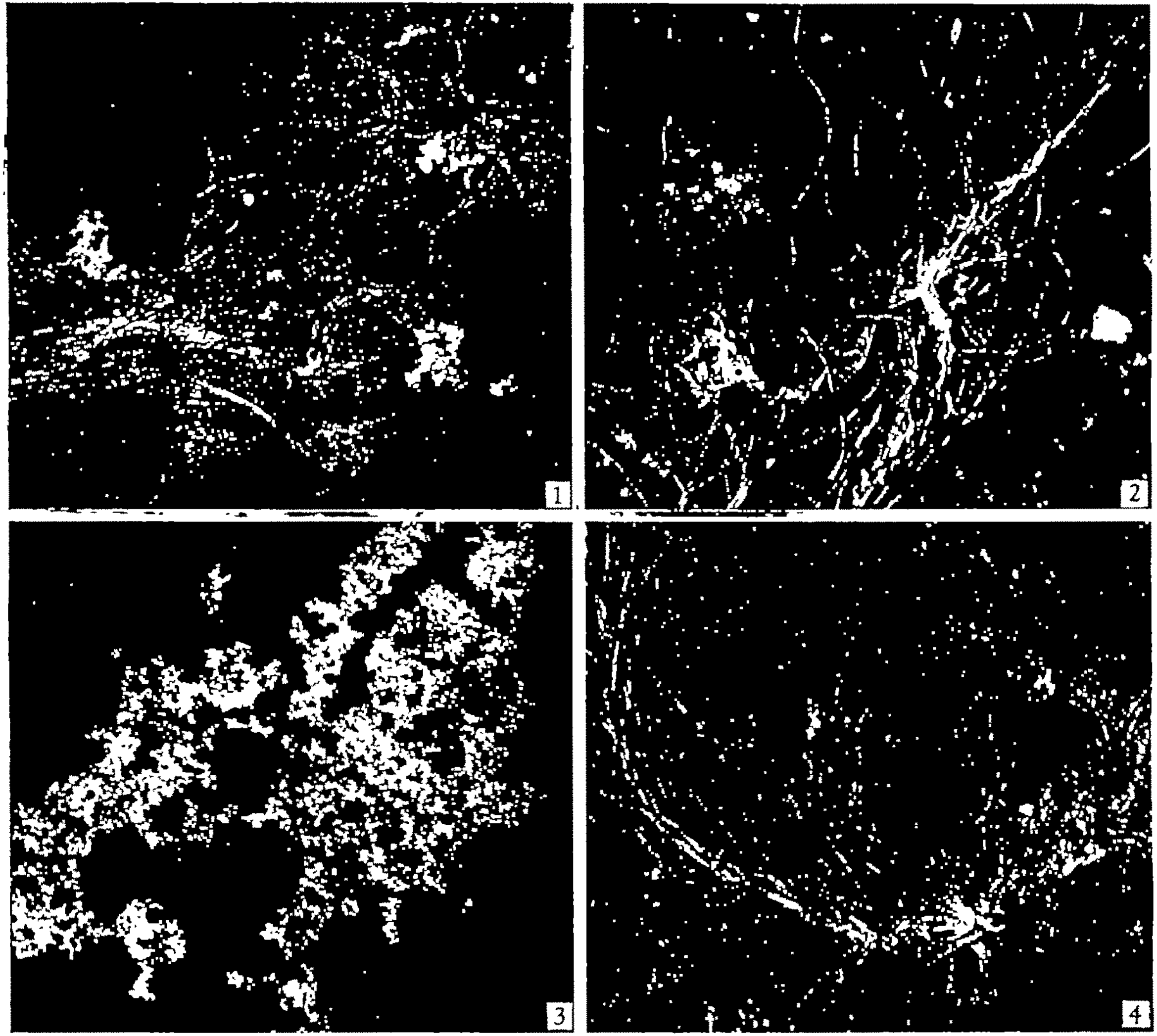
Acetobacter acetigenum (N.C.I.B. 8132) was inoculated from standard malt wort cultures[8] into a medium (*G.M.S.*, see previous communication). The cultures (200 ml. each in 1-l. conical flasks) were incubated at 28° for 40 hr., the cellulose produced then being in the form of an almost transparent gel. Cells were obtained from this gel by the method of Hestrin and Schramm[6]. The cells were washed, incubated with glucose solution, and the precursor of cellulose and the enzyme system were extracted from the cell suspension with ethanol. After removal of cells, the extract was evaporated to give an aqueous solution in which the enzymic reaction with the precursor took place. After evaporation to dryness, the residue was washed with alkali to remove protein and non-cellulosic materials, and then submitted to electron microscopy; all the above operations were carried out exactly as described by Colvin[1].

The resulting electron micrograph (Fig. 1) shows clearly the alkali-resistant, enzymically synthesized microfibrils, although they appear to differ from microfibrils obtained by ultrasonic disintegration of bacterial cellulose (obtained from *A. acetigenum* cultures) and shown in Fig. 2. Acid hydrolysis (2 *N* sulphuric acid for 18 hr. in a sealed tube at 100°) of the alkali-resistant fibrillar residue produced glucose only, when analysed by paper chromatography. Another sample of the ethanol extract was heated in steam at 125° for 20 min. to denature the enzymes present, and then treated as described by Colvin, with the result shown in Fig. 3, revealing no synthesis of cellulose.

Similar alkali-insoluble fibrillar material was obtained by a similar sequence of operations, starting by dropping the gel cellulose into ethanol (to give 75 per cent ethanol concentration, by volume), and then following the Colvin procedure with the ethanol extract.

The efficiency of sinter-glass filters of porosity 5 on 3 for the removal of *A. acetigenum* cells and of microfibrils was tested, in order to examine an alternative method to ethanol extraction. Filtration of an aqueous suspension of cells through such a filter gave a clear filtrate, which contained no cells on examination in the light microscope. Portions of this filtrate were inoculated into standard malt wort[10], and were incubated at 28° for 7 days; no cellulose was formed and no cells could be detected. Thus the filter removed cells completely. Bacterial cellulose was disintegrated ultrasonically (9 kc./s. for 1 hr. at 2°) in water to give microfibrils visible under the electron microscope. Filtration of this suspension through the glass filter, followed by centrifugation of the filtrate at $30 \times 10^3 g$, gave no visible residue, and no microfibrils could be observed in either the supernatant liquid or in washings from the centrifuge tube under the electron microscope. Thus the glass filter could be used to remove microfibrils from solution.

A *G.M.S.* culture (200 ml.), grown for 40 hr. at 28°, was passed through the glass filter and the filtrate was incubated for 1 hr. at 28°. The filtrate was then centrifuged at $30 \times 10^3 g$, and the pre-



Figs. 1–4. Electron micrographs of cellulose microfibrils (× c. 13,500) and of denatured enzyme experiment

cipitate was submitted to electron microscopy, with the result shown in Fig. 4; again clear evidence for the formation of microfibrils was obtained. These microfibrils were insoluble in sodium hydroxide solution (2 N at 100° for 5 min.), and again their appearance differed from both the samples obtained above (Figs. 1 and 2). The reasons for these differences are not yet known. The addition of sterile aqueous solutions of α-D-glucose-1-phosphate, uridine diphosphate glucose (sodium salt), cellotetraose and cellohexaose (2 mgm. each in 2 ml. water) separately to the ultrafiltered culture medium gave no visible quantity of cellulose, as would have been expected from enzymic synthesis if these substances were extracellular precursors of cellulose.

These experiments confirm the findings of Colvin[1] that the final stage (or stages) of cellulose biosynthesis by *Acetobacter* spp. occurs extracellularly, and also lend weight to the findings of Schramm, Gromet and Hestrin[16] that glucose-1-phosphates and uridine diphosphate glucose provided exogenously are not converted to cellulose on the outer surface of *A. xylinum* cells. All these findings support the hypothesis that an exogenous substrate (probably glucose) enters the cell, and is converted to a precursor which can be transported out of the intact cell and converted to cellulose extracellularly.

We wish to acknowledge the help and advice of Drs. J. Dlugosz and A. Sharples, and the practical assistance of Miss D. L. Peat and Mr. C. D. Shorey. This work forms part of the fundamental research programme of the British Rayon Research Association.

[1] Colvin, J. R., *Nature*, 183, 1135 (1959).
[2] Glaser, L., *J. Biol. Chem.*, 232, 627 (1958).
[3] Klungsöyr, S., *Nature*, 185, 104 (1960).
[4] Greathouse, G. A., *J. Amer. Chem. Soc.*, 79, 4503 (1957).
[5] Tosic, T., and Walker, T. K., *J. Soc. Chem. Indust.*, 65, 104 (1946).
[6] Hestrin, S., and Schramm, M., *Biochem. J.*, 58, 345 (1954).
[7] Duguid, J. P., *J. Path. Bact.*, 63, 673 (1951).
[8] Butt, E. M., Bonynge, C. W., and Joyce, R. L., *J. Inf. Dis.*, 58, 5 (1936).
[9] Muir, R., in Mackie and McCartney, "Handbook of Practical Bacteriology", seventh ed., 212 (E. and S. Livingstone, Ltd., Edinburgh, 1946).
[10] Cooper, P. D., *Bact. Rev.*, 20, 28 (1956).
[11] Repaske, R., *Biochim. Biophys. Acta*, 30, 225 (1958).
[12] Jose, A. G., and Wilson, P. W., *Proc. U.S. Nat. Acad. Sci.*, 45, 692 (1959).
[13] Steel, R., and Walker, T. K., *J. Gen. Microbiol.*, 17, 445 (1957).
[14] Wright, H. B., and Walker, T. K., *Chem. Indust.*, 18 (1955).
[15] Elsden, S. R., and Peel, J. L., "Annual Rev. of Microbiol.", 12, 145 (1958).
[16] Schramm, M., Gromet, Z., and Hestrin, S., *Biochem. J.*, 67, 669 (1957).

LETTERS TO THE EDITORS

PHYSICS

Electromagnetic Standing Waves and Ball Lightning

BY now it is well known[1–3] that charged particles moving in harmonically oscillating vacuum electromagnetic fields can be subject to time-average forces which establish a virtual potential minimum for them. The matter takes on a different aspect when the number of particles is so large as to form a highly conducting plasma, as in Kapitza's theory of ball lightning[4]. Then, quite aside from the details of the particle motions, we know that the radiation pressure of the inflowing electromagnetic radiation is exerted on the energy-dissipating plasma. Thus, if the maintenance of a local ball of fire requires about 20 kW. (2×10^{11} dyne cm. sec.$^{-1}$), the total force, irrespective of direction, associated with this energy conversion will be 6·7 dynes. To the extent that, besides the 20 kW. absorbed, there may be energy reflected, this number will be greater. A reflected 20 kW. will contribute 13·3 dynes. This is far too little to hold a fire-ball at several thousands of degrees temperature and, say, 10 cm. in diameter from rising under the unidirectional buoyant force of about 600 dynes.

The stability is far more likely to be fictitious, in that the discharge simply stays where the energy is available. This is what happens with a not-too-long horizontal arc in air. Relative to the fresh air moving upward into the arc (because the hot gas in the arc rises) the ionization front moves downward because the power comes from the fixed electrodes. The fireball can be expected to stay in that place relative to the Kapitza standing-wave pattern where the impedance match is best.

This raises a minor difficulty, because the ionization will start at an antinode of the electric field, but the fireball, being of low impedance compared to free space, will lie at a node. Somehow the shift has to be made and the electrical geometry of the space changed without destroying the standing-wave pattern.

A more serious difficulty for the Kapitza theory lies in the magnitude of the power required. This must be about the same as for an electric arc in air or nitrogen at one atmosphere pressure. Analysis of Cobine's Fig. 9·19 (ref. 5) gives as the relation of voltage gradient E to arc current I:

$$E = 82\, I^{-0\cdot 57} \text{ (V./cm., amp.)}$$

His Table 9·12 gives a current density of 6 amp./cm.^{2}. The surface area S of the arc per cm. of arc length therefore increases only as $\sqrt{I}$, in fact:

$$S = 1\cdot 45\, I^{0\cdot 5} \text{ (cm., amp.)}$$

Thus, the power dissipation per unit surface area is:

$$\frac{EI}{S} = 57\, I^{-0\cdot 07} \approx 57 \text{ watts/cm.}^2$$

Application of this to a fireball 10 cm. in diameter, presumably maintained by a 40-cm. Kapitza wave, yields a required power of 18 kW.

Suppose Nature to be an obliging wench faced now by the necessity of substantiating at least some of the all-too-human accounts of ball lightning; How could she proceed? First, she would recognize that she cannot use St. Elmo's fire as a stand-in, for we have learned to discriminate. Second, since the onset of the phenomenon must only alter the wave pattern a little and not react strongly on the power source, she must have about four times 18, or 72 kW., as a cushion. She will, therefore, have to generate about 90 kW. of short-wave power. At least twice this amount of primary power will be required. Third, to conform to some eye-witness testimony regarding the distance that lightning balls can be from other objects, she will have to be able to maintain the ball at a distance of some 400 cm., more or less, from conducting objects. This is ten 40-cm. wave-lengths, so that the frequency will have to be constant to a fraction of 10 per cent, say to 2 per cent. Of course she could arrange for a general background of powerful short-wave radio noise which, augmented locally by a weaker Kapitza standing-wave, could feed a fireball, but the over-all energy requirements would be greater.

She would have to design the wave-guide-system reflectors and lenses, which would focus the energy into a small volume at some distant (4 m.) point, and she would have to buy the klystrons or magnetrons and power amplifiers to put out 90 kW. for some 20 sec. of continuous operation.

This is not beyond our own capabilities, and we have the advantage of more suitable energy sources. A lightning stroke may discharge about 20 coulombs at 5×10^8 V. (ref. 6)—an energy of 10^4 MW.sec. In 20 sec. the fireball itself consumes only 0·36 MW.sec. The capacitance associated with the store of lightning energy is $3\cdot 6 \times 10^4$ cm., which would be the radius of an isolated conducting sphere bearing the 20 coulombs. This is a reasonable size for a cloud. Actually, the charge forms a dipole in the cloud, but we shall probably not make an order-of-magnitude error if we calculate the energy density as if the energy were uniformly distributed through a sphere of $3\cdot 6 \times 10^4$ cm. radius. We thus find $5\cdot 1 \times 10^{-11}$ MW.sec. cm.$^{-3}$. In the fireball it is $6\cdot 8 \times 10^{-4}$ MW.sec. cm.$^{-3}$, that is, the energy is $1\cdot 3 \times 10^7$ times as concentrated. Nature does not surpass this degree of augmentation even in the return lightning stroke, despite its being catastrophic. For her to do it over an interval of 20 sec. is another matter.

It seems highly probable that with 90 kW. of 40-cm. continuous-wave power a globular hot plasma floating in air can be formed and maintained by suitably focusing the radiation. Something along this line may, it seems, be contemplated[3], although it is to be noted that 50 kW. is the maximum power of commercial radio broadcasting stations in the United States. Some advantage could be gained by trying for a smaller fireball. A successful experiment will not, however, demonstrate the existence of Nature's own ball lightning. It would only show that, as in many cases, Nature, as both co-operator and frustrator, permits man to do it.

LEWI TONKS

General Electric Co.,
Vallecitos Atomic Laboratory,
Pleasanton,
California.

[1] Wuerker, R. F., Shelton, H., and Langmuir, R. V., *J. App. Phys.*, 30, 3, 342 (1959). Wuerker, R. F., Goldenberg, H. M., and Langmuir, R. V., *ibid.*, 30, 3, 441 (1959).

[2] Watson, W. K. R., *Nature*, 185, 449 (1960).

[3] Fischer, H., *Z. Physik*, 156, 1 (1959).

[4] Kapitza, P. L., *Doklady, U.S.S.R.*, 101, 245 (1955).

[5] Cobine, J. D., "Gaseous Conductors" (McGraw-Hill Book Co., 1941).

[6] Schonland, B. F. J., "Lightning", "Handbuch der Physik", 22, first ed. (J. Springer Pub. Co., New York, 1959).

Absorption of Ultra-violet and Visible Light by Ultra-thin Sections of Vitrinite from a High-volatile Bituminous Coal

IT is a commonly held view that coals contain aromatic structures and that they become more graphite-like with increase in rank. X-ray studies have tended to confirm this concept; however, recent work[1] has shown that small (about 100 atoms or less) aromatic and tetrahedral structures that have comparable numbers of atoms give rise to overlapping X-ray diffraction patterns in the angular regions of the (10), (11) and (20) reflexions of graphite-like layers. The question of distinguishing between the two types of structures will have to be resolved eventually by rigorous and more detailed X-ray or electron diffraction studies. Knowledge of other physical and chemical properties would be of great help in such structural analyses. It has been reported[2] that the extinction coefficients of a high-volatile *A* bituminous vitrinite in ultra-violet and visible light are too low to admit of an appreciable content of condensed aromatic structures. A detailed study of absorption became possible when we succeeded in cutting ultra-thin sections of coals of various ranks and in accurately measuring their thickness and refractive index by interferometry[3].

The ultra-thin sections of vitrinites were obtained by cutting on a microtome, using a diamond knife. The fragments were very small; in most instances the areas suitable for accurate absorption measurements were less than 800μ in diameter. Consequently, a very intense source of light, a 1,000-watt mercury-xenon arc lamp, was used. The light was passed through a grating monochromator and then a prism monochromator to obtain high purity before passing through the specimen. This was found to be necessary to minimize the effect of fluorescence. After traversing the sample, the beam was further monochromatized by reflexion from a precision grating before intensity measurements were made by a multiplier phototube sensitive in the ultra-violet and visible.

Because of the fluctuating brightness pattern of the lamp, it was found necessary to compare the transmission through the specimen mounted on an aperture with that of an identical aperture placed in the same position. Before mounting the specimen, transmission of the two apertures was compared throughout the spectral range of interest at different slit openings to assure that they were placed in the same position. The ultra-thin specimen, mounted on a quartz plate, was arranged over one aperture, using a microscope, and an equivalent clear quartz plate fastened over the reference aperture. The quartz plate in front of the specimen reduced reflexion losses. Relative transmission readings of the two mounts in the same position were then made at the different wave-length settings. In choosing the latter, emission peaks of the lamp above the continuum were used where possible so that minimum slit openings, as low as 0·001 mm., corresponding to a resolution of 0·02 Å., could be used. For readings in the continuum, slit openings ranged from 0·01 to 0·1 mm., usually less than 0·05 mm. Transmission of the reference aperture was measured before and after that of the specimen.

Following the absorption measurements, the thickness of the specimen was measured with an *AO* Baker interference microscope. Phase retardations were measured for the specimen immersed in both air and an immersion oil to permit simultaneous determinations of refractive index and thickness. However, these parameters are not readily calculated for absorbing materials by the interference microscope. The extinction coefficient k, refractive index n, and thickness t are all involved in the solution of the phase-change equation on transmission through an absorbing material; the product kt is obtained from the absorption measurements after slight corrections for reflexion. The calculations are made by a trial-and-error procedure or graphically. This technique will be more fully described elsewhere.

Spectral absorption results have been completed for vitrinite from Pittsburgh bed high-volatile *A* bituminous coal. The thickness of the ultra-thin section used was 550 ± 20 Å., and the refractive index at 5460 Å. was 1·80. The latter value compares favourably with 1·78 found by reflectance measurements on polished blocks[4]. Variations of the specific extinction coefficient of Pittsburgh vitrinite with wave-length are shown in Fig. 1. The coefficient is defined by $K = 10^8 (\log I_0/I)/td$, where the intensity falls from I_0 to I after traversing thickness t (Å.), and d is the density (gm./cm.^{3}). The extinction coefficient, a more fundamental measure of absorp-

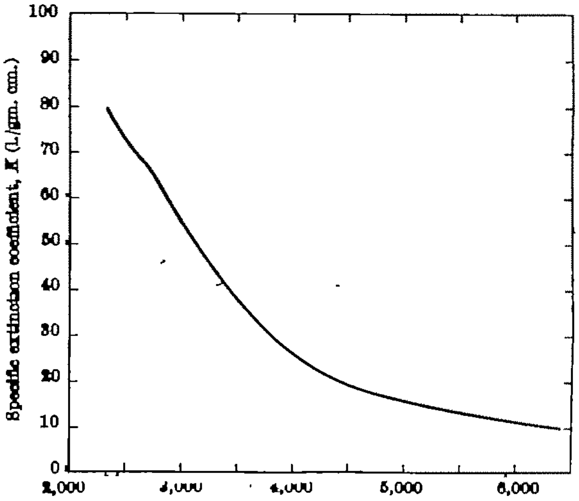


Fig. 1. Specific extinction coefficient of an ultra-thin section of vitrinite as a function of wave-length in the ultra-violet and visible. (High-volatile *A* bituminous coal, Pittsburgh bed-section, 550 Å. thick)

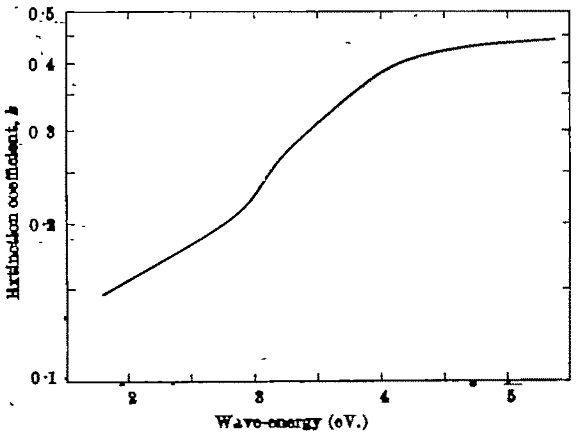


Fig. 2. Extinction-coefficient of an ultra-thin section of vitrinite as a function of wave-energy in the ultra-violet and visible. (High-volatile *A* bituminous coal, Pittsburgh bed-section, 550 Å. thick)

tion, is defined at wave-length λ_0' by $k = \lambda_0 \ln(I_0/I)/4\pi t$, and is equal to the product of refractive index and absorption index. Extinction coefficients for the Pittsburgh vitrinite are shown in Fig. 2 as a function of wave-energy and wave-length.

Ultra-violet and visible light cause the excitation of π electrons and free electron pairs. The electronic excitation is usually accompanied by the excitation of vibrational transitions, and hence absorption bands instead of lines are obtained when solids are examined. Figs. 1 and 2 show that the Pittsburgh vitrinite absorbs a considerable amount of light in the ultra-violet and visible regions. The absorption observed here is larger than that reported for a pyridine extract (in pyridine solution) of the same vitrinite[5]. The larger absorption appears to be reasonable when it is considered that the extract contained more hydrogen, and probably was composed of less-complex molecules than the vitrinite itself. Comparison of the above absorption with those of aromatic compounds indicates that the vitrinite studied contained major amounts of condensed aromatic structures.

High absorption by this coal in the visible region seems noteworthy. It may be caused by presence of structures similar to highly conjugated compounds containing oxygen or to polymerization of polycyclic hydrocarbon structures of 1–5 condensed rings. For example, rubicene, which may be regarded as a polymer of two benzene and one anthracene molecules, absorbs intensely in the red, indeed more than dinaphthocoronene, a ten-ring compound. The long wave-length edge of absorption, denoted by $A_{1g} \rightarrow B_{2u}$ in group theory notation, occurs at 2600 Å. in benzene and shifts progressively toward the red as the number of rings in the molecule increases[6].

The extinction coefficients obtained by Friedel and Queiser[2] for the Pittsburgh vitrinite are 3–4 times lower than those found here. These workers used hand-ground sections probably 3–5-μ thick on the average. We have attempted to prepare ground sections a few microns thick that would be suitable for accurate absorption measurements, but so far have been highly uncertain of effective thickness owing to the presence of very thin areas, scratches or holes in such sections. The possibility was considered that a 'skin' effect resulting from oxidation of the surfaces cut might exist and result in increased absorption. Identical extinction coefficients were obtained when another section of this coal 1060 Å. thick was employed. Furthermore, for other coals, thicknesses ranging from 500 to 1500 Å. had no influence on extinction coefficients, and identical refractive indexes were obtained for 500–1500 Å. and 1–2-μ thick sections. Therefore, it appears that such a 'skin' effect is not significant.

The present absorption results are not inconsistent with earlier X-ray diffraction results[7]. When analysed on the basis that the diffraction peaks at high angles were produced by two-dimensional reflexions of aromatic structures, the X-ray patterns showed that the average layer size was 7·0 Å., corresponding to 3–5 condensed rings. However, vacuum distillation of this vitrinite produced a distillate and residue showing X-ray patterns corresponding to a layer size of 5·8 Å. (1–3 rings)[7]. If the larger layers of the untreated vitrinite result from coplanar coalescence of smaller units or consist of imperfect larger aromatic structures, this vitrinite may be considered a polymer of small, partially oriented condensed aromatic units. However, an authentic analysis of aromatic and tetrahedral structures in coal will await more rigorous and detailed X-ray studies.

SABRI ERGUN
J. T. McCARTNEY
R. E. WALLINE

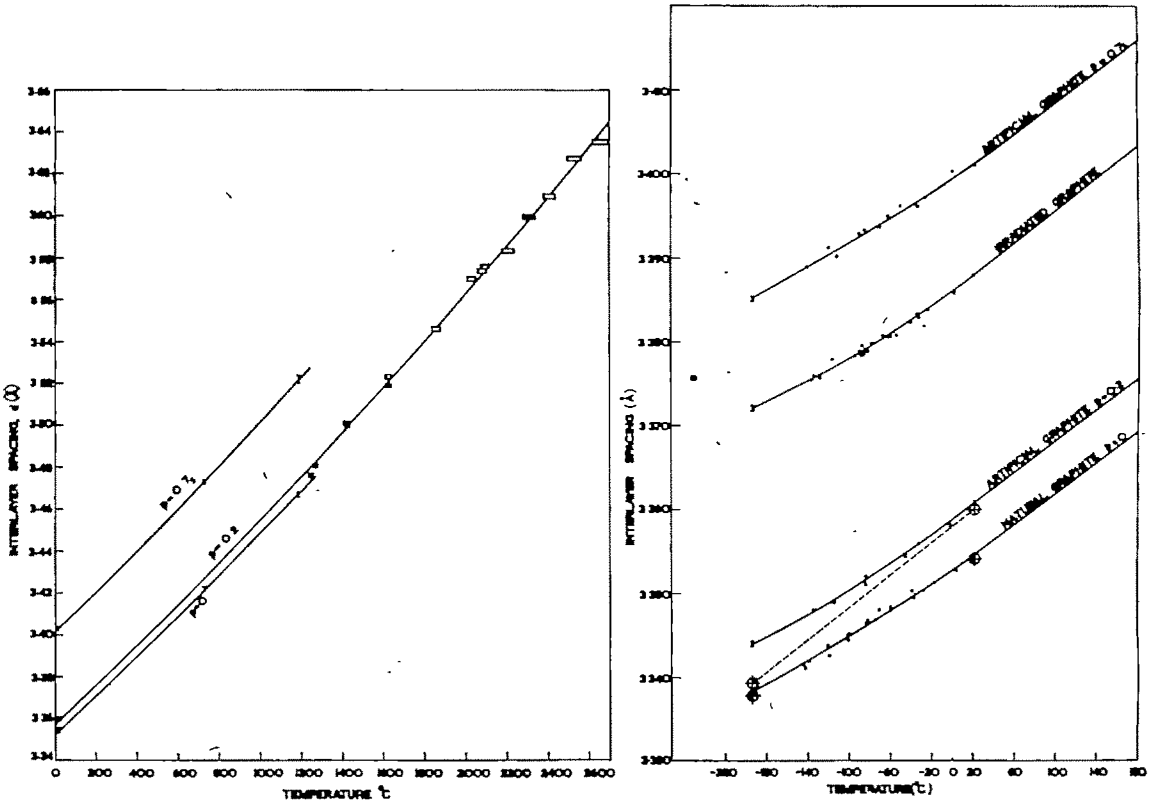
Special Coal Research Section,
Pittsburgh Coal Research Center,
U.S. Bureau of Mines,
Pittsburgh,
Pennsylvania.

[1] Ergun, S., and Tiensuu, V. H., *Acta Cryst.*, 12, 1050 (1959).
[2] Friedel, R. A., and Queiser, J. A., *Fuel*, 38, 369 (1959).
[3] McCartney, J. T., and Ergun, S., "Refractive Index and Thickness of Ultra-thin Sections of Coals and Graphite by Interferometry" (manuscript in preparation).
[4] McCartney, J. T., and Ergun, S., *Fuel*, 37, 272 (1958).
[5] de Ruiter, E., and Tschamler, H., *Brennstoff Chem.*, 39, 362 (1958).
[6] Humphreys-Owen, S. P. F., and Gilbert, L. A., "Industrial Carbon and Graphite" (Society of Chemical Industry, London, p. 40, 1958).
[7] Ergun, S., *Fuel*, 37, 365 (1958).

Dependence on Temperature of the Interlayer Spacing in Carbons of Different Graphitic Perfection

IN a previous communication[1], attention was directed to important inconsistencies and gaps in the literature concerning thermal expansion in graphitic carbons perpendicular to the hexagonal layer-planes. Preliminary experiments were reported, and, while these clarified the picture to some extent, the need for further experiments at higher (above 1,200° C.) and lower (below 20° C.) temperatures was indicated. Special diffractometer techniques required for these measurements have now been developed and will be described elsewhere: meanwhile, the extended results are reported.

In Fig. 1*a* measurements made at temperatures up to 2,600° C. are given for a material having a p value (the proportion of disoriented layers) of 0·2. This now clearly establishes a non-linear relationship between interlayer-spacing d (Å.) and temperature t (° C.): the empirical equation over the range 0°–2,600° C. (for $p = 0{\cdot}2$) is $d = 3{\cdot}357 + 91{\cdot}9 \times 10^{-6}\, t + 5{\cdot}3 \times 10^{-9}\, t^2$. For $p = 0$ and $p = 0{\cdot}7_5$, measurements[1] up to 1,188° C. indicate essentially similar curves translated parallel to the temperature axis, and it would seem that while the rate of expansion is dependent on the interlayer spacing it is not signifi-



(*a*) (*b*)

Fig. 1. Interlayer spacings at (*a*) high and (*b*) low temperatures. ⊕ denotes points due to Baskin and Meyer (ref. 3)

cantly dependent, for a given spacing, on stacking disorder.

In Fig. 1*b* measurements at temperatures down to −196° C. for materials having $p = 0$, $0 \cdot 2$ and $0 \cdot 7_1$ are shown. Also included are results for neutron-irradiated graphite having $p = 0 \cdot 2$, $d = d_1 = 3 \cdot 358$ (20° C.) Å. before irradiation, and $d = d_2 = 3 \cdot 388$ (20° C.) Å. after irradiation: with this material the small amount of irradiation produced little or no change in p as assessed from modulation of *hk* bands, while interstitials resulted in the increase in the average interlayer spacing[2]. The results in Fig. 1*b* give experimental support to the suggestion made previously[1] that for carbons of different graphitic perfection there will be different limiting distances of closest approach between the layers, with decreasing temperature. For $p = 0$, while the interlayer spacing at −196° C. agrees with that reported by Baskin and Meyer[3], the present results show the expected[1] gradual 'levelling-off' rather than the abrupt change in slope implied by those investigators: for $p = 0 \cdot 2$ a 'levelling-off' is again in evidence and the limiting spacing appears to be larger than that found by Baskin and Meyer. Results for $p = 0 \cdot 7_1$ are seen to be consistent with the general picture. With *n*-irradiated graphite, the results are interesting in that the interstitials, which have caused a certain increase in interlayer spacing (from d_1 to d_2) without deterioration in perfection of layer-stacking ($p = 0 \cdot 2$), have had essentially the same effect on the low-temperature behaviour as the greater stacking disorder of an unirradiated less-graphitic carbon ($p = 0 \cdot 6$) having the larger interlayer spacing (d_2).

Consideration of the family of curves for varying perfection over the extended temperature-range (−196° to 2,600° C.) shows that, while the high-temperature behaviour is controlled mainly by the interlayer spacing alone, low-temperature rate of expansion for a given spacing becomes dependent on imperfections and stacking disorder effects.

By adding a term to the quadratic equation given above for the range 0–2,600° C., it is possible to describe both the low- and high-temperature data by a single expression. For example, a term of the type $\frac{A}{(t+B)^n}$, with n a reasonably large number, gives the 'levelling-off' at low temperature and leaves the high-temperature behaviour still essentially described by the original quadratic. Curves for different p values are then derived by using the known (room-temperature) d–p relationships[4].

Further work should include consideration of the lattice dynamics.

We are pleased to acknowledge the assistance of Mr. M. W. Taylor in obtaining these results.

E. G. Steward
B. P. Cook
E. A. Kellett

Research Laboratories,
The General Electric Co., Ltd.,
Wembley,
England.

---

[1] Steward, E. G., and Cook, B. P., *Nature*, 185, 78 (1960).

[2] Bacon, G. E., and Warren, B. E., *Acta Cryst.*, 9, 1029 (1956).

[3] Baskin, Y., and Meyer, L., *Phys. Rev.*, 100, 544 (1955).

[4] Bacon, G. E., *Acta Cryst.*, 4, 558 (1951).

RADIOPHYSICS

Ionospheric Information from Satellite Signals

THE observation of radio signals from Earth satellites has opened up a new field of investigation for the examination of the ionosphere, particularly above the height of maximum ion concentration. The simplest features to observe are the fading-rate of signals resulting from the different phase paths of the ordinary and extraordinary rays, and the Doppler frequency shift.

To derive ionospheric information from a record of a single satellite transit requires very accurate observations and rather involved calculations, and the results derived in this way confirm the notorious variability of the ionosphere in both time and space.

Where an adequate series of observations is available, however, much useful information can be obtained very simply from the fading-rate. This rate, often referred to, rather loosely, as the 'Faraday fading' rate, is essentially a measure of the total ionization in the path from satellite to receiver. If a mean value is derived at the time of nearest approach, most of the minor variations are sufficiently smoothed out and even the transverse propagation dip[1] can be neglected except in low latitudes. The rate is not critical, as the Doppler shift is, of the closeness of the transit to overhead, so that a series of records over a few days can be used to obtain mean values. Moreover, in a consistent series of observations, it is possible to obtain a significant fading-rate even when much of the pattern is distorted by irregularities and diffuseness which, in themselves, are useful indications of ionospheric anomalies.

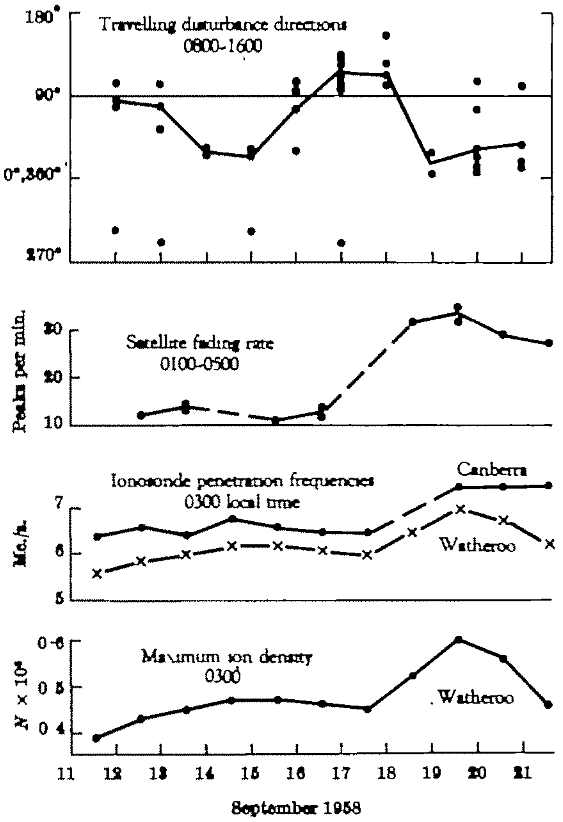


Fig. 2. Ionization changes during September 1958

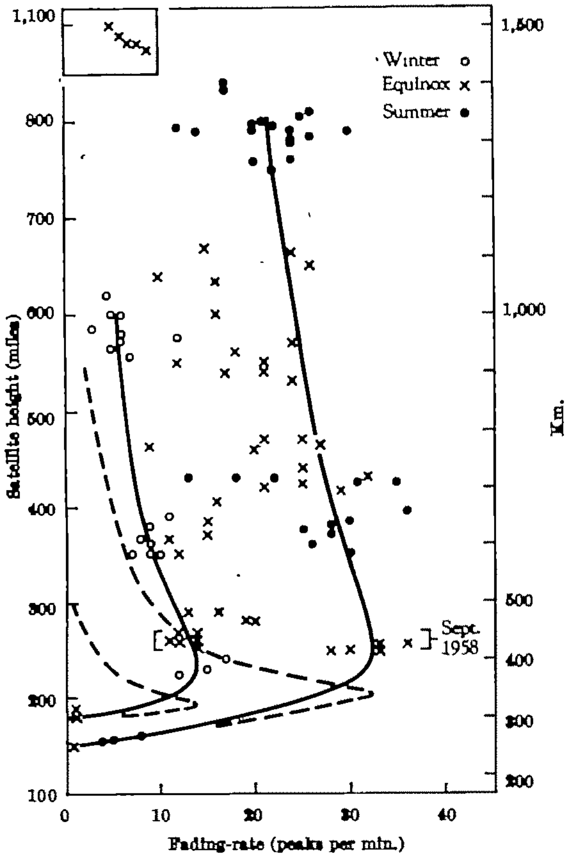


Fig. 1. Satellite signal fading-rates, June 1958–July 1960, 0100–0500

It is thus possible from regular observations at different times and heights to build up mean 'fading-rate profiles' for any particular observing site. These can then readily be converted to ionization profiles by comparison with corresponding ionosonde recordings, and deviations and their causes can then be studied.

Results derived in this way from two years observations of signals in the 20 Mc./s. band from the satellites *Sputnik III* (1958 Delta 1), *Explorer VII* (1959 Iota 1) and *Sputnik IV* (1960 Epsilon 1) are shown in Fig. 1 plotted as fades per minute against satellite height. Nearest approach times were obtained from Doppler shift records taken simultaneously by a method previously described[2]. Each point plotted represents the mean rate for a particular transit. These observations are for the period 0100–0500 local time when no direct solar influence is present and the decay in ionization is slow. The most obvious feature is the difference between the summer and winter distributions, and different symbols have accordingly been used for summer (November–January), winter (May–July) and the other months classed as equinoctial. Mean fading-rate curves are shown as full lines and the corresponding ionization profiles for summer and winter derived from them graphically in arbitrary units are indicated as dotted lines. The ratio of the summer and winter maxima of ionization is in good agreement with that obtained from ionosonde data.

The features so far mentioned will be dealt with in detail in future papers, and the main purpose of this communication is to report the remarkable result in September 1958 when the rate increased practically from winter to summer values within two days when the satellite was at a height of approximately 400 km.

An abrupt seasonal change in the ionosphere at this time of the year has been known for many years and has been consistently observed in travelling disturbance studies[3]. An examination of the available records for September 1958 did indeed show a marked change in direction of movement at this time, and also a correspondingly marked rise in critical frequency at Australian ionosonde stations. These results are shown in Fig. 2. There are some gaps in the data, but the conclusion is clear. It appears that the directional change occurred first, followed a day later by the change in rate, with the critical frequency change becoming obvious a day later again. Some fluctuation in direction after the main seasonal change is usual.

This sequence suggests a major change in the movement of ionization at this epoch which appears to be consistent with a reversal of the north–south seasonal component of drift indicated by travelling disturbances. Since this change occurred during the Geophysical Year, examination of records at other sites should yield interesting information. A magnetic storm of world-wide incidence but short duration occurred about this time, and its relation to the general change is being examined.

These results indicate the value of simple satellite observations, as a supplement to ionosonde recordings, for ionospheric studies and predictions. The 20 Mc./s. frequency band seems very satisfactory and an orbit such as that of *Explorer VII* is particularly suitable. Its height-range is 350–670 miles and this is swept through every 50 days in each transit at any site. The type of transmission used—continuous-wave with frequency modulation—is also satisfactory. The pulsed transmissions from *Sputnik III* made counting difficult at high rates, but short closely spaced pulses, as used in part of the coding of *Sputnik IV*, would be satisfactory and would enable study of multiple paths. Occasional breaks would be useful also for this purpose and for comparison of spaced receiver records. Telemetry information could also be conveyed as at present.

G. H. MUNRO

Radio Research Board Laboratory,
Electrical Engineering Department,
University of Sydney.

[1] Munro, G. H., and White, R. B., *Nature*, 181, 104 (1958).

[2] Munro, G. H., and Heisler, L. H., *Nature*, 183, 809 (1959).

[3] Munro, G. H., *Aust. J. Phys.*, 11, 1, 91 (1958).

Observations of 'Whistlers' and 'Chorus' at the South Pole

WHISTLERS and chorus are now being observed at the South Geographic Pole (79° geomagnetic), and the seasonal and diurnal variations in occurrence of these phenomena at this unique location follow interesting and perhaps significant patterns.

Maximum chorus activity occurred during the midsummer period, gradually diminished through February and March, and virtually disappeared when the Sun dropped below the horizon. Despite this seasonal dependence on solar zenith angle, there was a surprising and considerable diurnal variation in both strength and occurrence of chorus with a consistent maximum between 1500 and 1600 U.T. corresponding to approximately 1000 hr. local magnetic time.

No whistlers were apparent during the summer period, and it was not until March 8 that the first whistler was heard. Whistlers became quite prevalent after sunset, and the rate of occurrence increased through April and May to reach a maximum during the winter solstice. A considerable and consistent diurnal variation is apparent with maximum activity centred about 0630 U.T.

Although detailed characteristics of these polar whistlers cannot be determined until the tape recordings are available for spectrographic analyses, aural monitoring indicates that they generally resemble whistlers at lower latitudes. Pure tones, swishes and multiples are most common. Echo trains with about 2½ sec. delay between events were heard on May 10 and May 31. The rate of occurrence at Pole Station (averaging 2–3 per min. during active periods) is comparable with typical whistler-rates at middle-latitude stations.

Judging from the observed characteristics of these polar whistlers, it appears that they could have been produced at lower latitudes, reaching the receiver by reflexion between the Earth and lower ionosphere[1,2]. The seasonal and diurnal variations in the occurrence of whistlers at the South Pole may therefore be due to the seasonal and diurnal variations in *D* region absorption over the path of propagation. Assuming that the whistlers are propagated more readily along the path of least absorption, the diurnal peak at 0600 U.T. at Pole Station suggests that the whistlers penetrate the ionosphere somewhere along the 70° meridian, probably in the vicinity of Graham Land, approximately 55° south geomagnetic latitude. In middle latitudes whistler-rates are generally higher at night and in local winter, and therefore consistent with the hypothesis that *D* region absorption affects whistler propagation. If this interpretation is correct, coincidence should exist between whistler occurrences at South Pole Station and Port Lockroy. This will be investigated when the recordings from both stations are available for analyses.

The origin, or origins, of chorus are not fully understood. The seasonal variation of this phenomenon at the South Pole, with maximum activity occurring in midsummer, suggests direct dependence on solar radiation. It seems probable, therefore, that the polar chorus signals are initiated by solar corpuscular radiation impinging on the outer ionosphere.

The association between very-low-frequency hiss and aurora observed at Byrd Station, Antarctica, is also apparent at Pole Station[3]. However, whereas the auroral hiss observed at Byrd Station usually centres about a frequency of 8 kc./s., at Pole Station, 10° higher in geomagnetic latitude, the auroral hiss centres about 9·5 kc./s. This change in frequency of aurora-associated hiss with latitude is interesting. At 42° south geomagnetic Ellis[4] has associated very-low-frequency noise at 4–6 kc./s. with aurora, and current investigations also indicate that the frequency of aurora-associated hiss may decrease with geomagnetic latitude.

The very-low-frequency observations at Pole Station are being made by Oliver C. Morse of the United States Antarctic Research Program. The

work reported in this communication is supported by National Science Foundation Grant G-9511.

L. H. Martin

Radioscience Laboratory,
Stanford University,
Stanford, California.

[1] Martin, L. H., *Nature*, 181, 1796 (1958).

[2] Ungstrup, E., *Nature*, 184, 806 (1959).
Martin, L. H., Helliwell, R. A., and Marks, K. R., *Nature*, 187, 751 (1960).

[4] Duncan, R. A., and Ellis, G. R., *Nature*, 183, 1618 (1959).

GEOLOGY

Olivine–Spinel Transition on Nickel Orthosilicate

The pressure-induced transition of olivine to a denser spinel structure is probably of considerable importance in the Earth's mantle[1]. Olivine–spinel transitions are known in Mg_2GeO_4 (refs. 2 and 3) and Fe_2SiO_4 (ref. 1), while a variety of evidence indicates that Mg_2SiO_4 will undergo a similar transition around 125,000 atmospheres and 600° C. (refs. 1 and 3). These results suggested the desirability of exploring for olivine–spinel transitions in other substances which normally crystallize with an olivine structure.

Such a substance is nickel orthosilicate—Ni_2SiO_4. From preliminary[1] and recent (Ringwood, A. E., unpublished results) data on the solid solubility of Ni_2SiO_4 in Ni_2GeO_4 (spinel) and vice versa, I have calculated that Ni_2SiO_4 should undergo an olivine–spinel transition around 54,000 atmospheres at 1,500° C. However, Wentorf[4] has recently reported unsuccessful attempts to synthesize a spinel modification of Ni_2SiO_4 at pressures up to 110,000 atmospheres. I have carried out further high-pressure experiments using a uniaxial pressure apparatus (squeezer), in an attempt to resolve the conflict, and provide further information on olivine–spinel transitions.

Intimate mixtures of $Ni(OH)_2$ and silicic acid in orthosilicate ratios were prepared, and subjected to pressures between 0 and 50,000 atmospheres, at 650° C., for periods between 1 and 6 hr. Fourteen runs were made. After completion of a run, the pressure was rapidly released, while the sample was quenched and then examined by X-ray diffraction.

At pressures below 15,000 atmospheres the phases observed were Ni_2SiO_4 olivine, NiO, and nickel talc. It may be shown that the last two products constitute a metastable assemblage, due to incomplete reaction. Above 20,000 atmospheres, olivine disappeared and in its place a spinel phase appeared, together with NiO and talc. Between 15,000 and 20,000 atmospheres, spinel, olivine, talc and NiO appeared simultaneously. A run at 50,000 atmospheres, using a mix containing 20 per cent excess $Ni(OH)_2$ over that required to form the normal orthosilicate, produced spinel and NiO. Talc was absent.

A sample of Ni_2SiO_4 olivine was prepared by sintering a tablet of intimately mixed NiO and SiO_2 at 1,400° C. for 6 hr. The tablet was then crushed, reformed and resintered, this procedure being repeated twice. A sample thus prepared was subjected to 50,000 atmospheres and 700° C. for 2½ hr. About 80 per cent conversion to the spinel form was observed. Similar runs were carried out at 30,000 and 20,000 atmospheres. A small amount of spinel formed at 20,000 atmospheres, but curiously, no spinel formed at 30,000 atmospheres.

Mixtures of silicic acid, hydrous germanium dioxide, and nickel hydroxide were prepared at intervals in the composition range between Ni_2GeO_4 and Ni_2SiO_4. These were run at 33,000 atmospheres and 650° C. A complete series of spinel solid solutions was found to exist between Ni_2GeO_4 (normally a spinel) and Ni_2SiO_4. The solid solutions obeyed Vegard's law.

It is concluded that the new phase is the spinel modification of Ni_2SiO_4 and that the equilibrium pressure for the olivine–spinel transition in Ni_2SiO_4 at 650° C. is about 18,000 atmospheres. Ni_2SiO_4 spinel is green, transparent, and has a lattice parameter of 8·044 Å. The calculated density is 5·34 gm./c.c., which is about 9 per cent higher than that of the olivine modification.

The experimental transition pressure is in good agreement with the value calculated (54,000 atm.) from zero pressure equilibria at 1,500° C. in the system $Ni_2GeO_4 - Ni_2SiO_4$ if a reasonable allowance is made for the effect of temperature on transition pressure. A detailed description of equilibria in this system, and the calculations based upon it, will be published elsewhere.

Wentorf's failure to synthesize Ni_2SiO_4 spinel at much higher pressures than I used may be due to the different type of apparatus employed[4]. We both used mixtures of $Ni(OH)_2$ and silicic acid as starting materials, and operated at temperatures sufficiently high to cause the components to react and form Ni_2SiO_4. However, the uniaxial device which I used permits rapid quenching—in particular, the water vapour pressure can be instantaneously released. Published descriptions[5] suggest that Wentorf's apparatus may not have been able to quench the reaction products as quickly; furthermore, the quenching may be carried out in the presence of a high pressure of water vapour (from the pyrophyllite pressure medium). Thus it is possible that any spinel formed at high pressures afterwards became inverted to olivine during the quench.

A. E. Ringwood

Department of Geophysics,
Australian National University,
Canberra.
July 12.

[1] Ringwood, A. E., *Geochim. et Cosmochim. Acta*, 13, 303; 15, 18, 195 (1958).

[2] Goldschmidt, V. M., *Nachr. Ges. Wiss. Göttingen*, 1, 184 (1931).

[3] Dachille, F., and Roy, R., *Amer. J. Sci.*, 258, 225 (1960).

[4] Wentorf, R. H., *Nature*, 183, 1617 (1959).

[5] Bovenkerk, H. P., Bundy, F. P., Hall, H. T., and Wentorf, R. H., *Nature*, 184, 1094 (1959).

Potassium–Argon Ages of Some Rocks from the South Atlantic

The ages of micas separated from a number of rocks from the South Orkney Islands have been determined using the potassium–argon method.

In these particular measurements, the total volume of argon evolved on fusion of the samples was measured by means of a McLeod gauge, and a correction applied for atmospheric contamination using a mass spectrometer to resolve the argon isotopes. Potassium analyses were made with a flame photometer.

All the rocks measured were quartz–mica–schists[1], eight from Signy Island and one from Moe Island nearby (composite sample contains Moe Island material *H*.1365.1). Analytical results and calculated ages are given in Table 1.

Table 1

Mineral	Ref. No.	Weight of sample (gm.)	K_2O (per cent)	Total argon (mm³)	Approximate age (m. yr.)
Biotite	*H*. 60.3	6.6570	4.22	0.177	176
Biotite	*H*. 86.1	12.0716	7.51	0.625	199
Biotite	*H*. 154.8	14.3500	8.38	0.877	188
Biotite	*H*. 164.2	7.3086	4.75	0.226	184
Biotite	*H*. 205.2	8.9206	5.13	0.323	195
Biotite	*H*. 507.3	6.2023	4.00	0.181	195
Muscovite	*H*. 507.3	6.9700	6.38	0.306	176
Biotite	*H*. 1,369.1	6.2587	4.12	0.173	189
Biotite	*H*. 1,365.1 *H*. 1,384.1	7.3328	6.23	0.39	193

$\lambda_\beta = 4.76 \times 10^{-10}$ yr.$^{-1}$. $\lambda_e = 0.585 \times 10^{-10}$ yr.$^{-1}$.

Errors in the results arise from inaccurate measurement of the volume, in the estimation of potassium, or in measuring the argon-40/argon-36 ratio. In these measurements, a 1 per cent error in either the proportion of potassium oxide or the volume of radiogenic argon would result in a 1 per cent error in the age. The errors introduced in correcting for atmospheric contamination may be neglected. The total error of measurement is estimated to be less than ± 5 per cent.

The similarity between all the ages so far measured suggests that argon has not been released by recent weathering. They indicate a Lower-Jurassic–Upper-Triassic age[2] (Jurassic 135 ± 5 to 180 ± 5 m. yr., Triassic 180 ± 5 to 225 ± 5 m. yr.) either for the original metamorphism of the schists or for some subsequent metamorphism sufficiently intense to have released their radiogenic argon. The basement schists in the South Orkney Islands are overlain by intensely folded greywackes thought to be of carboniferous age[3], and by slightly folded conglomerates of Mesozoic age[4]. Results from the potassium–argon work are consistent with the hypothesis that radiogenic argon already present was released from the schists during the orogeny which folded the overlying greywackes. No mineralogical evidence of retrograde metamorphism of the schists of Signy Island has been reported.

Thanks are due to the Falkland Islands Dependencies Survey and Dr. R. J. Adie for providing the specimens used in this work, from their collection at the University of Birmingham, and to the Department of Scientific and Industrial Research for financing this work. I am indebted to D. H. Matthews of the Department of Geodesy and Geophysics, Cambridge, for suggesting to me the problem and its geological interpretation.

JOHN A. MILLER

Department of Geodesy and Geophysics,
Madingley Rise,
Madingley Road,
Cambridge.

---

[1] Tilley, C. E., "Report on Rocks from the South Orkney Islands". "Discovery" Report *X*, 333 (1935).

[2] Holmes, A., *Trans. Edin. Geol. Soc.*, 17, Pt. 3, 183 (1959).

[3] Adie, R. J., "The Petrology of Graham Land III. Metamorphic Rocks of the Trinity Peninsula Series". Falkland Islands Dependencies Survey Scientific Reports, No. 20, 21 (1957).

[4] Matthews, D. H., *Geol. Mag.*, 96, No. 6, 425 (1959).

Age of the Cambrian System

RECENT contributions by Wetherill[1] and Holmes[2] lay stress upon studies of the brannerite (so-called 'absite') from Crocker Well, South Australia, as affording critical evidence on the age of the base of the Cambrian System, but dispute the interpretation of the various results (in the range 520–915 million years) arrived at in dating this mineral. The publication of this discussion prompts me to report why these data from South Australia were ignored, as being irrelevant, in my own notes on the geological time-scale[3]. My conclusions were arrived at in the light of a first-hand knowledge of the Australian deposits, which I visited some years ago, and arose from the following considerations.

(1) Statements that the brannerite occurrences are overlain by Precambrian sediments of the Adelaide System are incorrect. The nearest sediments are six or seven miles away[4]. In these Precambrian strata, pebbles of granite are found which are akin to the adamellite forming the country-rock of the mineral deposits—but this in no way helps to fix the stratigraphical age of the brannerite unless this mineral can be shown to be contemporary with the country-rock.

(2) The samples of brannerite for which isotopic assays are available were not collected specifically for geochronological study with full records of paragenesis, but were presumably supplied out of a stock of concentrate from prospecting operations. It is thus not known whether they were derived from "porous shear zones", as claimed by some authors, or from the tight, breccia-like, stockworks of quartz veins which have formed the main source of the mineral. All the brannerite is amorphous due to metamictization. Consequently there is no geological basis for the several divergent hypotheses, postulating loss of radon due to rock porosity, or retention of radon due to well-defined crystallinity, adduced in argument about the discordant ages.

(3) In addition to brannerite the deposits also contain davidite, the two uraniferous titanates often being intimately intergrown. Greenhalgh and Jeffery[5] have shown that a specimen of this davidite, with an age of 1,600–1,700 m.y., is more than twice as old as the brannerite analysed.

(4) Throughout the whole Olary province, there are a great many occurrences of uranium mineralization (nearly all quite small), and the few that have been analysed isotopically show a wide range of ages. The oldest mineralization is roughly coeval with the great lead deposit of Broken Hill nearby. Both at Crocker Well and Radium Hill, primary uranium minerals bearing at least two widely divergent ages occur in a single ore deposit. In such cases it seems reasonable to attribute the younger datings to re-working, not necessarily as a result of late granitization but probably arising as a simple regeneration *in situ* in response to local tectonic conditions. Comparable regeneration is apparent in the Hercynian pitchblende deposits of Western Europe[6] and in many other uranium fields.

(5) There is no evidence that the latest period of regeneration at Crocker Well is Precambrian in age. Within the province there are many post-Proterozoic mineral veins cutting the strata of the Adelaide System, and the last re-working could be coeval with these lodes. The potassium : argon age of 520

m.y. reported by Greenhalgh and Jeffery[5] relates not to a biotite "hand-picked from the rock", as stated by Wetherill, but to a biotite "hand-picked from the brannerite". The two minerals occur intergrown in nests and may well have been re-constituted contemporaneously.

If these interpretations are correct, the brannerite mineralization is completely lacking in stratigraphical definition and contributes no information about Cambrian chronology. The dating of the base of the Cambrian System at about 600 ± 20 m.y., founded on other evidence, remains unassailed.

C. F. Davidson

Department of Geology,
University of St. Andrews.
August 3.

[1] Wetherill, G. W., *Nature*, 187, 34 (1960).

[2] Holmes, A., *Trans. Edin. Geol. Soc.*, 17, 183 (1960); *Nature*, 187, 35 (1960).

[3] Davidson, C. F., *Liverpool and Manchester Geol. J.*, 2, 311 (1960); *Nature*, 183, 768 (1959).

[4] Campana, B., and King, D., "Regional Geology and Mineral Resources of the Olary Province" (Dept. of Mines, Adelaide, 1958).

[5] Greenhalgh, D., and Jeffery, P. M., *Geochim. Cosmochim. Acta*, 16, 39 (1959).

[6] Davidson, C. F., *Econ. Geol.*, 55, 383 (1960).

CHEMISTRY

A Molecular Complex of Benzene and Hexafluorobenzene

In the course of experiments using mixtures of benzene and hexafluorobenzene, it was observed that a solid was formed on mixing these two substances although this frequently disappeared before the mixing process was complete. This observation has been followed up by the investigation of the freezing points, obtained from cooling curves, of mixtures of known composition of benzene and hexafluorobenzene.

The freezing-point diagram shows two eutectic points occurring at mole fractions of 0·15 and 0·85 of hexafluorobenzene, and melting at about 0·5° C. and −5·5° C. respectively. The diagram shows a maximum melting point of 23·7° C. corresponding to a mixture containing equimolar quantities of the two substances. Benzene and hexafluorobenzene have similar melting points (5·4° C. and 5·0° C. respectively). This clearly demonstrates the formation of a 1 : 1 molecular complex of the two compounds. Less-complete freezing-point diagrams have been obtained for the systems hexafluorobenzene and fluorobenzene, and pentafluorobenzene and benzene. The first of these shows evidence of the formation of a 1 : 1 complex of hexafluorobenzene and fluorobenzene melting at about −3° C., that is, above the melting point of fluorobenzene but below that of hexafluorobenzene. No solid complex appears to be formed between pentafluorobenzene and benzene. The complexes seem to be similar to that formed as a low-melting white solid on mixing aniline and hexafluorobenzene[1].

These complexes may be regarded as examples of the Lewis base–Lewis acid (electron donor-acceptor) or charge-transfer type, of which those between picric acid and a number of aromatic compounds, and between, for example, benzene and *sym*-trinitrobenzene[2], are familiar examples. Fluorine atoms show a strong negative inductive effect which is reflected by the observation that the ionization potentials of polyfluorobenzenes are higher than that of benzene[3], and by the behaviour of polyfluorobenzenes in chemical reactions. In showing a negative inductive effect, the fluorine atom resembles the nitro group, and it is likely that the conditions in polynitrobenzenes which favour the formation of complexes will also occur in polyfluorobenzenes. The substitution of groups showing a positive inductive effect in the 'basic' partners of the complexes should increase the stability of the complexes with hexafluorobenzene. A complex, melting at 34°, has been prepared from hexafluorobenzene and mesitylene. This complex, unlike that between hexafluorobenzene and benzene, is sufficiently stable to allow its crystallization from ether. A similar complex, melting at 56° C., has been obtained between hexafluorobenzene and 2-methylnaphthalene, and this also is sufficiently stable to allow its crystallization from ether.

Complexes of this type are generally characterized by a charge transfer spectrum. In the expectation that a transfer spectrum such as that observed (in the region 2800–3400 Å.) in the case of the complex between benzene and *sym*-trinitrobenzene would be found, a preliminary investigation has been made of the spectra of neat mixtures of benzene and hexafluorobenzene. No absorption band has been found in the region 2900–4000 Å., where the two liquids do not themselves absorb light. The spectra of mixtures of the two compounds have been measured in the region 2300–3000 Å. using ethanol and hexane as solvents. No absorption bands were observed other than those due to benzene and hexafluorobenzene, but it is probable that the concentrations used were too small to allow the formation of significant concentrations of the complex.

C. R. Patrick
G. S. Prosser

Chemistry Department,
The University,
Edgbaston,
Birmingham, 15.

[1] Brooke, G., Burdon, J., Stacey, M., and Tatlow, J. C., *J. Chem. Soc.*, 1768 (1960).

[2] Lawrey, D. M. G., and McConnell, H., *J. Amer. Chem. Soc.*, 74, 6175 (1952).

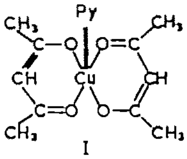
[3] Major, J. R., and Patrick, C. R. (unpublished work). Price, W. C., *et al.*, *Proc. Roy. Soc.* (in the press).

Structure of the 1 : 1-Adducts of Cupric β-Diketone Chelates with Heterocyclic Bases

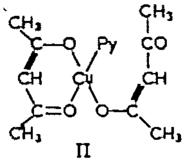
In a recent communication, Traill[1] raises the question of the structure of the 1 : 1-adducts formed by cupric β-diketone chelates with heterocyclic bases in organic solvents[2]. The same question has been raised privately by others, and it seemed, therefore, that we should seek some further evidence in support of the 5 : co-ordinated structure (I) originally proposed as against the 4 : co-ordinated structure (II) suggested by Traill.

The original attribution of structure I to these adducts was essentially intuitive, and as their low stability makes isolation improbable, a definitive structure determination seems unattainable. We believe, however, that the weight of available evidence strongly favours structure (I).

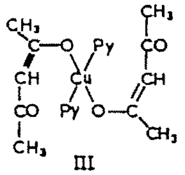
(1) The stability of acetylacetonates and related compounds is largely due to chelation. If reaction



I



II



III

with heterocyclic bases may result in the opening of a chelate ring, it is difficult to see why only one ring should be opened, giving (II) rather than both rings giving (III), or even complete displacement giving salts of the type $[Cu(C_5H_5N)_4]^{2+}$ 2(acac)⁻.

(2) Replacement of an oxygen donor by a heterocyclic base normally results in a shift of ligand-field bands to shorter wave-lengths. In this case the shift is very slightly to longer wave-length, an effect paralleled by co-ordination of a fifth ammonia molecule to the $[Cu(NH_3)_4]^{2+}$ ion[3] and in other cases of extension of formally 4 : co-ordinated species to 5 : co-ordination.

(3) Gaussian analysis of the absorption spectra of cupric ethyl-acetoacetate in solvents which do not form adducts shows that the broad absorption band in the visible region consists of two bands with maxima about 550 mμ and 710 mμ; but when the heterocyclic base adducts are formed, the band at 550 mμ disappears and a new band appears at about 900 mμ. Such drastic changes in the ligand-field absorption would not be explicable if the adduct had structure (II), in which the environment of the copper atom is fundamentally unchanged, but is consistent with the formulation of the adducts as 5 : co-ordinated species[4].

(4) In seeking further evidence for the structure of these adducts, we have now examined the infra-red absorption of *M*/40 chloroform solutions of cupric acetylacetonate and cupric ethyl-acetoacetate, and of the same solutions containing *M*/2 γ-picoline (chosen because it gives more complete adduct formation with the minimum concentration of heterocyclic base—under these conditions adduct formation is about 90 per cent complete). In the region 1,500–1,620 cm.⁻¹, metal β-diketone chelates show two very strong absorption bands, which are characteristic of the chelate ring system, as they do not appear in keto or enol forms of the free β-diketones or in acetyl-acetone acetate[5]. Opening of one of the two chelate rings to give (II) should thus be accompanied by a halving of the intensities of these bands. These bands are reported in the acetylacetonates of chromium-(II) and chromium-(III) (ref. 6) at 1,567–9 cm.⁻¹ and 1,517–8 cm.⁻¹ and of cerium-(III) (ref. 7) at 1,562 and 1,510 cm.⁻¹. In our complexes they are observed as follows:

	ν_1	ε_1	ν_2	ε_2
Cupric acetylacetonate	1,577	380	1,525	530
Cupric acetylacetonate/picoline	1,577	460	1,525	500
Cupric ethyl-acetoacetate	1,597	525	1,522	675
Cupric ethyl-acetoacetate/picoline	1,597	475	1,522	600

where ε is the extinction per mole of β-diketone.

While the accuracy of the extinctions is not high, due to heavy background absorption by the heterocyclic base, it is apparent that they remain almost unchanged, as required for structure (I).

D. P. GRADDON
E. C. WATTON

Inorganic Chemistry Department,
University of New South Wales, Sydney.

---

[1] Traill, R. C., *Nature*, 186, 631 (1960).

[2] Graddon, D. P., *Nature*, 183, 1610 (1959).

[3] Bjerrum, J., Ballhausen, C. J., and Jørgensen, C. K., *Acta Chem. Scand.*, 8, 1275 (1954).

[4] Graddon, D. P., *J. Inorg. Nucl. Chem.* (in the press).

[5] Weissberger, A. (ed.), "Technique of Organic Chemistry", 9, 494 (Intersci. Pub., New York, 1956).

[6] Costa, G., and Puxeddu, A., *J. Inorg. Nucl. Chem.*, 8, 104 (1958).

[7] Duval, C., Freymann, R., and Lecomte, J., *Bull. Soc. Chim.*, 19, 106 (1952).

Catalytic Racemization of *tris*(Ethylenediamine)Cobalt(III) Ion

ALTHOUGH the optical isomers of the *tris*(ethylene-diamine)cobalt(III) ion, ($[Coen_3]^{3+}$), are stable indefinitely in aqueous solution at 100° C., complete racemization can be effected at 90° C. in 2 min. in the presence of activated carbon[1]. It has been proposed that racemization is a surface phenomenon, and no decomposition of the complex cation occurs[1]. More recently[2], the isomerization of lævo-*tris*(*l*-propylenediamine)cobalt(III) ion to the equilibrium mixture of the *d* and *l* forms of the complex cation was carried out with activated carbon in aqueous solution at 20° C. in 15 min. These reactions are obviously of the same nature as the rapid equilibration of mixtures of cobalt(III) complexes in various preparative procedures[3,4] brought about by activated carbon, for which no satisfactory explanation has yet been proposed.

We have found, after treatment in aqueous solution with activated carbon, cobalt(III) complexes in general, for example, *tris*(acetylacetone)cobalt(III), *tris*(glycine)cobalt(III), hexammine cobalt(III) ion, *tris*(oxalato)cobaltate(III) ion, invariably contain small amounts of cobalt(II) complexes. The amounts of the latter have been found to depend on the temperature, time of contact with, and the nature of the carbon, as well as the presence or absence of oxygen or air.

In a typical experiment, a solution (10 ml.) containing *d*-*tris*(ethylenediamine)cobalt(III) chloride (0·2 gm.) and activated carbon (B.D.H. gas-absorption) was boiled for 3 min. The optically inactive solution, after removal of the carbon, was made acid with sulphuric acid. The Co^{2+} ion, estimated with triphenylmethylarsonium thiocyanate[5], was found to be 4·2 per cent of the total cobalt. Under the same conditions, but in sulphuric acid (0·1 *N*), the rotation decreased by only 6 per cent, but substantially the same amount of Co^{2+} ion was found (4·0 per cent). Schwarz and Kronig, who first used charcoal as a catalyst in cobalt(III) complex equilibria, failed to detect any cobalt(II) complex or salt, and subsequent workers have overlooked the reducing properties of charcoal.

These observations suggest electron-transfer racemization proceeding through the labile $[Coen_3]^{2+}$ ion, which is decomposed by acid. The carbon appears to serve three functions: (*a*) as a catalyst for the conversion of a small amount of the spin-paired $[Coen_3]^{3+}$ ion to the activated spin-free paramagnetic state which it then (*b*) reduces to the spin-free $[Coen_3]^{2+}$

ion, and (c) as a catalyst for the electron transfer process:

$$d[\mathrm{Coen}_3]^{3+}\ \text{spin-paired} + l[\mathrm{Coen}_3]^{2+}\ \text{spin-free} \rightarrow l[\mathrm{Coen}_3]^{3+} + d[\mathrm{Coen}_3]^{2+} \rightleftharpoons l[\mathrm{Coen}_3]^{2+}$$

Activated carbon is known to be capable of effecting mild reductions in aqueous solution, for example, ferric to ferrous ion, but would not be expected to reduce the spin-paired [Coen$_3$]$^{3+}$ ion because of the negative potential of couple [Coen$_3$]$^{3+}$ spin-paired/[Coen$_3$]$^{2+}$ spin-free ($E_0 = -0·232$ V.)[3]. The potential of the couple [Coen$_3$]$^{3+}$ spin-free/[Coen$_3$]$^{2+}$ spin-free, in which both oxidation states are electronically equivalent, would be expected to be very much more positive.

Because of electronic non-equivalence, electron transfer between cobalt(II) and cobalt(III) complexes in aqueous solution is usually slow[6]. For example, the complete electron-transfer racemization of d[Coen$_3$]Cl$_3$ (0·0551 M) in the presence of d,l-[Coen$_3$]SO$_4$ (0·02 M) and ethylenediamine (0·24 M) in a nitrogen atmosphere at 25° C. required 8 days[7]. Activated carbon (2 gm. in 100 ml. of solution) catalysed the above reaction strongly, and all activity was lost in 2 min. at 25° C.

Racemization was also catalysed by freshly prepared platinum, palladium and rhodium black, and small amounts of cobalt(II) complex could be detected. In the presence of these metals a reducing agent was necessary. This could be adsorbed hydrogen, sulphite ion or even alcohol.

F. P. DWYER
A. M. SARGESON

John Curtin School of Medical Research,
Australian National University, Canberra.

---

[1] Douglas, B. E., *J. Amer. Chem. Soc.*, 76, 1020 (1954).

[2] Dwyer, F. P., and Garvan, F. L., *J. Amer. Chem. Soc.*, 81, 290 (1959).

[3] Bjerrum, J., "Metal Ammine Formation in Aqueous Solution", 235 (P. Haase and Son, Copenhagen, 1941).

[4] Bailar, J. C., and Work, J. B., *J. Amer. Chem. Soc.*, 67, 176 (1945).

[5] Ellis, K. W., and Gibson, N. A., *Anal. Chim. Acta*, 9 (3), 275 (1953).

[6] Lewis, W. B., Coryell, C. D., and Irvine, J. W., *J. Chem. Soc.*, Supp. Issue, 2, S386 (1949).

[7] Dwyer, F. P., and Sargeson, A. M. (to be published).

'Eddy' Diffusion in Chromatography

UNDER the above title, J. Calvin Giddings[1] has discussed the axial spreading of the solute in chromatographic columns which is responsible for the smearing of zones and in particular the contribution made to this by 'eddy' diffusion.

In 'eddy' diffusion the spreading of the solute is less than could be derived from random walk considerations applied to the carrier fluid, since the uneven velocity distribution causes radial concentration gradients, which by radial molecular diffusion tend to keep the solute closer together in the axial direction.

For turbulent flow in unpacked tubes the appropriate theory has been worked out by Taylor[2]. The velocity distribution in laminar flow also produces a spreading effect which is counteracted by radial diffusion. This case has also been examined by Taylor[3]. A generalized treatment for tubes of arbitrary cross-section and for arbitrary velocity profiles is due to Aris[4].

In our publication[5] on the statistical treatment of mechanisms causing axial spreading we have expressed the view (*loc. cit.*, p. 267) that the velocity distribution (in this case a parabolic one) and the radial molecular diffusion cannot be considered as being statistically independent, the reason being that the second process reduces the effect of the first. Giddings (*loc. cit.*) states that the two processes are independent.

For independent processes, when variances must be added, as we have explained, both the apparent diffusion coefficient D and the height H corresponding to an ideal stage have conserved the property of additivity, since they are proportional to the variance.

However, in order to obtain a reduction in D (or H), Giddings has introduced the additivity in a factor n occurring in the denominator in his equation (1) on the strength of a statement that n is the sum of numbers of steps for the two supposedly independent processes. We fail to see the statistical justification for this procedure.

The fact that, for proper a and b, the form:

$$1 \Big/ \left(\frac{1}{a} + \frac{1}{b}\right)$$

has the correct limits for $b \rightarrow \infty$ and $a \rightarrow \infty$ is of course insufficient to justify the treatment.

A. KLINKENBERG
F. SJENITZER

Bataafse Internationale Petroleum
Maatschappij N.V.,
Royal Dutch/Shell Group,
The Hague.

---

[1] Giddings, J. Calvin, *Nature*, 184, 357 (1959).

[2] Taylor, G. L, *Proc. Roy. Soc.*, A, 223, 446 (1954).

[3] Taylor, G. L, *Proc. Roy. Soc.*, A, 219, 186 (1953).

[4] Aris, R., *Proc. Roy. Soc.*, A, 235, 67 (1956).

[5] Klinkenberg, A., and Sjenitzer, F., *Chem. Eng. Sci.*, 5, 258 (1956).

VARIANCES add[1], for certain independent processes which, by virtue of an elementary random event, contribute directly to the variance. Lateral diffusion is not such a process. The variance is caused by non-equilibrium established by the difference in downstream velocity from point to point. Lateral diffusion acts to reduce this variance as can be seen by the inverse relationship between variance or plate height and diffusion coefficient. The random change in velocity which occurs along a given stream path, as found in packed columns but not in capillary columns, also reduces the variance. Both factors act independently to exchange molecules between fast- and slow-moving regions.

The fact that independent processes do not necessarily contribute additive terms to the variance can be seen by use of a simple example which, unlike the above, can be accounted for in an exact fashion. Let the transition between two discrete species, A_1 and A_2, with downstream velocities v_1 and v_2 occur by two independent mechanisms. The forward and reverse rate constant for the first mechanism are k_1 and k_2, respectively, and for the second mechanism, k_1' and k_2'.

Using a method developed elsewhere[2] for obtaining asymptotic expressions for plate height with complex kinetics, we obtain:

$$H = \frac{2R\,(1-R)\,(v_1 - v_2)}{k_2 + k_2'}$$

where R, the ratio of average solute to average fluid velocity, is an equilibrium property. Rate effects appear only in the denominator, and, in fact, are additive in the denominator as proposed for eddy diffusion[3]. We see that "the second process reduces the effect of the first"[1], but the processes are, none the less, physically independent. This fact in no way depends upon having a single-step mechanism. If solute molecules are shuttled laterally by two independent diffusion processes, it can be shown[1], as expected, that the diffusion coefficients add in the denominator, one reducing the effect of the other. In close analogy with eddy diffusion, both diffusion processes "act independently to exchange molecules between fast- and slow-moving regions". It is, in fact, possible to assign an effective coefficient of lateral diffusion (even though lateral diffusion, as such, is not necessarily involved) to describe the effect of velocity variations along a streamline. A close analysis of this shows that the effective diffusion coefficient varies with the distance across the interstice while the molecular diffusion coefficient is constant[4]. At any point these two are additive in the denominator, but the addition of the averages of the two, and this is essentially what was done in the earlier treatment[3], is an approximation. I am at present looking for an improvement of the admittedly approximate derivation previously given.

J. CALVIN GIDDINGS

Department of Chemistry,
University of Utah,
Salt Lake City 12, Utah.

[1] Klinkenberg, A., and Sjenitzer, F. (previous communication).

[2] Giddings, J. C., *J. Chem. Phys.*, **31**, 1462 (1959).

[3] Giddings, J. C., *Nature*, **184**, 357 (1959).

[4] Giddings, J. C., *J. Chromatography* (in the press).

BIOCHEMISTRY

Exclusion of Inulin from Solutions of Hyaluronic Acid

THE partition of inulin between buffer and solutions containing hyaluronic acid has been observed by dialysing inulin to equilibrium between the two solutions. 'Millipore *HA*' membranes were used which are readily permeable to inulin but impermeable to hyaluronic acid. The hyaluronic acid was prepared from ox synovial fluid by the method of Ogston and Stanier[1]; inulin was Kerfoot biochemical reagent twice 'recrystallized' from dilute ammonia.

The partition depended on the concentration of hyaluronic acid according to $\log K = 2w$, where K is the ratio of concentration of inulin in buffer to that in the hyaluronic acid solution at equilibrium and w is the weight of hyaluronic acid/100 ml. The partition was independent of the concentration of inulin, the direction of equilibration, *p*H and ionic strength. Thus at $w = 0{\cdot}2$, $K = 2{\cdot}5$, and this can be thought of as the exclusion of inulin from 60 per cent of the volume of the hyaluronic acid solution. These results have a bearing on the use of inulin for determining the volumes of tissue spaces.

The effect is not peculiar to inulin, but is shown by other carbohydrates and by proteins, to degrees depending on their effective molecular volumes; this suggests that the mechanism of exclusion is steric.

This work was assisted by a Medical Research Council grant to one of us (C. F. P.). It will be published in full elsewhere.

A. G. OGSTON
C. F. PHELPS

Department of Biochemistry,
University of Oxford.

[1] Ogston, A. G., and Stanier, J. E., *Biochem. J.*, **46**, 364 (1950).

Alkaline C-1 Fructose-1,6-diphosphatase: Evidence for its Participation in Photosynthesis

PATHWAYS proposed for the conversion of carbon dioxide to hexose monophosphate during photosynthesis require the cleavage of the phosphate linked to carbon-1 of either fructose-1,6-diphosphate, or sedoheptulose-1,7-diphosphate, or both[1–3]. A C-1 alkaline phosphatase specific for fructose-1,6-diphosphate has been prepared from spinach leaves and characterized by Racker and Schroeder[3]. This enzyme was not thought to participate in photosynthesis since it did not appear to be localized in the chloroplasts. Recently it was reported[4] that pea chloroplasts isolated in various aqueous media lost about 90 per cent of their ribulose-1,5-diphosphate carboxylase, an enzyme considered to play an essential part in photosynthesis[1]. Since this finding indicated that photosynthetic enzymes were not necessarily retained in chloroplasts isolated by the usual procedures, the possible function and intracellular distribution of alkaline fructose-1,6-diphosphatase in photosynthetic tissues were re-investigated.

A survey of a number of plants and bacteria disclosed that alkaline fructose-1,6-diphosphatase was widely distributed in photosynthetic tissues. In addition to spinach[3] and pea[4] leaves, alkaline fructose-1,6-diphosphatase has been demonstrated in cell-free extracts of photosynthetic tissues from barley, alfalfa, *Spirodela*, the fern *Pteris gautheri*, the algae *Euglena gracilis* and *Chlamydomonas reinhardii*, and the photosynthetic bacteria *Rhodospirillum rubrum* and *Chromatium*. Conversely, the enzyme was not found in extracts of pea root or an apoplastidic strain (streptomycin-bleached) of *Euglena gracilis*. The activity of the enzyme in etiolated pea leaves was less than 5 per cent of the maximum activity found in green pea leaves. In related work in which quantitative measurements were made of the levels of various enzymes in growing pea leaves, it was observed that the alkaline fructose-1,6-diphosphatase activity of the leaf followed a pattern of development similar to that previously ascertained for a number of photosynthetic enzymes[4]. The above evidence attests to a close correspondence between alkaline fructose-1,6-diphosphatase and chloroplast development and function.

Intracellular distribution studies of cell particulates isolated in either 0·5 *M* sucrose or 0·35 *M* sodium chloride were inconclusive because of the apparent loss of most of the photosynthetic enzymes from the chloroplasts during the fractionation procedure. However, this work did show that a small amount of

Table 1. THE DISTRIBUTION OF ALKALINE FRUCTOSE-1,6-DIPHOSPHATASE IN PEA LEAF AND *Euglena* FRACTIONS ISOLATED IN NON-AQUEOUS MEDIA

Plant material	Density of isolated fraction	Fructose-1,6-diphosphatase*	
		Per cent activity in fractions	Activity per chlorophyll (μmoles P/min./mgm. chlorophyll)
Pea leaf	<1·34	68	0·52
	1·34–1·40	28	0·57
	>1·40	4	0·56
Autotrophic *Euglena*	<1·29	88	0·32
	1·29–1·36	9	0·57
	>1·36	3	0·57

* The reaction mixture contained *tris*(hydroxymethyl)aminomethane buffer, *p*H 8·5 (100 μmoles/ml.), fructose-1,6-diphosphate (8·5 μmoles/ml.), magnesium chloride (5 μmoles/ml.), and ethylenediamine tetraacetate (1·5 μmoles).

the total cellular alkaline fructose-1,6-diphosphatase was retained in the chloroplasts to an extent equivalent to that reported previously for ribulose-1,5-diphosphate carboxylase[4]. Furthermore, the specific activity of the enzyme in the chloroplast fraction was higher than in the other fractions. More informative results were obtained from experiments in which fractionations of pea leaves and *Euglena* cells were carried out in non-aqueous media. The procedure detailed by Stocking[7] for spinach leaves was followed, except that the *Euglena* cells were broken by grinding with glass beads (0·1–0·25 mm. diameter) with a pestle and mortar. This fractionation procedure produced an enrichment of chloroplast material in the low-density fractions[4,7]. The results in Table 1 show that the majority of the alkaline fructose-1,6-diphosphatase activity was associated with the lightest fractions and that the activities in the various fractions closely followed the distribution of chlorophyll. The low value for the activity of fructose-1,6-diphosphatase expressed on a chlorophyll basis in the *Euglena* fraction less dense than 1·29 was accounted for by the presence in this fraction of unbroken *Euglena* cells. Separate experiments showed that no significant amounts of protein were released from unbroken cells during the fractionation procedure. These distribution studies suggest that the alkaline fructose-1,6-diphosphatase of pea leaf and *Euglena* is localized in the chloroplasts.

Although it has been shown that leaf extracts also contain an acid fructose-1,6-diphosphatase[3], no evidence has been obtained to implicate this enzyme in photosynthesis. The developmental studies and intracellular distribution experiments indicated that the leaf acid fructose-1,6-diphosphatase did not participate directly in photosynthesis, nor was it localized in chloroplasts. Extracts of *Chromatium*, an obligate anaerobe and phototroph, contained only the alkaline fructose-1,6-diphosphatase.

On the basis of the observations mentioned above, it is suggested that alkaline fructose-1,6-diphosphatase constitutes an integral part of the enzymic mechanism for the photosynthetic conversion of carbon dioxide to carbohydrates.

This investigation was carried out at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission.

ROBERT SMILLIE

Biology Department,
Brookhaven National Laboratory,
Upton, New York.

[1] Bassham, J. A., Benson, A. A., Kay, L. D., Harris, A. Z., Wilson, A. T., and Calvin, M., *J. Amer. Chem. Soc.*, 76, 1760 (1954).

[2] Racker, E., "Harvey Lectures", Ser. 51, 143 (1957).

[3] Racker, E., and Schroeder, E. A. R., *Arch. Biochem. Biophys.*, 74, 326 (1958).

[4] Smillie, R. M., and Fuller, R. C., *Plant Physiol.*, 34, 651 (1959).

[5] Gibbs, M., and Horecker, B. L., *J. Biol. Chem.*, 208, 813 (1954).

[6] Smillie, R., and Fuller, R. C., *Fed. Proc.*, 19, 328 (1960).

[7] Stocking, C. R., *Plant Physiol.*, 34, 56 (1959).

Transiodination of Proteins during Enzymic De-iodination of Thyroxine

DURING the enzymic de-iodination of thyroxine labelled with iodine-131, triiodothyronine and related compounds with tissue homogenates, a fraction of the radioactivity consistently appeared in a material of $R_F = 0$ in various chromatographic systems[1]. The amount of 'origin' radioactive material found on chromatograms increased almost in parallel with the de-iodination of the substrate. With the identification of ferrous ions and flavin as activators for thyroxine dehalogenase[2], the formation of this material was found to be dependent only on flavin derivatives. The nature of the 'origin' iodine-131 labelled material was studied with purified preparations of thyroxine dehalogenase[3]; it was found to be radioiodinated protein(s) present in the tissue enzymic extracts, as described below.

L-Thyroxine labelled with iodine-131 was incubated at 37° with thyroxine dehalogenase prepared from rabbit skeletal muscle, at *p*H 7·1 (ref. 3). The radioactive products of the reaction were analysed by paper chromatography and electrophoresis. Full experimental details have been described elsewhere[4]. Next to iodide, the material of $R_F = 0$ was the only other major labelled product formed. As shown in Fig. 1, the rate of formation of iodide was only slightly diminished in the absence of flavin mononucleotide in a ferrous ion-activated enzyme system, whereas the formation of radioactive 'origin' material was almost abolished.

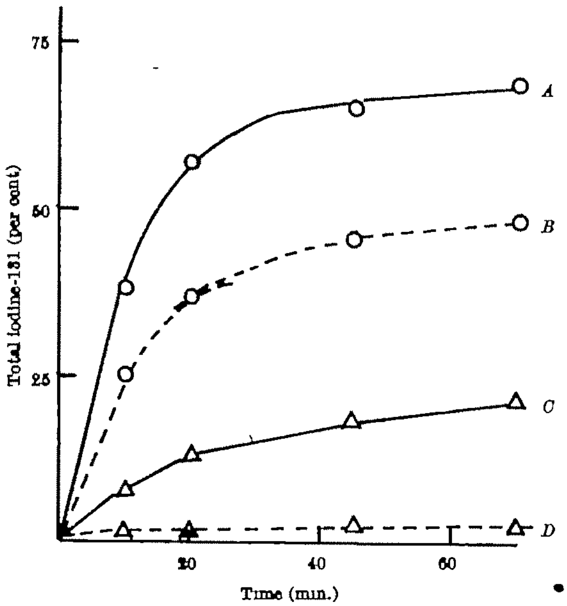


Fig. 1. Formation of radioactive iodide (○) and 'origin' material (△) as the principal products of enzymic de-iodination of thyroxine labelled with iodine-131 by rabbit skeletal muscle thyroxine dehalogenase as measured by chromatographic analysis. Each flask contained in 2·5 ml. *tris*-hydrochloric acid – potassium chloride buffer[3], *p*H 7·1, 5·0 μmoles of L-thyroxine, 12 mgm. of enzyme of × 72 purification. Additions: *A* and *C*, 0·035 μmole ferrous ion and 0·1 μmole flavin mononucleotide; *B* and *D*, 0·035 μmole ferrous ion alone

After incubation of labelled thyroxine with a fully activated enzyme, the 'origin' material was separated by paper chromatography. It was non-dialysable and precipitated with trichloroacetic acid; it was then digested with crude trypsin or pancreatin. The hydrolysate on chromatographic analysis was found to contain most of the iodine-131 as 3-iodo-tyrosine with traces of 3 : 5-diiodotyrosine, which suggested the presence of iodinated proteins.

In order to confirm that proteins were iodinated with the iodine released from thyroxine, extraneous proteins were added in relatively large amounts to the muscle enzyme extract. Insulin and egg-white lysozyme were most suitable because of the ease of distinguishing from muscle proteins by electrophoresis and their feeble thyroxine-binding activity (thyroxine

Table 1. IODINATION OF INSULIN AND EGG-WHITE LYSOZYME PRESENT DURING INCUBATION OF ^{131}I-LABELLED L-THYROXINE (T_4) WITH RABBIT SKELETAL MUSCLE THYROXINE DEHALOGENASE

Protein added	Amount (mgm./ml.)	T_4 de-iodinated in 60 min. (per cent)	Percentage of ^{131}I protein-bound	Percentage of protein-bound ^{131}I recovered in added protein
None	—	83·6	15·1	—
Insulin	2·0	72·7	22·0	50·2
	5·0	60·0	28·7	68·5
Lysozyme	2·0	74·4	18·2	31·8
	5·0	70·1	24·5	43·6

Conditions identical to those in Fig. 1. Enzyme fully activated with ferrous ions and flavin mononucleotide.

dehalogenase can only attack 'free' substrate). Both these proteins were readily radioiodinated in the presence of radioactive thyroxine and the enzyme (Table 1), and on tryptic hydrolysis after separation by paper electrophoresis gave rise to labelled monoiodotyrosine. Since free iodotyrosines were not a product of action of dehalogenase, the transfer of iodine atoms from thyroxine to the tyrosyl radicals of added proteins represents a true process of transiodination.

Observations reported elsewhere[2] have suggested that the iodination of proteins is not a secondary process of a flavin-mediated oxidation of the iodide released by the dehalogenase but rather a direct substitution. It was proposed that the contribution of the flavin was to release part of the iodine atoms at a level of oxidation necessary for iodination under conditions of incubation. It should be noted that the fraction of thyroxine iodine available for tyrosyl substitution was twice the fraction of protein-bound iodine-131 shown in Fig. 1 or Table 1 according to R.H. + 2I^{+} → R.I. + R.I.

Since enzymic dehalogenation of thyroxine is not a peroxidative process[3], the iodination of proteins reported here does not resemble the 'transiodination' of some iodotyrosines and iodothyronines with peroxidase[4].

The physiological significance of transiodination of proteins coupled to a de-iodination of thyroid hormones, which had hitherto remained unnoticed, remains doubtful. Considering the extremely high ratio of proteins to thyroxine in tissues, it would be difficult to demonstrate such a transiodination *in vivo*.

J. R. TATA*

National Institute for Medical Research,
Mill Hill,
London, N.W.7.

* Belt Memorial Fellow.

[1] Tata, J. R., Ball, J. E., and Rawson, R. W., *Endocrinol.*, 60, 83 (1957); *Proc. Soc. Exp. Biol., N.Y.*, 95, 362 (1957).

[2] Tata, J. R., *Biochim. Biophys. Acta*, 35, 567 (1959).

[3] Tata, J. R., *Biochem. J.* (in the press).

[4] Saunders, B. C., and Stark, B. P., *Tetrahedron*, 4, 169 (1958).

Stabilization by Manganous Ions of Ribosomes from Embryonic Plant Tissue

PREPARATIONS of microsomal ribonucleoprotein (ribosomes[1]) from sources such as yeast, pea shoots, rat liver and clover leaves have been shown to consist largely of particles with sedimentation coefficient approximately 70 *S* (refs. 2–5). These particles are stable when dialysed against solutions containing magnesium ions at concentrations between 1 and 2 m*M*; but removal of magnesium by dialysis or addition of chelating agents leads to dissociation of the 70 *S* particles with production of sub-units of sedimentation coefficients 50 *S* and 30 *S*. By contrast, I have found with ribosomes from wheat germ that in order to preserve intact 70 *S* particles on dialysis, manganese and calcium are required in addition to magnesium in the dialysing solution.

Wheat germ was blended for 2 min. with four times its weight of a solution containing 5 m*M* magnesium chloride, 2 m*M* calcium chloride, and 0·025 *M* *tris*(hydroxymethyl)ammomethane/hydrochloric acid (*tris*) buffer at *p*H 7·3. The ribosomes were isolated by two stages of fractional centrifugation in the same buffered medium[3]. The material thus obtained was homogeneous on examination in the analytical ultracentrifuge, and contained only the 70 *S* component (Fig. 1*a*).

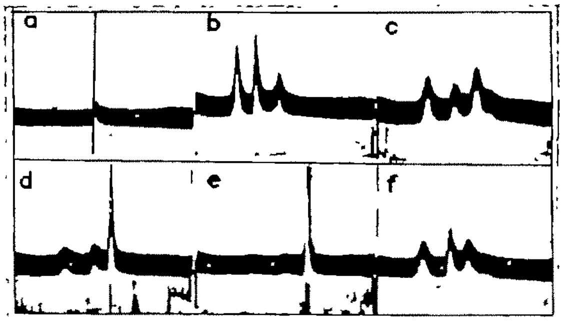


Fig. 1. Ultracentrifuge diagrams of wheat germ ribosomes: *a*, as prepared in 0·025 *M* *tris*, 5 m*M* magnesium sulphate, 2 m*M* calcium chloride; *b*, dialysed v. 0·025 *M* *tris*, 1 m*M* magnesium sulphate; *c*, dialysed v. 0·025 *M* *tris*, 2 m*M* magnesium sulphate; *d*, dialysed v. 0·025 *M* *tris*, 1 m*M* magnesium sulphate, 0·2 m*M* manganous chloride; *e*, dialysed v. 0·025 *M* *tris*, 1 m*M* magnesium sulphate, 0·2 m*M* manganous chloride, 0·5 m*M* calcium chloride; *f*, dialysed v. 0·025 *M* *tris*, 1 m*M* magnesium sulphate, 0·2 m*M* nickel sulphate. All solutions at *p*H 7·3. Ribosome concentration: *a*, 10 mgm./ml., *b*–*f*, 5 mgm./ml. All photographs taken after 9 min. at 42,000 r.p.m. Sedimentation left to right

In order to test the stability of these ribosomes under different conditions, 1·0-ml. samples at a concentration of about 5 mgm./ml. were dialysed against three changes of 300 ml. of the test solution for 24-hr. periods. The dialysed sample was then examined in the ultracentrifuge.

It will be seen from Fig. 1 that dialysis against a buffer containing 1·0 m*M* magnesium sulphate led to almost complete dissociation of the 70 *S* particles, and increasing the concentration to 2·0 m*M* was only partially effective in counteracting this dissociation. Dialysis against higher concentrations of magnesium led to production of aggregated material. When 0·2 m*M* manganous chloride was added to the 1·0 m*M* magnesium, however, the dissociation was largely suppressed. Increasing the manganese concentration to 0·5 m*M* further repressed the dissociation, but the most effective medium for preserving the 70 *S* particles intact on dialysis has been found to be a *tris* buffer containing 1·0 m*M* magnesium sulphate, 0·2 m*M* manganous chloride and 0·5 m*M* calcium chloride (Fig. 1*e*). In the presence of manganese, the effect of calcium was specific. Increasing the magnesium concentration did not have the same effect. In the absence of magnesium or calcium, complete dissociation of the 70 *S* particles was not prevented by addition of manganese to 0·5 m*M* concentration.

Similar concentrations of divalent salts of nickel, cobalt, iron, zinc and copper were all closely similar; and all much less effective than manganese in stabilizing the 70 *S* particles (Fig. 1*f*).

We have also observed a similar stabilizing effect of manganous ions on ribosomes prepared from pea seeds.

Analysis of wheat germ ribosomes for manganese[6] gave values of 0·12–0·14 μgm. per mgm. ribonucleic acid. The extract from which they were isolated contained approximately ten times as much manganese per mgm. ribonucleic acid.

This dissociation of 70 *S* particles on dialysis in the presence of magnesium is in contrast to the reported behaviour of ribosomes prepared from the sources referred to earlier[2-4]. A further difference exhibited by wheat germ ribosomes is the irreversibility of the dissociation which occurs on dialysis either in the presence or absence of magnesium. Further dialysis of the dissociated particles against the buffer containing magnesium, manganese and calcium, which was effective in repressing dissociation, led to aggregation of the 50 *S* and 30 *S* components, but little if any 70 *S* component was regenerated.

It is possible that the difference in properties of the ribosomes studied here may be due to their having originated from embryonic rather than fully differentiated tissue. Further work will be required to check this.

J. W. LYTTLETON

Plant Chemistry Division,
Department of Scientific and Industrial Research,
Palmerston North,
New Zealand.

[1] Roberts, R. B., "Microsomal Particles and Protein Synthesis", viii (Washington Academy of Sciences, 1958).

[2] Chao, F. C., *Arch. Biochem. Biophys.*, 70, 426 (1957).

[3] Ts'o, P. O. P., Bonner, J., and Vinograd, J., *Biochim. Biophys. Acta*, 30, 570 (1958).

[4] Hamilton, M. G., and Petermann, M. L., *J. Biol. Chem.*, 234, 1441 (1959).

[5] Lyttleton, J. W., *Biochem. J.*, 74, 82 (1960).

[6] Johnson, C. M., and Ulrich, A., Calif. Agric. Experiment Station Bull. 766 (1959).

The β-D-Fucosidase Activity of Mammalian Tissues and its Relation to other Glycosidases

AN earlier communication[1] described the occurrence of the enzyme α-L-fucosidase in mammalian tissues. These tissues have now been surveyed for β-D- and β-L-fucosidase activity, using the appropriate *p*-nitrophenyl fucosides as substrates. The β-D-fucoside was hydrolysed by all the mammalian tissues that were studied, and also by an extract from the limpet, *Patella vulgata*, but no β-L-fucosidase activity was detected anywhere.

Table 1 gives figures for some of the richest sources of β-D-fucosidase, alongside comparable figures for β-D-galactosidase[2]. Since fucose is 6-deoxygalactose, β-D-fucosidase could be identical with β-D-galatosidase, but the parallelism which would then be expected between the two enzyme activities, within at least a single species, was not observed. Inhibition experiments with the appropriate aldonolactones[3] are shown in Table 2. While the results for the preparations from the rat are consistent with the action of a single enzyme, with a higher affinity for the galactose than for the fucose residue, the figures for ox liver suggest the very opposite. In any event, the enzyme or enzymes in the two species are evidently quite different. This is reflected in differences I have observed in the *p*H-activity curves.

Whether or not it is due to β-D-galactosidase, the β-D-fucosidase activity of mammalian tissues is considerable. D-fucose has not been reported in animals, but both D- and L-fucose occur in plants. Although L-fucose has been positively identified in mammalian preparations in at least two instances, in other cases its presence has been inferred from evidence that does not distinguish it from the D-enantiomorph. As with other galactose derivatives, the biological interconversion of D- and L-fucose by an end-to-end oxidation-reduction would appear to be feasible.

Table 1. β-D-FUCOSIDASE AND β-D-GALACTOSIDASE ACTIVITIES OF MAMMALIAN TISSUES

	β-D-Fucosidase			β-D-Galactosidase		
	Pig	Ox	Rat	Pig	Ox	Rat
Liver	22,800	29,700	1,910	14,500	7,260	4,710
Kidney	31,700	1,010	4,050	28,550	1,860	11,400
Epididymis	360	900	3,300	970	1,740	47,300

Results expressed as μgm. *p*-nitrophenol (fucosidase) or *o*-nitrophenol (galactosidase) liberated per gm. moist tissue in 1 hr. at 37°.

Table 2. INHIBITION OF β-D-FUCOSIDASE AND β-D-GALACTOSIDASE BY D-ALDONOLACTONES

Source of enzyme	β-D-Fucosidase Fucono-lactone	Galactono-lactone	β-D-Galactosidase Fucono-lactone	Galactono-lactone
Rat epididymis	0	56	0	60
Rat liver	0	64	0	65
Ox liver	0	0	32	0

The experiments were done at *p*H 4 in 0·05 *M* acetate buffer with 1 m*M* substrate and inhibitor. Results are expressed as inhibition per cent.

One interesting observation made in this work was a great variation in the β-D-fucosidase activity of cow ovary, which was found to be related to the amount of luteal tissue present. The corpus luteum had a mean activity of 1,000 units per gm., whereas the remainder of the tissue had only one-tenth of this activity and the enzyme was virtually absent from the follicular fluid. This phenomenon was shown to extend to α-L-fucosidase, β-D-galactosidase, α-D-mannosidase, β-D-glucuronidase and β-*N*-acetyl-D-glucosaminidase in cow ovary. While the physiological significance of these results is obscure, they point to a common function for all six enzymes, and to direct or indirect control of their activity by the anterior pituitary. As already shown for the other four enzymes[4], β-D- and α-L-fucosidase in epididymis and uterus respond to castration by steep falls in activity.

Grateful acknowledgment is made to Dr. J. Conchie for help with some of the enzyme assays, and to Mr. A. McAllan for skilled technical assistance.

G. A. LEVVY*

Rowett Research Institute,
Bucksburn,
Aberdeen.

[1] Levvy, G. A., *Nature*, 186, 472 (1960).

[2] Conchie, J., Findlay, J., and Levvy, G. A., *Biochem. J.*, 71, 318 (1959).

[3] Conchie, J., and Levvy, G. A., *Biochem. J.*, 65, 389 (1957).

[4] Conchie, J., and Findlay, J., *J. Endocrinol.*, 18, 132 (1959).

Biosynthesis of Squalene by the Annelid *Lumbricus terrestris*

LARGE amounts of sterols have been shown to be present in many of the invertebrates, although cholesterol does not seem to occur predominantly among the more primitive animals. Instead, as Bergmann has pointed out, the lower phyla especially appear to contain a diverse group of sterols with structures which are more similar to those of plants[1]. Moreover, since some Protozoa and insects have been shown to require dietary cholesterol[2], it has been suggested that the invertebrates cannot synthesize their own sterols, but rather modify the steroid nucleus present in their food sources.

Mevalonic acid, isolated as a growth factor for a strain of *Lactobacillus acidophilus*[3], has been shown to be a precursor of squalene and cholesterol with *in vivo* experiments using the rat[4], and in isolated mammalian[5,6] and yeast systems[7]. The extent of mevalonic acid utilization by invertebrate animals is now being studied to determine by isolation and identification of radioactive components of the non-saponifiable fraction what genetic blocks exist in various phyla.

A species from the phylum Annelida has been found to convert mevalonic acid to squalene, but is incapable of cyclizing the hydrocarbon. Specimens of *Lumbricus terrestris* were placed in moist cellulose powder which contained 0·1 per cent 'Moldex' and 10,000 units penicillin (Lilly) and were allowed to burrow in this medium for six days to remove symbionts undoubtedly present in the alimentary canal. Additional penicillin solutions were added on the second and fourth days, and the worms averaging 6–8 in. long and 3–4 gm. in weight remained quite lively. Potato agar plates streaked with coelomic fluid from a treated worm showed only a few small, slow-growing colonies of *Clostridium* sp. The mevalonic acid solution contained penicillin and aureomycin and was always injected into the coelomic cavity.

In one experiment, 11 animals were administered 6 μm. 2-^{14}C mevalonic acid (Tracerlab) with a total activity of 700,000 counts/min. Twenty-four hr. later they were homogenized in a Waring blendor with water in a nitrogen atmosphere prior to four extractions at *p*H 11 with double volumes of petroleum ether (30–60° C.)/ethanol (9 : 1 mixture by vol.). The sodium sulphate-dried extracts were combined for solvent removal *in vacuo*, and the residue with approximately 10 per cent of the injected activity was dissolved in light petroleum ether for chromatography on an acid-washed alumina (Merck) column. After 150 ml. petroleum ether wash had passed through the column, the squalene was eluted with a 100 ml. mixture of benzene/petroleum ether (1 : 9). Solvents were removed *in vacuo* and the residue was counted on a Nuclear Chicago gas-flow counter. Eighteen mgm. squalene (Eastman Organic Chemicals), previously redistilled and purified by alumina chromatography, were added as carrier to the colourless oil, which weighed 7 mgm. and had an activity of 16,000 counts/min. The hexahydrochloride derivative, prepared according to the Heilbron method modified by Loud and Bucher[4], had a specific activity of 475 c.p.m./mgm., while a second recrystallization from acetone resulted in an increase to 630 c.p.m./mgm. Results of an elemental analysis of the squalene hexahydrochloride synthesized by this micro procedure corresponded to the theoretical percentages of carbon (57·26), hydrogen (8·92), and chlorine (33·83) (analysis by Geller Lab. carbon (57·21), hydrogen (8·85), chlorine (34·10)).

In another experiment purified carrier squalene was added to the non-saponifiable fraction obtained from another group of animals prior to separation by alumina chromatography. The squalene fraction had a specific activity of 86 c.p.m./mgm. before the derivative was made, and the activity remained relatively constant over four recrystallizations (Table 1).

Table 1. RECRYSTALLIZATION OF ^{14}C SQUALENE HEXAHYDROCHLORIDE TO CONSTANT SPECIFIC ACTIVITY

Recrystallization	Weight (mgm.)	Counts/min.	C.p.m./mgm. squalene hexahydrochloride (Corrected to infinite thinness)
1	9·7	1,820	185
2	7·6	1,112	182
3	5·6	840	176
4	5·0	767	176

The alumina column was developed further with 1 per cent acetone in petroleum ether and radioactivity was found associated with a β-carotene band. β-carotene (N.B.C. recrystallized) was added as carrier, but after crystallization it was inactive. Then several milligrams of coenzyme Q_{10} (Merck) were dissolved in an ether solution of the labelled compound and chromatographed on 'Florisil'. Though the activity moved with the carrier, on recrystallization coenzyme Q_{10} was inactive and the bulk of the carbon-14 compound was recovered in the supernatant liquid. Rechromatography on alumina with very small cuts assayed indicated that the radioactive compound moved slightly faster than the coloured component, but its identity is unknown.

Cholesterol was eluted from the alumina column with acetone/petroleum ether (1 : 1) and after removal of solvent was precipitated with 1 per cent digitonin in 80 per cent ethanol. The resulting voluminous complex was inactive. In addition, the homogenate of three animals injected with labelled mevalonic acid was subjected to saponification procedures which involved refluxing on a steam-bath for 8 hr. with 2 *N* alcoholic potassium hydroxide. Five petroleum ether extractions were made, combined, dried over sodium sulphate, and the activity measured after removal of solvent *in vacuo*. This residue with 6,200 counts/min. was dissolved in 6 ml. ethanol and 3 ml. of 1 per cent digitonin solution was added. After ethanol and ether washes 77·2 mgm. of digitonide were plated and found to be devoid of radioactivity.

Thus, the conversion of mevalonic acid to squalene has been shown to occur in the phylum Annelida. However, a genetic block on the pathway from squalene to the β-hydroxy and/or 5 αH sterols appears to exist in the species studied.

Grateful acknowledgment is made to Dr. H. A. Schneiderman for his interest and helpful suggestions.

JOYCE M. WOOTTON*
LEMUEL D. WRIGHT

Department of Biochemistry and
Graduate School of Nutrition,
Cornell University,
Ithaca, New York.

* Present address: Department of Biochemistry, University College, London.

[1] Bergmann, W., in "Cholesterol", 436 (Academic Press Inc., New York, 1958).

[2] Clark, A. J., and Bloch, K., *J. Biol. Chem.*, 234, 2578 (1959).

[3] Wright, L. D., Cresson, E. L., Skeggs, H. R., MacRae, G., Hoffmann, C. H., Wolf, D. E., and Folkers, K., *J. Amer. Chem. Soc.*, 78, 5273 (1956).

[4] Loud, A. V., and Bucher, N. L. R., *J. Biol. Chem.*, 233, 37 (1958).

[5] Tavormina, P. A., Gibbs, M. H., and Huff, J. W., *J. Amer. Chem. Soc.*, 78, 4498 (1956).

[6] Cornforth, J. W., Cornforth, R. H., Popjak, G., and Gore, I. Y., *Biochem. J.*, 69, 146 (1958).

[7] Amdur, B. H., Rilling, H., and Bloch, K., *J. Amer. Chem. Soc.*, 79, 2646 (1957).

Phosphate Esters produced by Mammalian Skin from 2-Deoxy-D-glucose

IN a recent report concerning the phosphate esters synthesized by skin maintained on various substrates *in vitro*[1] we described the formation of two phosphate esters from 2-deoxy-D-glucose which were not detected with skin maintained on D-glucose. One of these was identified as 2-deoxy-D-glucose-6-phosphate; this communication describes the identification of the second ester.

Three phosphate esters commonly formed from D-glucose-6-phosphate in living cells are D-fructose-6-phosphate, D-glucose-1-phosphate and D-gluconate-6-phosphate. 2-Deoxy-D-glucose-6-phosphate cannot, for obvious structural reasons, be converted to a product corresponding to D-fructose-6-phosphate, so it seemed likely that the unknown ester was either 2-deoxy-D-glucose-1-phosphate or 2-deoxy-D-gluconate-6-phosphate. The latter possibility was chosen for investigation since 2-deoxy-D-glucose-1-phosphate is probably unstable.

Oxidation of D-glucose-6-phosphate with bromine is known to yield D-gluconate-6-phosphate[2] so that a similar oxidation of 2-deoxy-D-glucose-6-phosphate appeared to be a suitable method for preparing 2-deoxy-D-gluconate-6-phosphate. Barium 2-deoxy-D-glucose-6-phosphate was obtained as described previously[1] by the phosphorylation of 2-deoxy-D-glucose using yeast hexokinase and adenosine triphosphate. The oxidation was carried out with bromine in aqueous solution at 40° C. for 22 hr. in the presence of sodium benzoate as a buffer. After cooling, the precipitated benzoic acid was removed by filtration, the solution aerated until colourless and treated with silver carbonate to remove bromide ions. The resultant solution was passed through an 'Amberlite *IR*-120' (H^+ form) column, concentrated under reduced pressure and extracted with chloroform to remove the remaining benzoic acid. It was then neutralized with calcium carbonate and the filtered, neutral solution freeze-dried to a white powder.

A solution of the product, converted to the sodium salt by treatment with sodium carbonate, was mixed with an extract prepared from skin slices (about 20 mgm.) previously incubated for 24 hr. at 37° C. on a medium consisting of 0·02 *M* 2-deoxy-D-glucose in Krebs–Ringer phosphate labelled with 15 μc. phosphorus-32 per ml. This mixture was subjected to two-dimensional paper chromatography and a radioautograph of the chromatogram prepared; the experimental procedure was exactly as previously described[1] with other reference compounds. The spot obtained on spraying the paper chromatogram for phosphate esters coincided exactly with the position of the unidentified spot produced on the radioautograph; the same result was obtained on repetition of the experiment. The R_I values obtained in propan-1-ol/aq. ammonia solution (sp. gr. 0·880)/water (60 : 30 : 10 by vol.) were 0·95 and 1·03; in picric acid/2-methyl propan-2-ol/water (4 : 8 : 20, w/v/v) they were 0·78 and 0·78. Therefore the product of bromine oxidation of 2-deoxy-D-glucose-6-phosphate appears to be identical to the previously unidentified phosphate ester produced by skin in the presence of 2-deoxy-D-glucose.

However, chemical investigation of the synthetic product showed that it was not calcium 2-deoxy-D-gluconate-6-phosphate. Treatment with *N*-hydrochloric acid at 100° C. for 30 min. produced no hydrolysis of the phosphate group whereas the phosphate group in 2-deoxy-D-glucose-6-phosphate is 70 per cent hydrolysed under these conditions[3]; it is unlikely that the formation of a carboxylic acid group at C(1) would decrease the acid-lability to this extent. The periodate consumption, measured spectrophotometrically[4], was 1 mole per 111 gm. compared to the calculated consumption of 1 mole per 158 gm. These properties and the elementary composition are consistent with a calcium hexonate-6-phosphate (found: C, 22·0; H, 3·7; P, 9·3; $C_6H_{10}O_{10}PCa_{1\frac{1}{2}}$ requires C, 21·6; H, 3·0; P, 9·3 per cent). Oxidation of 2-deoxy-D-glucose-6-phosphate at C(2) as well as at C(1) could lead to D-gluconate-6-phosphate or D-mannonate-6-phosphate. Comparison of the products of bromine oxidation of both D-glucose-6-phosphate and of 2-deoxy-D-glucose-6-phosphate gave indistinguishable results for periodate consumption and infra-red spectra, but on two-dimensional chromatograms different R_I values were obtained. A pure sample of D-mannonate-6-phosphate could not be obtained from D-mannose-6-phosphate; even after four days oxidation some D-mannose-6-phosphate remained. Chromatography of the reaction mixture showed a component having R_I values consistent with those obtained for the oxidation product of 2-deoxy-D-glucose-6-phosphate. As the bromine oxidation product of 2-deoxy-D-glucose-6-phosphate is indistinguishable from calcium D-gluconate-6-phosphate by periodate consumption, infra-red absorption, acid hydrolysis and elementary composition but differs chromatographically; this product is almost certainly calcium D-mannonate-6-phosphate.

Since the previously unidentified phosphate ester produced by skin from 2-deoxy-D-glucose is identical chromatographically with the product of bromine oxidation of 2-deoxy-D-glucose-6-phosphate this ester is presumably D-mannonate-6-phosphate. It seems probable that in both the chemical and the biological synthesis 2-deoxy-D-gluconate-6-phosphate is formed initially and is then immediately converted to D-mannonate-6-phosphate. The production of 2-deoxy-D-gluconate-6-phosphate by cells has not previously been reported although cell-free extracts of *Leuconostoc mesenteroides* have been found[5] to contain an enzyme which catalyses the reduction of triphosphopyridine nucleotide by 2-deoxy-D-glucose-6-phosphate. The relative intensity of blackening of the two spots on our radioautographs indicates that although D-mannonate-6-phosphate is formed, most of the 2-deoxy-D-glucose is converted only to 2-deoxy-D-glucose-6-phosphate.

S. A. Brooks
J. C. Lawrence
C. R. Ricketts

Medical Research Council
Industrial Injuries and
Burns Research Unit,
Birmingham Accident Hospital,
Bath Row,
Birmingham 15.

[1] Brooks, S. A., Lawrence, J. C., and Ricketts, C. R., *Biochem. J.*, 73, 566 (1959).

[2] Seegmiller, J. E., and Horecker, B. L., *J. Biol. Chem.*, 192, 175 (1951).

[3] Brooks, S. A., Ph.D. Thesis, University of London (1959).

[4] Aspinall, G. O., and Ferrier, R. J., *Chem. and Indust.*, 1216 (1957).

[5] De Moss, R. D., and Happel, M. E., *J. Bact.*, 70, 104 (1955).

An Antibiotic Complex derived from a *Streptomyces* and active against Gram-positive Bacteria

CULTURE medium in which a *Streptomyces* (Strain No. 1415 of the Montecatini collection; now listed as No. 3838 of the collection of the Institute of Microbiology, Rutgers University) had been grown was found to contain an antibiotically active complex of eight components, effective against Gram-positive bacteria.

The organism in question produced pinkish growth with a diffusible pink pigment. The spores were spherical to ovoid, and the sporophores in the form of tufts of short hyphæ with slightly curled ends.

It was capable of hydrolysing starch and decomposing gelatin and casein.

Cultures for antibiotic production were made in a medium containing (per cent w/v) 0·25 peptone, 0·25 meat extract, 1·0 glucose, 0·5 sodium chloride and 1 per cent (v/v) corn steep liquor (40 per cent solids), in a 20-litre tank at 27° C. These were grown for 72 hr., constantly stirred, and aerated with 15–20 litres/min. of air.

The medium was then filtered and extracted with ethyl acetate, the solvent dried, reduced *in vacuo* and washed in dilute sodium hydroxide. The ethyl acetate was further reduced in volume and passed through a short column of an intimate mixture of 'Darco *G* 60' and 'Hyflo-Supercel' (1 : 1). After elution with ethyl acetate and concentration, the crude complex was precipitated by petroleum ether, dissolved in hot carbon tetrachloride and passed through a similar, longer column, eluted with benzene and again precipitated by petroleum ether.

The purified complex was a white, amorphous powder, soluble in lower alcohols, acetone, chloroform and ether, insoluble in water. The percentage composition was approximately: C, 59·5; H, 8·0; N, 2·0 ($c = 1$ per cent in methanol) $[\alpha]_D^{20} = -34·5°$. In the hydrolysate, seven amino-acids were detected: glycine, proline, alanine, valine, phenylalanine, leucine and aminobutyric acid (probably the γ-isomer). The ultra-violet adsorption spectrum showed a maximum at 282 mμ.

By paper chromatography, eight components of the complex could be recognized.

The *LD*50 in albino mice was 400 mgm./kgm. intravenously, 600 mgm./kgm. intraperitoneally and 2 mgm./kgm. subcutaneously.

The complex was active against *Bacillus* spp., staphylococci and hæmolytic streptococci at 0·25 μgm./ml. or less, but was inactive against Gram-negative bacteria and non-hæmolytic streptococci.

B. Sgarzi
A. M. Lugli
G. Giolitti

Montecatini Antibiotics Research Laboratories,
Milan.

PHYSIOLOGY

Effect of Hydration on Hexobarbitone-induced Sleep in Mice

Hydration of laboratory animals and man produces a complex picture generally indicating increased excitability of the central nervous system. This is attributed to osmotic disturbances produced by fall of the extracellular electrolytes[1]. It is therefore interesting to find in albino mice that after hydration the sensitivity of the central nervous system to hexobarbitone was increased simultaneously. This conclusion is based on the results obtained from the following experiments.

Adult albino mice received intraperitoneally hexobarbitone sodium 100 mgm./kgm. after water-load. Control mice received only hexobarbitone. In some control experiments mice received water (or normal saline or 5 per cent glucose) just after recovering from sleep (Table 1).

About 2–4 hr. before becoming absorbed, intraperitoneally administered 5 per cent glucose solution is known to remove electrolytes from the extracellular body fluid, thus producing a condition comparable to hydration[2]. Mice receiving this treatment were used ½ and 2 hr. later for hexobarbitone sleep. The effect of normal saline was also studied (Table 2).

Table 1. Effect of Hydration on Hexobarbitone Sleeping Time in Mice. Water at 37° C. injected Intraperitoneally. Animals were kept at 32–35° C.

Hydration ml. % of body-weight	Min. between hydration and hexobarb.	Sleeping time min. ± *S.D.*	No. of mice used	Value of *P* (*t* test)
Nil	Nil	21 ± 4·1	20	
5	30	18 ± 6·8	21	*
10	0	36 ± 9·5	12	< 0·01
10	15	56 ± 12·7	15	< 0·01
10	30	49 ± 11·2	20	< 0·01
10	60	40 ± 12·3	15	< 0·01
10	240	26 ± 6·8	8	< 0·05
10	Just after hexobarb. sleep	22 ± 5·5	20	

* Not significant.

Table 2. Effect of 0·9 per cent Sodium Chloride Solution or 5 per cent Glucose at 37° C., injected Intraperitoneally, on Hexobarbitone Sleeping Time in Mice. Room Temperature 32–35° C.

Fluid ml. % of body-weight	Min. between fluid and hexobarb.	Sleeping time min ± *S.D.*	No. of mice used	Value of *F* (*t* test)
10 (Glucose)	30	25 ± 5	18	< 0·02
10 (Glucose)	120	54 ± 12·9	18	< 0·01
10 (Saline)	30	22 ± 8·8	18	*
10 (Saline)	120	17 ± 8·4	12	*

* Not significant.

Results indicate that 10 per cent but not 5 per cent hydration prolongs hexobarbitone sleeping time, the maximal effect occurring 15 min. after hydration. The effect was also seen 30 and 60 min. after hydration. The rate of water excretion can explain these results. Animals recovering from sleep go back again to sleep after hydration but not after saline load. This suggests sensitization of the central nervous system and excludes other mechanisms of action. Hydrated mice were quieter but essentially normal in their behaviour. All experiments could be repeated on the same animals after 2–3 days.

Glucose solution, requiring a certain time-interval to deplete the extracellular electrolytes, produces a distinct effect 2 hr. later. Further work is in progress.

N. K. Bhide

Department of Pharmacology,
All-India Institute of Medical Sciences,
New Delhi, 16.

[1] *Lancet*, i, 425 (1953).

[2] Swinyard, E. A., Toman, J. E. P. and Goodman, L. S., *J. Neurophysiol.*, 9, 47 (1946).

Evidence for the Identity of Natriferin, the Frog Water-Balance Principle and Arginine Vasotocin

Maetz, Morel, and Lahlouh[1] recently reported that pituitary extracts from amphibians and teleosts contain a principle which promotes the active transport of sodium by the isolated skin of the frog *Rana esculenta*. This factor cannot be oxytocin or a vasopressin since it has approximately ten times more activity on sodium transport than do mammalian extracts of similar oxytocic activity. Maetz *et al.* named this principle 'natriferin'.

Heller[2,3] first pointed out that fish, amphibian, avian, and reptilian pituitary extracts exert far more effect on frog water-balance than can be attributed to their content of oxytocin or vasopressin. Pickering and

Table 1. Relative Activities of Oxytocin, Arginine Vasopressin, Arginine Vasotocin, and a Bull-frog Neurointermediate Lobe Extract on Natriferin Assays, and on other Assays (Refs. 5, 8, 9, 12)

Preparations	Activities (μgm./mgm. dry weight)				
	Rat vasopressor	Rat uterus (no Mg^{++})	Frog bladder	Frog antidiuretic	Frog natriferic
Bullfrog neurointermediate lobe	0·52 (0·50–0·54)	0·59 (0·55–0·64)	79	190	47
Arginine vasotocin	64 (62–67)	37 (34–41)	10,000	19,000	4,400
Arginine vasopressin	300	9	70	—	70
Oxytocin	—	430	360	360	360

The figures shown in parentheses are the 95 per cent confidence limits.

Heller[4] have recently succeeded in separating the 'water-balance principle' by paper chromatography of fish, frog, and fowl pituitaries. From chromatographic and pharmacological studies on the chicken neurohypophysis Munsick *et al.*[5] conclude that this gland contains oxytocin and a peptide pharmacologically indistinguishable from arginine vasotocin (arginine[8] oxytocin). This analogue of the mammalian neurohypophysial hormones has been synthesized by Katsoyannis and du Vigneaud[6,7] and generously supplied by them for study in this Department. It has much greater activity on the water permeability of the frog bladder than any other neurohypophysial hormone or analogue that I have yet tested[8]. It is also extremely potent in causing water uptake (water-balance response) and antidiuresis in frogs[9]. I have gathered pharmacological evidence for its existence in pituitary extracts from cyclostomes, teleosts, amphibians, reptiles, and birds[10]. It is probably not present in elasmobranchs or mammals.

Natriferin has been clearly demonstrated in teleosts and amphibians, but appears to be absent in mammals and elasmobranchs[1]. The correspondence of the phyletic distributions of natriferin, the water-balance principle, and what I believe to be arginine vasotocin strongly suggests that they are identical. It is of pressing interest, therefore, to assay synthetic arginine vasotocin for 'natriferic' activity.

I have used a simplified Ussing–Zerahn[11] short-circuited frog skin for natriferic assays. An inside-out skin bag from the leg of *Rana pipiens* is suspended in a carbon dioxide–bicarbonate-buffered Ringer's solution. The bag is filled with the same solution. 'Sodium current' is measured by balancing the electromotive force across the skin and recording the applied current. Extracts and synthetic peptides are added to the bath bathing the physiological inside (dermal surface) of the skin. The maximum increase in sodium current recorded in the 15-min. period following the addition is taken as the response. Four-point balanced assays are performed. Synthetic oxytocin ('Syntocinon', Sandoz) is used as standard. Relative potencies are expressed in terms of units, one unit of natriferic activity being defined as the natriferic activity of one oxytocic unit of oxytocin. Calculations are based on the assumption of a linear regression of response on the logarithm of dose.

The results of natriferic assays on a bull-frog (*Rana catesbiana*) neurointermediate lobe extract, on synthetic arginine vasotocin, and on arginine vasopressin are shown in Table 1. There are wide variations of the values obtained for natriferic activity of arginine vasotocin and frog extract on different assays (the figures shown are geometric means of the results of five assays on each preparation). The variation appears primarily to be due to a 20-fold difference in the doses of oxytocin that must be used to obtain good responses in different frog skins. The sensitivity of the skins to frog extract or arginine vasotocin remains much more constant among different frogs. If one compares the natriferic values obtained when both frog extract and arginine vasotocin are assayed on the same skin there is a much more constant relationship between their natriferic activities. This may be taken as additional evidence in support of the contention that frog extract contains arginine vasotocin.

Activities of arginine vasopressin, oxytocin, bullfrog neurointermediate lobe extract and arginine vasotocin on other selected assays are also shown in Table 1. It appears that arginine vasotocin could, if present in the bull-frog neurointermediate lobe in a concentration of approximately 8 μgm./mgm. dry weight, account for the vasopressor, frog bladder, frog antidiuretic, and frog natriferic activities of the extract. The high oxytocic activity of the frog extract is believed to indicate that oxytocin is also present[10].

It appears probable that both natriferin and the frog water-balance principle are arginine vasotocin. It would not appear necessary, therefore, to ascribe the natriferic activity of frog and teleost pituitary extracts to a new hormonal principle[1] unless there is commanding evidence that such exists distinct from principles previously described.

Further work on the relationships between peptide structure and natriferic activity are planned. It is anticipated that this response will show a high degree of specificity as does the frog bladder response[8]. The presence of natriferic activity in neurohypophysial extracts from vertebrates other than those investigated by Maetz *et al.*[1] should also be investigated.

This investigation was supported by Grant No. A1940 from the National Institute of Arthritis and Metabolic Diseases, National Institutes of Health, U.S. Public Health Service.

Wilbur H. Sawyer

Department of Pharmacology,
College of Physicians and Surgeons,
Columbia University,
New York.

[1] Maetz, J., Morel, F., and Lahlouh, B., *Nature*, 184, 1236 (1959).

[2] Heller, H., *J. Physiol.*, 100, 125 (1941).

[3] Heller, H., *J. Physiol.*, 101, 317 (1942).

[4] Pickering, B. T., and Heller, H., *Nature*, 184, 1463 (1959).

[5] Munsick, R. A., Sawyer, W. H., and van Dyke, H. B., *Endocrinol.* (in the press).

[6] Katsoyannis, P. G., and du Vigneaud, V., *J. Biol. Chem.*, 233, 1352 (1958).

[7] Katsoyannis, P. G., and du Vigneaud, V., *Nature*, 184, 1465 (1959).

[8] Sawyer, W. H., *Endocrinol.*, 66, 112 (1960).

[9] Uranga, J., and Sawyer, W. H., *Amer. J. Physiol.* (in the press).

[10] Sawyer, W. H., Munsick, R. A., and van Dyke, H. B., *Nature*, 184, 1464 (1959).

[11] Ussing, H. H., and Zerahn, K., *Acta Physiol. scandinav.*, 23, 110 (1951).

[12] Munsick, R. A., *Endocrinol.*, 66, 451 (1960).

Effect of Reserpine on the Nucleotide and Catecholamine Content of the Denervated Adrenal Medulla of the Rat

RESERPINE causes a depletion of the catecholamines and adenosine triphosphate stored in the amine granules of the adrenal medulla[1-3]. This effect may, however, have been produced indirectly through the secretory nerves[3]. Such a stimulation of the medulla induced by insulin hypoglycaemia or morphine causes a concomitant release of amines and adenosine triphosphate[4,5]. The essential problem, however, is how reserpine causes amine depletion by direct action on the cells. As a preliminary attempt to elucidate this problem, the effect of reserpine on the nucleotide and amine content of the denervated rat medulla was studied.

The left adrenal medulla of twelve male rats (body-weight 350–400 gm.) was denervated by cutting the splanchnic nerves. This produces a total denervation[7]. After ten days the animals were divided into three equal groups. Reserpine (10 mgm./kgm. subcutaneously) was administered to each of the rats. The animals were killed 24 hr. after the injection and the adrenal medullæ were dissected, extracted and analysed for catecholamines and adenosine phosphates by means of high-voltage paper electrophoresis in the way described in a previous paper[6]. This method yields values for the adenosine phosphates which are somewhat higher than the real ones owing to the presence of other nucleotides[3]. Each extract contained the four left or right medullæ from the rats in each group. The rats were of the same weight and stock as those used in an experiment made at the same time. The normal animals in that work[6] were therefore taken as controls. Denervation of the medulla does not produce any certain changes of the nucleotide or amine content[6].

The results are presented in Table 1.

Table 1. µMOLES IN MEDULLÆ FROM 4 GLANDS

Normal glands		Catecholamines	ATP	ADP	AMP
	Mean	0·365	0·0845	0·0315	0·0096
Reserpine					
Denervated glands	I	0·280	0·0650	0·0235	0·0077
	II	0·190	0·0415	0·0225	0·0061
	III	0·230	0·0550	0·0215	0·0070
	Mean	0·235	0·0540	0·0225	0·0069
		−36%	−36%	−29%	−28%
Non-denervated glands	I	0·110	0·0245	0·0175	0·0063
	II	0·0570	0·0140	0·0115	0·0048
	III	0·0915	0·0200	0·0130	0·0052
	Mean	0·0860	0·0195	0·0140	0·0054
		−76%	−77%	−56%	−44%

Reserpine produced an amine depletion which was on an average 77 per cent in the normal glands and 36 per cent in the denervated ones. As previously found for normal medulla in fowl[1], rat[2], and sheep[3], disappearance of a corresponding amount of adenosine triphosphate occurred in both the normal and the denervated glands. The adenosine monophosphate and adenosine diphosphate content also decreased, but to a lesser extent.

Thus it seems that the release of amines from the adenosine triphosphate amine storage complex produced by reserpine through direct action on the cells is accompanied by a release and/or breakdown of an equivalent amount of adenosine triphosphate which, furthermore, does not lead to an accumulation of adenosine diphosphate or adenosine monophosphate. In this respect the direct reserpine action and the action of nervous secretory stimuli give a similar effect. This may mean that both reserpine and secretory stimuli act through the same mechanism (for example, activation of a release or inhibition of a storage mechanism). Considering the structure of the adenosine triphosphate amine storage complex[8], it seems probable, however, that an amine release—irrespective of the way in which it is brought about—must always be accompanied by a corresponding release (or breakdown) of adenosine triphosphate. The findings, therefore, only seem to imply that the amines released from the granules by reserpine do not accumulate to any appreciable extent in the cytoplasmic sap.

The investigation was aided by a grant from the Swedish Medical Research Council.

NILS-ÅKE HILLARP

Department of Histology,
University of Lund.

---

[1] Schumann, H. J., *Arch. exp. Path. Pharmakol.*, 233, 237 (1958).

[2] Kirpekar, S. M., Goodlad, G. A. J., and Lewis, J. J., *Biochem. Pharmacol.*, 1, 232 (1958).

[3] Hillarp, N.-Å., *Acta physiol. scand.* (in the press).

[4] Carlsson, A., and Hillarp, N.-Å., *Acta physiol. scand.*, 37, 235 (1956).

[5] Carlsson, A., Hillarp, N.-Å., and Hokfelt, B., *J. Biol. Chem.*, 227, 243 (1957).

[6] Hillarp, N.-Å., Jonsson, B., and Thieme, G., *Acta physiol. scand.*, 47, 310 (1959).

[7] Hillarp, N.-Å., *Acta anat.*, Suppl. 4 (1946).

[8] Hillarp, N.-Å., *Acta physiol. scand.*, 47, 271 (1959).

Effect of Three Compounds related to Diethylstilbœstrol on the Phagocytic Activity of the Reticulo-Endothelial System

IT has been reported previously that diethylstilbœstrol is a strong stimulant of the phagocytic activity of the reticulo-endothelial system[1]; that the minimum dose required to stimulate the phagocytes is about 100 times greater than that necessary to induce œstrus[2]; and that after treatment with 0·5 mgm. diethylstilbœstrol daily for six days the phagocytic activity returns to within normal control limits in about eight days[3].

The present communication is a report of the action on the phagocytic activity of the reticulo-endothelial system of three compounds related to diethylstilbœstrol.

Twenty-five male white mice (*T.O.* Swiss strain) of 20–25 gm. body-weight were used in these experiments. Five animals were used to test each compound, each animal receiving one subcutaneous dose of 0·5 mgm. of the compound in 0·05 ml. arachis oil daily for six days. On the eighth day after the commencement of the treatment the phagocytic activity was measured by the rate of disappearance of a known amount of specially prepared carbon from the circulating blood[4], the procedure used being that described in previous communications[1], and the total-body phagocytic activity or phagocytic index being denoted by the symbol *K*.

Ten of the animals were used as controls and were given 0·05 ml. arachis oil once daily for six days. The phagocytic activity was then measured on the eighth day by the carbon method referred to above. The arachis oil controls showed a phagocytic index or *K* value of 13 ± 2·4.

The results are shown in Table 1. The three compounds are active œstrogens, and it can be seen that all of them are strong stimulants of phagocytic activity. These results again suggest that the configuration of the molecule which confers œstrogenic activity is also essential for reticulo-endothelial stimulation. In addition, the results show that phagocytic stimulation

Table 1. Effect of Three Compounds related to Diethylstilboestrol on the Phagocytic Activity of the Reticulo-Endothelial System

Compound used	Phagocytic index (*K* value)	Weight of liver (gm.)	Weight of spleen (gm.)	Oestrogenic activity (R.U.)
Diethylstilboestrol monomethyl ether	85±31	1·79±0·11	0·13±0·01	0·0025 mgm.
Diethylstilboestrol dimethyl ether	88±19	1·66±0·17	0·15±0·04	0·02 mgm.
4-Hydroxy-α: β-diethyl dibenzyl	74±14	1·45±0·14	0·13±0·03	0·04 mgm
Arachis oil controls	13±2·4	1·14±0·17	0·11±0·03	

is accompanied by a corresponding enlargement of the liver and spleen. These are the principal reticulo-endothelial organs and it has been recorded previously that about 90 per cent of the carbon is removed from the blood by the liver, about 3 per cent by the spleen and the remainder by the phagocytes of the lymph nodes, connective tissue and bone marrow[5]. It was also found that the enlargement of liver and spleen is not due to water retention, but appears to be the result of hypertrophy of hepatic and splenic tissue.

In these investigations we gratefully acknowledge financial assistance from the Central Research Fund of the University of London and from the Medical Research Council.

T. Nicol
G. Brownlee
C. Druce
C. C. Ware

Department of Anatomy,
King's College, London, W.C.2.

---

[1] Nicol, T., Bilbey, D. L. J., and Ware, C. C., *Nature*, 181, 1538 (1958).

[2] Nicol, T., and Ware, C. C., *Nature*, 185, 42 (1960).

[3] Ware, C. C., and Nicol, T., *Nature*, 186, 974 (1960).

[4] Biozzi, G., Benacerraf, B., and Halpern, B. N., *Brit. J. Exp. Path.*, 34, 441 (1953).

[5] Halpern, B. N., Biozzi, G., Nicol, T., and Bilbey, D. L. J., *Nature*, 180, 503 (1957)

Infra-red Examination of the Association of Cornea Proteins with Water

Water, the most abundant molecular constituent of the body, is the necessary polar solvent in which physiological and biochemical units associated with cellular biology occur. It forms hydrogen bonds with cellular components which contain polar structural groups such as the protein collagen[1] found in the cornea. Direct evidence for molecular perturbations that occur during change in water content in intact tissue has been lacking, although changes are believed to occur. The present work is concerned with the demonstration and interpretation of the changes that occur in the infra-red spectra of the ox cornea during dehydration and during attempts at re-hydration.

The tissue chosen for investigation was the ox cornea, which has a water content of 75–80 per cent with collagen making up about 70 per cent of the solids. Corneas were excised 1–3 hr. after the animals were slaughtered and then stored at 4° C. until ready for use. They were dehydrated by exposure to infra-red radiation during the runs, which usually lasted ½ hr. each, and they were allowed to dry between runs at room temperature in a desiccator. The Perkin-Elmer model 12 infra-red spectrometer with a sodium chloride prism was used for recording the spectra of the cornea, which was mounted in the slit position. The region of the spectra covered was 1·2–2·7μ.

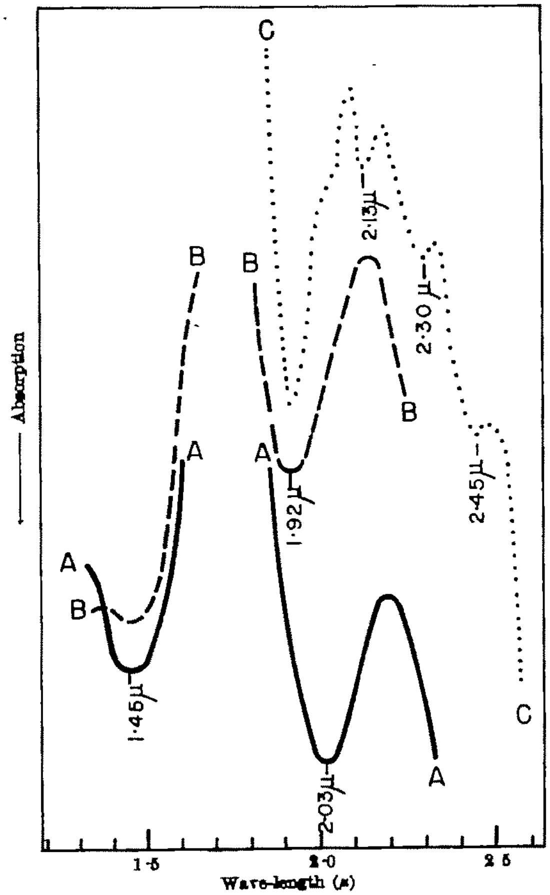


Fig. 1. Infra-red spectra of the ox cornea. —— *A*, fresh cornea; - - - *B*, 5-hr. specimen; · · · · *C*, 2-day specimen

Progressive stages in drying of the ox cornea are shown in Fig. 1. Curve *A* represents the spectral absorption curve immediately after excision. The spectra after 5 hr. and 2 days of drying are indicated by curves *B* and *C*, respectively. Immediately after excision, the maximum absorption bands were obtained at 1·45μ and 2·03μ. After dehydration for 5 hr., the wave-lengths of the absorption bands were 1·45 and 1·92μ, and after two days, they were 1·92, 2·13, 2·30 and 2·45μ. The absorption at 1·45μ in curves *A* and *B* of Fig. 1 is ascribed to water, which decreases between curves *A* and *B*. The absorption band in curve *A* at 2·03μ has been eliminated in the 5-hr. specimen (curve *B*) although water is known to be present since there is a residual absorption at 1·45μ. After 5 hr. the background absorption of the corneal protein is sufficiently intense in the 2μ region to obscure the absorption of the small amount of water present.

Attempts to rehydrate the corneas which had been dehydrated for 2 days were carried out by dampening with water and immersing in water for 30 min. and 2 days. In each case, there is an increase in absorption at 1·45μ and 1·92μ, which are approximately the absorption bands of water. The combined absorption curves of the 2-day-old specimen and that of water do not correspond to the original spectrum shown in Fig. 1, curve *A*. A number of determinations were made, and reproducibility was obtained for the initial and final runs.

The infra-red absorption curve obtained with dehydrated cornea to which water had been added does not correspond to the absorption spectrum of the original tissue. It is apparent that the withdrawal of water from the tissue leads to structural changes of the cornea, which are revealed by the infra-red absorption bands found in the dried tissue. The inability to re-establish the infra-red curve *A*, Fig. 1, by adding water to the dried tissue indicates that the polar groups which were associated with water in the fresh cornea are no longer available. The loss of water in the cornea apparently breaks the association between the protein and water molecules. Since the final dried cornea is hard and has the physical characteristics of a high molecular weight polymer, it is suggested that the active polar groups of the released protein may then become re-oriented among themselves to form higher molecular weight components.

We are grateful to the Air Reduction Research Laboratories, Murray Hill, New Jersey, for the use of their spectrometer and facilities in this investigation. This investigation was supported, in part, by a fellowship (S. B.), grant 2*G*125, from the U.S. Public Health Service.

S. Bakerman

Pathology Department, University of Kansas,
Medical Center, Kansas City, Kansas.

C. Mitchell

78 Nepas Road, Fairfield, Conn.

---

[1] Fraser, R. D. B., and Macrae, T. P., *Nature*, 183, 179 (1959).

Diuretic Activity of 2-Amino-4-metachloro-anilino-1,3,5,triazine (*R*-37)

A series of new derivatives of *s*-triazine synthesized in the Department of Chemotherapy, Haffkine Institute, Bombay, have been tested for their diuretic activity. Of the 12 compounds tested, 2-amino-4-meta-chloro-anilino-1,3,5,triazine (*R*-37), which is the metachloro analogue of amanozine, was found to be most promising. Diuretic activity was determined by a modified method of Lipschitz *et al.* (1943) developed in this laboratory[1].

Unanaesthetized rats received normal saline orally, 2·5 per cent of body-weight, followed by the drug under test. Urine was collected over a period of 5 hr. Dogs were anaesthetized, hydrated with normal saline, 2·5 per cent of body-weight, and the drug given intravenously. Urine was collected for the next 5 hr. by catheterizing both ureters, and urinary sodium, potassium and chloride were determined.

Results obtained with *R*-37 were compared with those obtained with urea and hydrochlorothiazide in rats, and with hydrochlorothiazide in dogs. The results of experiments with rats are given in Table 1, and those with dogs in Table 2.

Table 1. Results for Rats

Average of percentage excretion of initial load of water, sodium and chloride in groups of four animals. Potassium values represent average of total amount of potassium thrown out by each group

	Urea	Hydrochlorothiazide		*R*-37	
Dose (mgm./kgm.)	750	1·25	2·50	5 0	10·0
Groups	(14)	(8)	(8)	(8)	(8)
Sodium	30	80*	89	60*	154
Chloride	111	217	211	157	237
Water	61	71	64	58	122
Potassium	0 50	0 76†	0·90*	0·64	0·77*†

A '*t*' test for significance was carried out. Any two values not underscored by the same line or marked with same signs are significantly different (*P*, 0 01).

Table 2. Results for Dogs

Average of percentage increase over control values of urine volume and electrolyte excretion over intravenous administration of the drug; control observations are for 1 hr., while 'test' values are average of 5 hr. in each animal. Each figure is an average from three animals

Drug	Hydrochlorothiazide	Hydrochlorothiazide	*R*-37	*R*-37
Dose (mgm /kgm.)	2·5	5 0	5 0	10 0
Sodium	270	1,590*	100	1,130*
Potassium	315*	280*	55	360*
Chloride	390	1,185	265	835
Urine volume	470	225	230	1,110

A '*t*' test for significance was carried out. Any two values not underscored by the same line or marked with asterisks are significantly different (*P*, 0·01).

These results show that *R*-37 is a very powerful diuretic in animals and compares favourably with hydrochlorothiazide in the range of dosages of the two drugs employed by us. The drug has a good margin of safety in animals and is not toxic when used in diuretically active dosage given daily over a period of four weeks in animals. None of the dogs given *R*-37 in doses of either 5 mgm./kgm. (3 dogs) or 10 mgm./kgm. (3 dogs) showed any sign of hæmaturia or crystalluria.

D. J. Mehta
U. K. Sheth

Department of Pharmacology,
Seth G.S. Medical College,
Bombay 12.

C. V. Dhliwala

Department of Chemotherapy,
Haffkine Institute, Bombay 12.

---

[1] Mehta, D. J., Kharante, R. G., and Sheth, U. K., *Indian J. Physiol. Pharmacol.*, 3, 111 (1959).

A Suggested Effect on Levels of Catecholamine in Brain produced by Small Doses of Reserpine

In a recent communication, Sheppard and Zimmerman[1] criticized the results obtained by numerous other workers indicating that reserpine reduces the content of brain norepinephrine and serotonin. Their objections were based on the "toxicological doses" which had been used. However, they failed to mention that reserpine had also been reported to reduce levels of brain serotonin[2] and norepinephrine[3] in non-toxic doses as low as 0·1 mgm./kgm. and to deplete heart norepinephrine in doses as low as 5 μgm./kgm.[4]. Sheppard and Zimmerman's results showed that the administration of 0·1 mgm./kgm. of reserpine subcutaneously to female guinea pigs weighing 300 gm. elicited a rise of 74 per cent in brain norepinephrine in 20 min. and a rise in heart norepinephrine of 30 per cent in 20 min. and 45 per cent in 2 hr. No diminution in brain and heart norepinephrine was noted for 8 hr. In contrast, serotonin-levels in the brain fell by 50 per cent in 4 hr. They concluded that their results constituted the first demonstration of a rise in catecholamine content following the administration of reserpine.

Sheppard and Zimmerman measured norepinephrine fluorometrically by a procedure using a filter for isolating the activation and fluorescent light bands. Since filters have relatively wide spectral bands, the validity of their values is contingent on proof that the method for norepinephrine is specific. This is especially relevant in view of the presence of reserpine and its metabolites in the body. However, no evidence is offered for the specificity of the method.

We have repeated the experiments using a fluorescent spectrofluorometer which permits use of narrow spectral bands and methods of proved specificity for norepinephrine[5] and serotonin[6]. The administration of 0·1 mgm. of reserpine per kgm. subcutaneously to female guinea pigs weighing about 300 gm. at no time caused a rise in brain or heart norepinephrine. In 20 min., when Sheppard and Zimmerman had found a 74 per cent rise in brain norepinephrine, we found that serotonin and norepinephrine showed no change from normal, or perhaps a small decline. After 4 hr. the brain amine-levels were 60–70 per cent of normal (Table 1).

Table 1. GUINEA PIG BRAIN AND HEART AMINES AFTER ADMINISTRATION OF 0·1 MGM./KGM. OF RESERPINE SUBCUTANEOUSLY

		γ/gm.* ± *S.D.*	Percentage of normal
Brain serotonin	Control	0·28 ± 0·04	100
	Reserpine, 20 min.	0·28 ± 0·02	100
	Reserpine, 4 hr.	0·19 ± 0·04	68
Brain norepinephrine	Control	0·42 ± 0·04	100
	Reserpine, 20 min.	0·40 ± 0·02	95
	Reserpine, 4 hr.	0·25 ± 0·07	60
Heart norepinephrine	Control	2·71 ± 0·34	100
	Reserpine, 20 min.	2·46 ± 0·38	91
	Reserpine, 4 hr.	0·63 ± 0·30	23

* Each value represents the average from 6 animals.

Heart norepinephrine fell to 90 per cent of normal in 20 min. and was only 20 per cent of normal in 4 hr. (Table 1).

These results show that the fall in brain and heart amines after the administration of small doses of reserpine to female adult guinea pigs is qualitatively similar to that observed in other animal species when using larger doses of reserpine.

F. BARBARA ORLANS
BERNARD B. BRODIE

Laboratory of Chemical Pharmacology,
National Heart Institute,
National Institutes of Health,
Bethesda, Maryland.

---

[1] Sheppard, H., and Zimmerman, J. H., *Nature*, 185, 40 (1960).

[2] Pletscher, A., Shore, P. A., and Brodie, B. B., *J. Pharmacol. Exp. Therap.*, 116, 84 (1956).

[3] Shore, P. A., and Brodie, B. B., "Psychotropic Drugs", 427 (Elsevier Pub. Co., Amsterdam, 1957).

[4] Carlsson, A., Rosengren, E., Bertler, Å., and Nilsson, J., "Psychotropic Drugs", 363 (Elsevier Pub. Co., Amsterdam, 1957).

[5] Shore, P. A., and Olin, J. S., *J. Pharmacol. Exp. Therap.*, 122, 295 (1958).

[6] Bogdanski, D. F., Pletscher, A., Brodie, B. B., and Udenfriend, S., *J. Pharmacol. Exp. Therap.*, 117, 82 (1956).

THE preceding communication contains data refuting the rise in catecholamines which we had observed 20 min. after the subcutaneous injection of reserpine (0·1 mgm./kgm.). In repeating the experiment in order to check the questioned specificity of the analytical method, we found that we were unable to reproduce our original findings. Instead, the brain catecholamine-levels expressed as percentage of controls were found to be 105, 100, 64, 26, 37 and 31 per cent after ½, 2, 4, 6, 8 and 72 hr. The shape of the curve was very much like that observed for serotonin and the 4-hr. values agreed with those reported by Orlans and Brodie. We are, at present, unable to detect the factors in the original experiments which gave us the values we reported, but we intend to pursue this matter further. In spite of this discrepancy, the serotonin values remain undisputed and the main conclusion remains valid, namely, that there exists no correlation between the levels of brain amines and the intensity of observable effects.

It is unfortunate that Orlans and Brodie, while correctly questioning the method of analysis for catecholamines, misinterpreted and mis-stated what was written in our original letter. Suffice it to say that our communication was not a criticism of the many skilled workers who had demonstrated the ability of reserpine to lower tissue amine-levels. Contained in it, however, was a criticism of the attempts by some workers to attribute the presumed central effects of large doses of reserpine (1–5 mgm./kgm.) to changes in the levels of brain serotonin or norepinephrine. The actions of reserpine described by Brodie *et al.*[1] as "loss of righting reflex, enhanced salivation and active closure of the eyelids" would be considered as undesirable toxic side-effects if found to occur clinically. To imply that such effects describe in equal fashion such terms as tranquillizing, sedative and central action of reserpine does little to clarify a terminology which is already too vague for scientific usage. It is important to define terms more clearly and to signify what responses one is trying to correlate with changes in tissue amine-levels. It remains to be determined which, if any, of the effects of reserpine may be attributed to changes in serotonin or norepinephrine-levels alone. Previous work with reserpine labelled with carbon-14 or tritium[2] had demonstrated that the alkaloid was present in the brain during the entire period of visible action of the drug, but that here too no correlation could be made between the intensity of response and drug-level. It is important to recognize that the application of other techniques as used in the study of behaviour may bring to light some actions of the drug which are not readily observed, and for which a correlation can be found with changes in brain amine and/or reserpine-levels. In our opinion, no experiment has been reported which conclusively eliminates reserpine, *per se*, as the active agent and establishes serotonin and/or norepinephrine in its place. It remains for future work to establish the true mechanism of action of reserpine and similar alkaloids.

HERBERT SHEPPARD
JOSEPH H. ZIMMERMAN

Ciba Pharmaceutical Products, Inc.,
Summit, N.J.

---

[1] Brodie, B. B., Finger, K. F., Orlans, F. B., Quinn, G. P., and Sulser, F., *J. Pharmacol. Exp. Therap.*, 129, 250 (1960).

[2] Sheppard, H., Tsien, W. H., Plummer, A. J., Peets, E. A., Giletti, B. J., and Schulert, A. R., *Proc. Soc. Exp. Biol. Med.*, 97, 717 (1958).

HÆMATOLOGY

β-Globulin Polymorphism in Chimpanzees

INTRASPECIFIC variation in the electrophoretic mobility of serum iron-binding β-globulins ('transferrins') have been described in man[1,2], cattle[3–5], sheep[6,7], goats[8] and certain monkeys[4,9]. In all but monkeys these variations have been established as inherited.

We have recently examined the sera of 25 chimpanzees, *Pan satyrus*, and observed seven β-globulin phenotypes. Prior to our examination, these animals had been used for the assay of poliomyelitis vaccine. Fifteen were affected with spontaneously acquired tuberculosis. Serum was held 2–20 weeks at – 15° C. before use. Electrophoresis on borate-

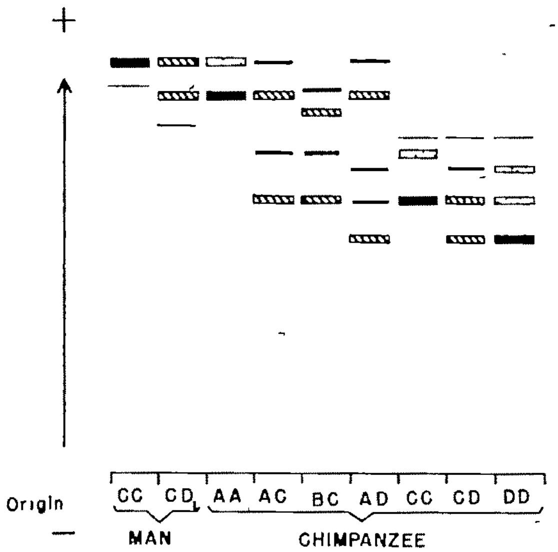


Fig. 1. Diagram showing the relative mobilities and intensities of iron-binding β-globulins in various phenotypes of man and chimpanzees. Order of decreasing intensity is as follows: black bar, hatched bar, stippled bar, thin bar, line

Table 1. Frequency of β-globulin ("Transferrin") Phenotypes in Chimpanzees

Phenotype	No. of animals in which phenotype was observed
AA	1
AC	3
BC	4
AD	5
CC	9
CD	1
DD	2
	25

buffered hydrolysed starch gel was performed according to the technique described by Smithies[10]. Use of gel buffered with *tris*(hydroxymethyl)aminomethane[11] yielded less-satisfactory separation. The serum β-globulin of each animal was saturated *in vitro* with iron-59 (ferrous citrate)[3], a constant voltage of 4–5·5 V./cm. applied for 18–21 hr., and radioautographs obtained[3]. The serum of each animal was compared repeatedly with those of other animals. A diagram of observed transferrin types is shown in Fig. 1 and the frequency of these types in Table 1.

The inheritance of the observed phenotypes is unknown and likely to remain so because of the difficulty attendant on mating these animals in captivity. The designation of phenotypes as shown is thus entirely arbitrary. It seems possible, however, that the β-globulin phenotypes AA, CC and DD represent homozygous states. These phenotypes exhibit two to four bands the intensity of which is inversely related to mobility and in these respects are similar to cattle homozygous at the β-globulin locus[3]. Moreover, the *in vitro* mixture of equal parts of AA and CC sera results in an electrophoretic appearance indistinguishable from AC serum, suggesting that AC animals are hybrid at the β-globulin locus. Similarly, mixtures of phenotypes AA–DD and of phenotypes CC–DD are indistinguishable from AD and CD phenotypes, respectively. A BB phenotype was not observed although its existence might be predicted by the occurrence of BC sera.

The presence of faintly labelled zones of iron-binding β-globulins was overlooked in preliminary experiments, and thus there may be numerous additional zones, characteristic of each phenotype, which cannot be detected by the technique employed. The appearance of multiple β-globulin zones in homozygotes has been observed in a variety of animals[4–8] and may occur in man. Indeed, several human sera of Tf–CC type frequently exhibited, as shown in Fig. 1, a faintly labelled band lying midway between the position of C and D$_1$ in man. The serum of one CD$_1$ individual, a Negro woman with systemic lupus erythematosus, was repeatedly examined and exhibited the faintly labelled slow-moving band indicated in Fig. 1. Such bands may, of course, be artefactual in nature.

One explanation for a multiplicity of 'transferrin' zones may lie in the polymerization of some parent protein unit. Such a hypothesis appears quite likely in the case of human haptoglobins[12].

It was noted in passing that the haptoglobin of each chimpanzee, when fully saturated with human hæmoglobin A, appeared as a single band lying in approximately the same position as human haptoglobin *Hp* 1–1. Some animals with gross anatomical evidence of pulmonary tuberculosis had haptoglobin hæmoglobin binding capacities in excess of 300 mgm. per cent, while others with the same disease had less than 30 mgm. per cent[13].

We wish to thank Dr. David Bodian for providing the chimpanzees studied and Dr. Neal Nathanson for his assistance.

This work was supported in part by United States Public Health Service Grant No. B2053 from the National Institute of Neurological Disease and Blindness.

SAMUEL H. BOYER

Division of Medical Genetics,
Department of Medicine,

WILLIAM J. YOUNG

Department of Anatomy,
The Johns Hopkins University School of Medicine,
Baltimore, 5, Maryland.

[1] Smithies, O., and Hiller, O., *Biochem. J.*, 72, 121 (1959).
[2] Giblett, E. R., Hickman, C. G., and Smithies, O., *Nature*, 183, 1589 (1959).
[3] Ashton, G. C., *Nature*, 180, 917 (1957).
[4] Ashton, G. C., *Nature*, 182, 370 ((1958).
[5] Ashton, G. C., *Nature*, 184, 1135 (1959).
[6] Ashton, G. C., *Nature*, 181, 849 (1958).
[7] Ashton, G. C., *Nature*, 182, 1102 (1958).
[8] Ashton, G. C., and McDougall, E. I., *Nature*, 182, 945 (1958).
[9] Blumberg, B., *Proc. Soc. Exp. Biol. Med.* (in the press).
[10] Smithies, O., *Biochem. J.*, 71, 585 (1959).
[11] Poulik, M. D., *Nature*, 180, 1477 (1957).
[12] Smithies, O., and Connell, G. E., Ciba Symposium on Biochemistry of Human Genetics, 178 (1959).
[13] Nyman, M., *Scandinav. J. Clin. Lab. Invest.*, 11, Supp. 39 (1959).

Effect of Ribonuclease on Erythrocyte Antigens

RESULTS reported earlier from this laboratory suggest that the Rh and Lutheran human blood-group antigens owe at least some portion of their specificity to ribonucleic acid derivatives[1,2]. These observations were later confirmed by Allen (personal communication). Boyd, McMaster and Waszczenko-Zacharczenko[3] reported that they could not confirm the results cited above. However, more recently Boyd (personal communication) has observed an inhibitory effect reported earlier for these ribonucleic acid derivatives. This hypothesis has been further tested by treating erythrocytes with the enzyme ribonuclease. (Two samples from Worthington and one from Nutritional Biochemicals were used.) If, indeed, any antigenic specificity is due to ribonucleic acid derivatives, then treatment with this enzyme should remove these, at least partially, from the cells, and thus lower the agglutinability of these cells with the antibodies specific for the affected antigens. On the other hand, those antigens which are presumed not to involve ribonucleic acid derivatives should be unaffected by this treatment.

Table 1

Antibody	Sample No.	Titration scores Treated with ribonuclease	Titration scores Untreated (saline control)	Enzyme concentration (mgm./ml.)	Time (hr.)
Anti-A	1	85	85	2	2
	2	91	91	2	4
	3	93	93	2	4
	4	88	88	2	11
Anti-B		88	88	2	4
Anti-M	1	47	48	2	2
	2	60	59	2	4
Anti-N		53	53	4	4
Anti-P		12	12	2	4
Anti-I	1	36	36	2	2
	2	35	33	2	2
Anti-Lu^a		16	28	4	4
Anti-Lu^b		12	30	4	4
Anti-D	1	41	56	2	2
	2	30	56	2	2
	3	45	60	4	4
	4	50	71	2	11
Anti-C	1	52	72	2	2
	2	51	62	2	11
	3	52	64	4	4
	4	27	48	2	2
	5	21	48	2	2
Anti-E		29	47	2	2
Anti-c		13	25	2	2
Anti-e	1	43	59	2	2
	2	38	50	2	4

Samples of packed cells were incubated for varying times, as is shown in Table 1, with the enzyme ribonuclease. The enzyme concentration was 2 mgm./ml. or 4 mgm./ml., and ten volumes were used with a single volume of cells. Identical controls were set up using saline instead of ribonuclease. After incubation with either ribonuclease or saline, the cells were washed, and matched cell suspensions prepared. These were titrated with the various antisera shown in Table 1, and scored on the Race scale[4]. Only saline agglutinins were used.

With anti-A, -B, -M, -N, -P and -I, as can be seen in Table 1, there is no appreciable difference in titration scores between the cells treated with ribonuclease and the controls incubated in saline. However, with the anti-Rh and the anti-Lutheran antibodies, the agglutinability of the treated cells is apparently much less than the untreated controls. While not attempting here to evaluate optimum time or enzyme concentration for the reaction, it seems clear that under all sets of conditions tested, the treated cells have lost part of their Rh and Lutheran specificities at the same time as the other antigens tested for were unaffected. Since the activity of the enzyme, ribonuclease, is highly specific in that it acts only on polyribonucleic acids, it seems reasonable to conclude that the loss of ribonucleic acid components from the cell caused the lowering of agglutinability of the cells. This, added to the evidence of inhibition of agglutination cited above, would suggest still more strongly that there are one or more ribonucleotide components of the Rh and Lutheran antigens.

This work was supported by Grant No. *NSF–G* 6208 of the National Science Foundation.

EMANUEL HACKEL
ROBERT E. SMOLKER*

University College,
Michigan State University,
East Lansing, Michigan.

---

* Present address: State University College on Long Island, Oyster Bay, New York.

[1] Hackel, E., Smolker, R. E., and Fenske, S. A., *Vox Sang.*, 3, 402 (1958).

[2] Hackel, E., and Spolyar, K. S., *Vox Sang.* (in the press).

[3] Boyd, W. C., McMaster, M. H., and Waszczenko-Zacharczenko, E., *Nature*, 184, 989 (1959).

[4] Race, R. R., and Sanger, R., "Blood Groups in Man", third ed. (Blackwell Scientific Pub., Oxford, 1958).

BIOLOGY

A Bleached Variant of *Euglena gracilis* showing a Doubling of the Content of Deoxyribonucleic Acid

WHEN certain strains of the green flagellate *Euglena gracilis* are grown at 34–35°, cultures devoid of chloroplasts are obtained[1]. These cells, which we term bleached, resemble the normal organisms cultivated in the dark (designated colourless), but they have lost a hereditary character necessary for the formation of the plastids[2]. In the course of a study of the chemical changes attending the loss of the photosynthetic apparatus in *Euglena*, a bleached culture ('Bleached II') derived from the normal strain *z* by thermal treatment, which had been carried through frequent liquid transfers for about three years, was found to contain twice the amount of deoxyribonucleic acid that is present in the original green or colourless cells. A comparison of the properties of this bleached variant with those of colourless cells showed the first to contain also more ribonucleic acid and protein and to have a slower rate of growth. Although the nuclei of these two cell types, when treated by the Feulgen method, appeared of equal size, those of the bleached organisms were coloured more intensely.

In an attempt to study this phenomenon in more detail, we produced clones of bleached cells by cultivation either at 34° or in the presence of streptomycin (10 mgm./ml.)[3]. These newly produced bleached organisms ('Bleached I') contained, to our surprise, an amount of deoxyribonucleic acid identical with that of the normal cells; nor did the further cultivation of these cells at 34° for several weeks with frequent transfers bring about an alteration in the normal nucleic acid content. Clones obtained from spontaneously occurring bleached cells also were found to contain the normal quantity. Table 1 records the contents of nucleic acid and protein found in the colourless cells and the two types of bleached organisms. The quantity of deoxyribonucleic acid present in green cells grown in the light is the same as that found in the colourless organisms.

It would appear that the doubling of the content of deoxyribonucleic acid in the bleached strain of type II constitutes a newly acquired and stable hereditary characteristic that may be described tentatively as an instance of experimentally induced polyploidy or polyteny. A change in the timing of the duplication of deoxyribonucleic acid during the interphase could, however, also simulate an alteration

Table 1. Properties of Colourless and Bleached Cells of *Euglena gracilis*, Strain z*

Type of cells	Deoxyribonucleic acid (µmol. per 10^7 cells)	σ	Ribonucleic acid (µmol. per 10^7 cells)	Protein (mgm. per 10^7 cells)	Generation time (hr.)
Colourless	0·09	0·02	0·60	2·1	7·3
Bleached I	0·11	0·02	0·67	2·2	8·0
Bleached II	0·20	0·04	0·80	3·3	8·8

* The cells were grown in the medium described previously (ref. 4). The chemical analyses were performed on large cell samples taken from cultures in the late logarithmic phase. The nucleic acids were determined by a modification, to be described later, of the Ogur–Rosen method (ref. 5), protein was estimated by means of the biuret procedure (ref. 6). The standard deviation is given as σ. The generation time was measured in cultures in the early logarithmic phase.

of the cellular content of this substance; and in the absence of a detailed cytochemical study this possibility cannot be excluded entirely. Our observations on the bleached cultures of type I demonstrate that the increase in deoxyribonucleic acid is not an obligatory consequence of the loss of chloroplasts in *Euglena*. That this augmentation is connected in some manner with the bleaching treatment is indicated by our findings with the bleached cells of type II and also by a recent report[7] describing a 50 per cent increase over the normal in the deoxyribonucleic acid contents of two bleached strains of *Euglena gracilis*. The reason for this phenomenon is obscure. It could, perhaps, be considered as significant that all bleached strains exhibiting the increase in deoxyribonucleic acid had been carried for several years before being analysed. Though the nature of the environmental stimulus giving rise to this alteration cannot be defined, a selection effect may be ruled out, since the cells characterized by a doubling of deoxyribonucleic acid, having a longer generation time, could scarcely have competed successfully, in the medium employed, with the organisms carrying the normal complement.

We are indebted to Dr. Arline D. Deitch for the examination of the preparations treated by the Feulgen procedure. This work was supported by research grants from the American Cancer Society and the National Science Foundation.

George Brawerman
Carole A. Rebman
Erwin Chargaff

* Cell Chemistry Laboratory,
Department of Biochemistry,
College of Physicians and Surgeons,
Columbia University,
New York 32.

[1] Pringsheim, E. G., and Pringsheim, D., *New Phyt.*, 51, 65 (1952).
[2] Brawerman, G., and Chargaff, E., *Biochim. Biophys. Acta*, 37, 221 (1960).
[3] Provasoli, L., Hutner, S. H., and Schatz, A., *Proc. Soc. Exp. Biol. Med.*, 69, 279 (1948).
[4] Brawerman, G., and Chargaff, E., *Biochim. Biophys. Acta*, 31, 164 (1959).
[5] Ogur, M., and Rosen, G., *Arch. Biochem.*, 25, 262 (1950).
[6] Crampton, C. F., Lipshitz, R., and Chargaff, E., *J. Biol. Chem.*, 206, 499 (1954).
[7] Neff, R. H., *J. Protozool.*, 7, 69 (1960).

Plastids of the *Avena* Coleoptile

Phototropic curvature of the *Avena* coleoptile may, for reasons which have been summarized elsewhere[1], be mediated through the plastids. Geotropic curvature may have a similar basis, for it has long been thought[2,3] that the geotropic responses of both shoots and roots are mediated by special starch grains or 'statoliths', and these in fact are plastids in which relatively large amounts of starch have been deposited. It is thus worth considering that the many similarities between these two types of tropism may have an anatomical basis. For this reason a closer study has been made of the plastids of the etiolated *Avena* coleoptile. The observations have been made with the light and phase microscope, utilizing either fresh material vitally stained with neotetrazolium chloride, or microtome sections fixed in chrome-acetic-formalin and embedded and sectioned in 'Carbowax'. (We wish to thank Prof. R. H. Wetmore and Dr. J. Riopel for assistance and for putting at our disposal the newly developed 'Carbowax' method.) Principal attention has been directed to the most apical part of the coleoptile.

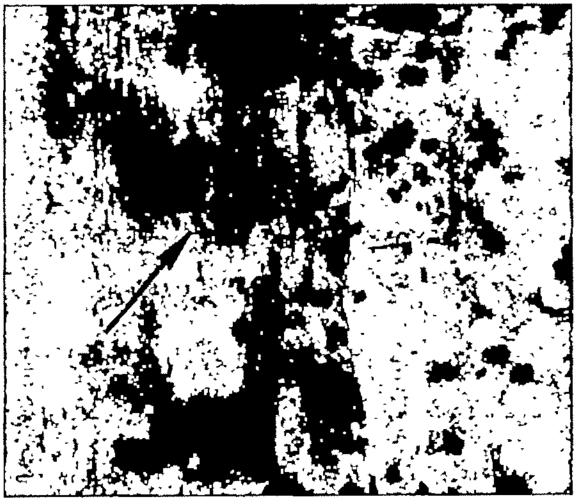


Fig. 1. From lower part of the coleoptile. Basal arrangement of the statoliths in two rows of cells only. (× 733)

Plastids are seen in all cell-layers except the inner and outer epidermis, which appear not to contain them. Our observations indicate that they are of two types. The first do not react with neotetrazolium, when fully developed, and contain mainly starch, which stains red-brown with iodine. These occur in abundance at the very tip of the coleoptile and also in

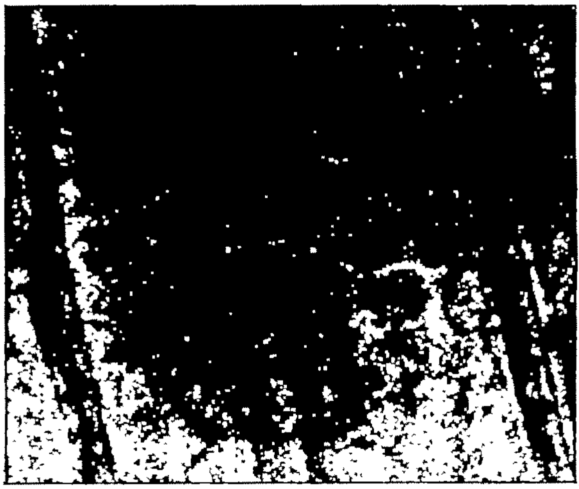


Fig. 2. Prolamellar body of the etiolated plastid after treatment with neotetrazolium and succinate showing the localization of dehydrogenase activity. (× 1,755)

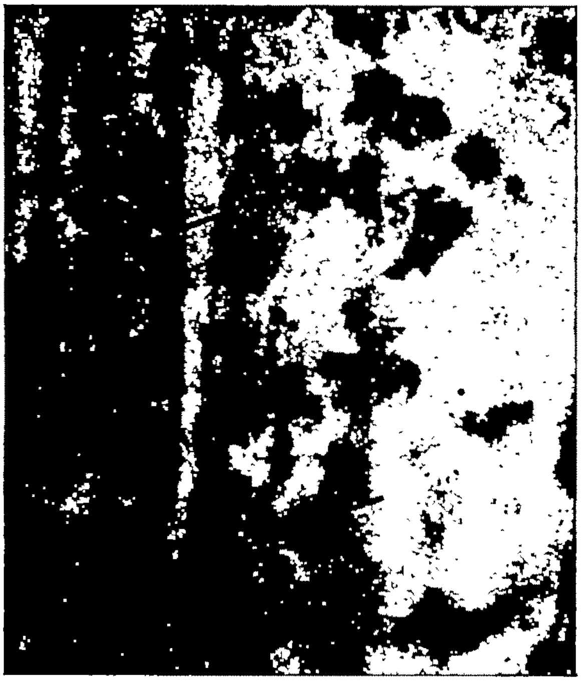


Fig. 3. Lobate outgrowth of the prolamellar body in cells similar to Fig. 2 after 1 hr. exposure to red light. Treatment as in Fig. 2. (× 1,755)

the subepidermal and middle layers around the fibro-vascular bundles. Thus these plastids are principally located in an arch rising outside and around the bundles; in the lower part of the coleoptile the sides of the arch have a thickness of two cells (Fig. 1), while the top has many layers. In plants which have been held vertical, sectioned under red light, mounted in iodine solution, and examined immediately, these bodies are found congregated at the basal end of the cells (Fig. 1). In plants which had been illuminated beforehand the basal arrangement of these plastids is not evident. Plastids of this type are without doubt identical with the statoliths described by von Guttenberg[4]; Yocum[5] has shown that these bodies roll down to rest on the lateral wall shortly after the plant has been placed horizontal. In the cells on the two sides remote from the bundles, these plastids occur sporadically and do not take up the characteristic basal position.

The second type occurs in highest concentration near the base of the tip portion, close to the apical termination of the vascular bundles; this point lies some 200μ below the extreme tip and 50μ above the uppermost end of the cavity. These plastids vary in size from 1 to 4μ and often contain a granule, 1–1·5μ in diameter, which stains strongly with neotetrazolium in presence of $M/20$ succinate or malate (Fig. 2). There is reason to identify this granule with the prolamellar body of etiolated plastids. Other cells contain these plastids in smaller numbers.

When the plants are illuminated with red light (wave-length 600 mμ and above) for 30 min. or more, the granule is found to have expanded into an X or lobate form (Fig. 3). This observation parallels that of the outgrowth of the 'crystalline' body into the lamellated structure of the typical chloroplast, which has been several times figured by the electron microscopists[6-9] and appears to establish this type of plastid as a pro-chloroplast. It is of interest, however, that the 'prolamellar body' is made evident by its dehydrogenase activity rather than by any special optical property. It is of still further interest that pre-exposure of the coleoptile to red light markedly modifies its subsequent phototropic sensitivity to white light[10]; such parallelism helps to support the concept of a close and causal relation between the proplastids and phototropic sensitivity.

This research has been supported by grants from the American Philosophical Society and the National Science Foundation.

HELEN P. SOROKIN
KENNETH V. THIMANN

Harvard Biological Laboratories,
Cambridge, Mass.

[1] Thimann, K. V., in "Life and Light", McCollum Pratt Symposium, Johns Hopkins University, Baltimore, Maryland, 1960 (in the press).

[2] Haberlandt, G., "Physiological Plant Anatomy" (1914).

[3] Larsen, P., Abs. Ninth Int. Bot. Cong., Montreal, 216 (1959.)

[4] von Guttenberg, H. R., *Jahrb. wiss. Botanik*, 50, 289 (1912).

[5] Yocum, C. L., unpublished observations made in our laboratory in 1955.

[6] Leyon, H., *Exp. Cell Res.*, 7, 608 (1954).

[7] Heitz, E., *Exp. Cell Res.*, 7, 606 (1954)

[8] Hodge, A., McLean, J., and Mercer, F., *J. Biophys. Biochem. Cytol.*, 2, 597 (1956).

[9] Muhlethaler, K., and Frey-Wyssling, A., *J. Biophys. Biochem. Cytol.*, 6, 507 (1959).

[10] Curry, G., Ray, P., and Thimann, K. V., *Physiol. Plantarum*, 9, 429 (1956).

Anastomoses in the Phycomycetes

IT is commonly assumed, either explicitly[1] or implicitly[2-4], that the vegetative mycelium of the Phycomycetes is incapable of vegetatively anastomosing and that this whole class of fungi is thereby precluded from developing complex fruiting-bodies and from undergoing variation by those means, such as heterokaryosis, which largely depend on the vegetative transfer of nuclei from the cells of one thallus to another.

Such an assumption is certainly confirmed by an examination of most cultures, but one of us (D. M. G.) has occasionally noticed the presence of anastomoses in a number of mycelia which, by their completely aseptate nature, are certainly those of Phycomycetes. Such cultures, isolated from soil in Britain and Australia, have usually been sterile, although one produced a few *Mortierella* sporangia, and the growth characteristics of the others lead us to believe that they belong to the same genus. Some are characterized by a normal system of scalariform anastomoses; but recently an isolate has come to hand in which the anastomoses are massive and comparatively crude, consisting of roughly conical projections, fused at their apices, from two adjacent hyphæ. In both types, extensive protoplasmic flow through mature anastomoses and their supporting hyphæ has been observed. A survey of other genera in the Phycomycetes, especially in the Aplanatae, and of other species of *Mortierella*, has failed to demonstrate the presence of further anastomoses, nor are they mentioned in Turner's[5] detailed description of *M. globulifera*.

This demonstration of the occurrence of anastomoses in at least one phycomycetous genus disrupts one of the "boundary conditions describing the Phycomycetes"[1]. It is also of interest in the fields of fungal variation and plant pathology, for it does not seem inconceivable that anastomoses could occur in other species under certain conditions, with the consequent possibility of heterokaryosis, etc. Such an occurrence would be particularly difficult to detect in the obligate pathogens of the Peronosporales.

D. M. Griffin
Helen N. Perrin

School of Agriculture,
University of Sydney.

[1] Gregory, P. H., *Trans. Brit. Mycol. Soc.*, 35, 1 (1952)

[2] Jinks, J. L., *Proc. Roy. Soc.*, B, 140, 83 (1952).

[3] Langeron, M., and Vanbreuseghem, R., "Précis de Mycologie" (Masson et Cie, Paris, 1952).

[4] Pontecorvo, G., *Cold Spring Harbor Symp. Quant. Biol.*, 11, 193 (1946).

[5] Turner, Myfanwy, *Trans. Brit. Mycol. Soc.*, 39, 291 (1956).

Occurrence and Function of the Provisional Embryonic Cuticle of a Lepidopteran

The provisional embryonic cuticle has been noticed in several groups of insects such as Aphidae, Orthoptera, Hemiptera, Neuroptera and some types of Coleoptera[1]. It was, therefore, of interest to note the presence of the provisional embryonic cuticle in the hitherto unreported group of Lepidoptera.

Various roles have been ascribed to the provisional embryonic cuticle. It has been described as acting as an "egg burster" by Wigglesworth and Sikes[2] and others. It is also regarded by some as affording protection to newly emerged nymphs of grasshoppers when the young ones crawl from the buried egg-pods to the surface.

I believe[3] that the moulting of the provisional embryonic cuticle in *Locustana pardalina*, *Tenebrio molitor* and *Dysdercus cingulatus* (unpublished work) is due to developmental causes. Moulting is induced in order to synchronize the rate of deposition of cuticle with the development of muscle ends, so that a proper integration between the muscle and the cuticular exoskeleton can take place. The provisional cuticle is precociously formed, in the sense that it is formed at a time when the muscles are not in a position to become attached to it by means of tonofibrils. While the other functional interpretations are certainly valid, there is reason for believing that they are secondary adaptations.

In *Attacus ricini* (Lepidoptera), the provisional embryonic cuticle was first detected histologically and also with the help of histochemical methods at about eighty hours before emergence. The second or definitive cuticle was secreted soon after the sloughing of the provisional embryonic cuticle. A thorough examination of the development of skeletal muscles showed that the muscle bands were in an early state of development, mostly in the form of myoblasts at the time of secretion of the provisional embryonic cuticle. The muscles were well formed at the time of the secretion of the definitive cuticle, and it is to this cuticle that the muscles could become properly attached (Fig. 1).

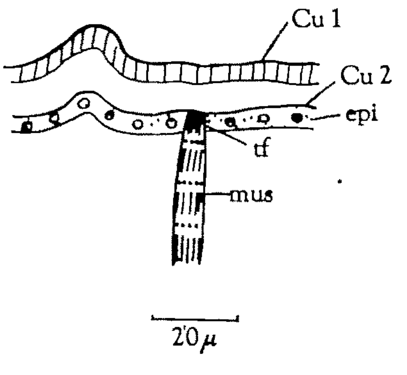


Fig. 1. epi., epidermis; Cu 1, provisional embryonic cuticle; Cu 2, definitive cuticle; mus., striated muscle fibre; tf., tonofibrils

The present investigation on *Attacus ricini*, therefore, confirms the conclusions reached for *Locustana*, *Tenebrio* and *Dysdercus*.

It is hoped to publish details elsewhere with Mr. Sahani of this Department. Mr. Barkat, of Government Farm, Ranchi, kindly made the eggs available for this work.

R. K. Sharan

Department of Zoology,
Science College, Patna, India.

[1] Wigglesworth, V. B., "Insect Physiology", second ed. (Methuen, London, 1950).

[2] Sikes, E. K., and Wigglesworth, V. B., *Quart. J. Micro. Sci.*, 73, 165 (1931).

[3] Sharan, R. K., *Ann. Zool.*, 3, 1 (1958); *Curr. Sci.*, 28, 72 (1959).

Incorporation of Acetate into Protein by Obligately Parasitic and Saprophytic Fungi

The germ tubes of obligate parasites such as the rust fungi and powdery mildews fail to grow in the absence of host plants. This may be caused by metabolic blocks, the general location of which should be revealed by studies on the distribution of radioactive tracer among the various broad classes of metabolites. To determine if this would be a feasible approach to the problem of obligate parasitism, the assimilation of radiocarbon by uredospores of a rust fungus (*Uromyces phaseoli* (Pers.) Wint.) and conidia of a saprophyte (*Aspergillus niger* van Tiegh) was studied to see if any important differences in metabolism occurred between them. The preliminary experiments reported here were made with non-germinated spores, so the metabolism studied was essentially catabolic in character.

Spores of the two fungi were compared with respect to their capacities to incorporate the methyl carbon of $^{14}CH_3COONa$ into sugars, amino-acids, Krebs-cycle acids, proteins, nucleic acids, and lipids. Spores of each species were incubated with 10 μc. of $^{14}CH_3COONa$ for various time-periods and then killed with boiling 80 per cent ethanol. Techniques for the separation and analysis of the various components have been described elsewhere[1].

The results are given in Table 1 and Fig. 1. The principal differences between the two species occurred in the total activity incorporated and the patterns of

Table 1. Distribution of Carbon-14 in Amino-acids from Fungous Spores incubated 10 hr. with 10μc. $^{14}CH_3COONa$

Amino-acid	Free amino-acids		Protein amino-acids	
	U. phaseoli	*A. niger*	*U. phaseoli*	*A. niger*
Alanine	2	1	6	6
γ-Aminobutyrate	1	0	—	—
Arginine	2	0	3	1
Asparagine	2	0	—	—
Aspartate	18	4	29	23
Glutamate	20	46	43	45
Glutamine	40	23	—	—
Leucines	1	19	0	5
Lysine	1	0	11	11
Proline	—	—	1	3
Serine	1	0	5	3
Threonine	1	0	1	1
Tyrosine	0	0	0	0
Valine	13	0	0	1
Total c.p.m. per mgm. N	72,000	265,000	26,500	221,000

Results are given as percentage of total c.p.m. per mgm. protein nitrogen. Detectable label was not found in cysteine, methionine, phenylalanine, histidine or glycine. About 200 c.p.m. were required for detection by the methods employed.

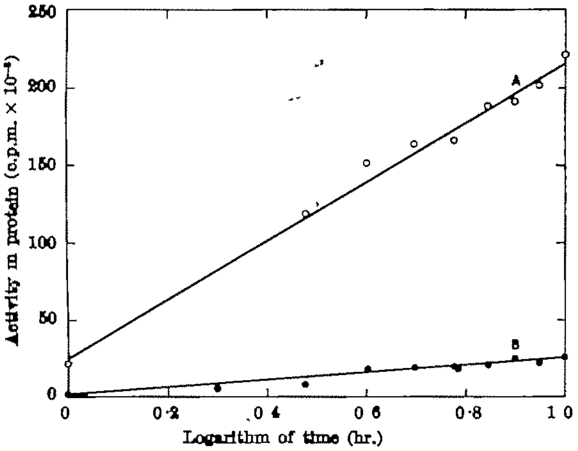


Fig. 1. Rate of incorporation of carbon-14 from $^{14}CH_3COONa$ into the protein fractions of: *A*, conidia of *A. niger*; *B*, uredospores of *U. phaseoli*

labelling of the protein fractions. Conidia of *A. niger* incorporated about 2,000,000 c.p.m. per mgm. of protein nitrogen during a 10-hr. exposure period, or about 10 times the amount of label assimilated by uredospores of the bean rust fungus. Most of the amino-acids in the protein fraction of *A. niger* became labelled in 10 hr. except for cysteine, methionine, phenylalanine, histidine, and glycine. Labelling in the free amino-acid fraction of this fungus was much more restricted, being confined to the leucines, glutamic acid, and glutamine. The specific activities of the amino-acids in the protein fraction of uredospores were much lower, and label was not found in valine or the leucines in addition to the acids not labelled by *A. niger*. A larger number of free amino-acids were labelled by bean rust spores than by *A. niger*; but specific activities were much lower than those isolated from conidia, reflecting low incorporation of exogenous substrate by uredospores.

Thus the rust spores were able to synthesize the same amino-acids from acetate as conidia of *A. niger*, but the over-all incorporation of substrate was lower. In addition, amino-acids were synthesized much more rapidly by conidia than by uredospores. For example, labelled valine was found in conidia in 2 hr., but did not appear in uredospores until 5–10 hr.

At least two amino-acids labelled by uredospores, valine, and leucine(s) were not incorporated into protein. This may have arisen from the fact that the capacity of uredospores for incorporating label into protein fell rapidly with time. When radioactivity in the protein fractions was plotted against the logarithm of time, linear relationships were obtained for both fungus species (Fig. 1). The regression equation relating carbon-14 assimilated, in terms of c.p.m. × 10^{-3} per mgm. protein nitrogen (L), to time of incubation in hr. (t) was found to be:

$$L = 26 \log_{10} t - 0{\cdot}8$$

for the bean rust fungus, with a correlation coefficient of $+0{\cdot}975$.

For *A. niger* the regression equation was found to be:

$$L = 220 \log_{10} t + 3{\cdot}7$$

with a correlation coefficient of $+0{\cdot}995$. Thus it is seen that the regression coefficient relating activity in the protein fraction to the logarithm of incubation time was 8·6 times higher for *A. niger* than for *U. phaseoli*, suggesting that failure of the latter species to incorporate valine and the leucines may arise from a loss of the mechanism for this incorporation.

Therefore, amino-acids which require long periods of time for synthesis may not become labelled soon enough for activity to be incorporated into protein. At least 5 hr. must elapse before the label can be detected in the free leucines isolated from rust spores, by which time incorporation of label into protein has fallen to a small fraction of the initial rate. The results indicate that the metabolism of resting uredospores is characterized by a rapid loss of ability to incorporate substrates into protein, coupled with low utilization of exogenous substrate, and a very slow rate of synthesis of some important amino-acids.

This work was supported in part by a grant from the Rockefeller Foundation.

RICHARD C. STAPLES
H. P. BURCHFIELD

Boyce Thompson Institute,
Yonkers, New York.

[1] Staples, R. C., and Weinstein, L. H., *Contrib. Boyce Thompson Inst.*, 20, 71 (1959).

MICROBIOLOGY

Adaptive Chain in the Conversion of Antimetabolites into Metabolites

THE adaptation of micro-organisms[1] and insects[2] to antimetabolites used in the control of the latter is an important contemporary problem. It has been conjectured that a possible mechanism for such adaptation might be: formation of new metabolic pathways, creation of inhibitors or enzymes neutralizing antimetabolites, or modification of the permeability of structures sensitive towards antimetabolites[3,4]. These mechanisms, in so far as they concern penicillin, would involve an induced biosynthesis of penicillinase which suppresses the antimetabolic activity of penicillin, an autotrophic biosynthesis of amino-acids the assimilation of which by the milieu is inhibited by penicillin[5], or a modification of bacterial surface structure[6]. All or any of these mechanisms might make the antimetabolite innocuous to the living cell.

The present investigation was undertaken to direct attention to some accessory mechanisms subsequent to the adaptation of micro-organisms to antimetabolites.

We established in 1956 (ref. 7) that, for penicillin-resistant *Staphylococci* (not penicillin-dependent), benzylpenicillin serves as a growth factor, replacing thiamine in a nutrient medium containing nicotinic acid[8] but deficient in thiamine. We found that this effect occurs solely with benzylpenicillin and its derivatives, which lack antibacterial activity, benzylpenicilloinic and benzylpenillic acids; it does not occur with other derivatives of penicillin and similar antibiotics[9]. The growth effect observed for concentrations of 10^{-10}–10^{-11} *M* is of the same order as that due to thiamine. A similar growth effect due to vitamins was observed only in the case of thiamine pyrophosphate, thiamine and biotin.

These results should show whether, as a result of adaptation to benzylpenicillin, there appears a novel growth factor, or whether it is converted to thiamine

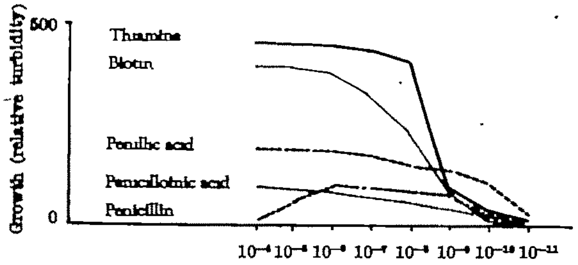


Fig. 1. Growth of *Staph. aureus* 671, cultivated during 48 hr. at 37° C. on a nutrient medium containing $1 \cdot 6 \times 10^{-8}$ *M* nicotinic acid (ref. 8), as well as the substances named at concentrations given on the abscissa

or biotin. In order to clarify the mechanism involved, the effect of the substances named in Fig. 1 on various metabolic processes has been studied.

With *Staphylococci* deficient in thiamine and resistant to penicillin[10], it has been established that thiamine, penicillin and biotin all activate respiration in a similar degree, approximately 60 per cent, on a glucose substrate. Respiration in the case of pyruvate and lactate as substrates is activated particularly by thiamine and thiamine-pyrophosphate, and rather less—though to a practically similar degree—by biotin and benzylpenicillin (also benzylpenicilloinic and benzylpenillic acids); see Table 1.

Table 1. RESPIRATION OF *Staph. aureus* WITH 0·025 *M* PYRUVATE OR LACTATE AS SUBSTRATE AND CONCENTRATION OF SUBSTANCES TESTED $2 \cdot 5 \times 10^{-4}$ *M*

	Thiamine	Biotin	Penicillin	Control
		Substrate pyruvate		
QO_2	7·84	6·12	5·67	4·90
Per cent	160	125	116	100
		Substrate lactate		
QO_2	34·3	26·6	29·2	21·8
Per cent	157	122	134	100

Penicillin stimulates the respiration of penicillin-resistant *Staphylococci*. Thus, if our penicillin-resistant strain (*Staph. aureus* 315) is cultivated on a nutrient medium containing benzylpenicillin in a concentration equal to that showing resistance, but not with the object of modifying resistance, the activating effect of the penicillin on respiration is increased about threefold as compared to the initial stage. The stimulating effect of penicillin on respiration is not shown immediately on the introduction of penicillin, but after some 45 min.; whereas with thiamine, thiamine-pyrophosphate and biotin, activation of respiration is shown immediately on their introduction.

These tests suggest that penicillin is an adaptively formative growth factor, probably different from thiamine and related to or identical with biotin.

In order to study the interaction between penicillin and biotin as metabolites for penicillin-resistant *Staphylococci*, we have tested the introduction of the carbon from bicarbonate into the protein mass of penicillin-resistant *Staphylococci* (Table 2).

Conditions were as follows: 2 hr. incubation at 40° C. in a medium containing, in ml.: 4 mgm. casein hydrolysate-vitamin free; 5 mgm. dipotassium hydrogen phosphate, 4 mgm. glucose, 0·8 μc. sodium bicarbonate-^{14}C, nicotinic acid, 10^{-8} *M*, substances under test at 10^{-8} *M* concentration, micro-organisms 3·4–4·6 mgm. nitrogen and *p*H 7·4. The results are given in impulses/min. for 0·6 mgm. protein nitrogen, while the values in brackets indicate the percentage relating to the control less growth-factor. The tests were carried out with the penicillin-sensitive strain 209, its resistant variant 209*P*, obtained by culture on nutrient media containing penicillin and the penicillin-resistant strain 671.

Likewise, we have measured the rate of introduction of methionine-^{35}S. Under similar conditions, the increased rate of introduction of amino-acid under the influence of penicillin was found not to exceed 10 per cent.

The results obtained indicate that penicillin, similar to biotin, activates the fixation of carbon dioxide (Wood and Werkman reaction), forming products presumably converted into amino-acids, utilized for protein synthesis. It is difficult to appreciate whether the penicillin is adaptively converted into biotin, or whether it acts as a new, adaptively formed metabolite synergistic to biotin. With resistant strains, the rate of introduction of carbon dioxide into the protein mass is many times greater than in the sensitive strains. This is probably the manifestation of the autotrophic formation established by Gale and Rodwell[9] of the amino-acids necessary for protein synthesis in the case of penicillin-resistant *Staphylococci*. Evidently, penicillin as a metabolite for penicillin-resistant *Staphylococci* is introduced precisely into those links of the metabolism which develop with the establishment of resistance.

Our results show that, in the case of penicillin-resistant *Staphylococci*, both penicillin and its product for rendering penicillinase innocuous—penicilloinic acid—serve as metabolites. Similar cases have been described with other metabolites. Thus, chloramphenicol is made innocuous by bacteria, being transformed into *p*-aminobenzoic acid[11]. The antimetabolite of riboflavin-6-chloro-7-methyl-9-(1′-D-ribityl)-*iso*alloxazin may be adaptively utilized by *Lactobacillus casei* as a metabolite[12].

These manifestations lead us to believe that they are an expression of a more general biological occurrence of an adaptive conversion of antimetabolites to metabolites. The chain of complete adaptation as regards some metabolites may be rendered schematically thus:

antimetabolite → indifferent product → metabolite

The adaptation of *Staphylococci* to penicillin observed by us embraces this entire, complete adaptive process. Further, the penicillin antimetabolite converted into a metabolite is launched into a diametrically contrary direction, assisting the organ-

Table 2. INTRODUCTION OF THE CARBON FROM BICARBONATE INTO THE PROTEIN OF *Staphylococci* UNDER THE INFLUENCE OF VARIOUS FACTORS

Strain	Resistance (U./ml.)	Control	Biotin	Penicillin	Thiamine
Staph. aureus 209	0·03	218 (100)	288 (132)	147 (68)	257 (118)
Staph. aureus 209*P*	5,000	297 (100)	365 (123)	344 (116)	293 (99)
Staph. aureus 671	1,000	839 (100)	1,128 (134)	1,006 (120)	727 (87)

isation of autotrophic mechanisms which lead to the by-passing of metabolic links affected by penicillin.

K. I. MARKOV
Department of Microbiology,
G. K. SAEV
Department of Biochemistry,
E. V. GOLOVINSKY
Department of Medical Chemistry,
Higher Medical Institute,
Sofia 32.

[1] Wolstenholme, G. E. W., and O'Connor, C. M. (edit.), "Drug Resistance in Micro-organisms", Ciba Found. Symposium (Churchill, London, 1957).
[2] Symposium on Metabolism of Insecticides, *Canad. J. Biochem. Physiol.*, 37, 1059 (1959).
[3] Davis, B. D., "Drug Resistance in Micro-organisms", Ciba Found. Symposium, edit. by Wolstenholme, G. E. W., and O'Connor, C. M. (Churchill, London, 1957).
[4] Pollock, M. R., "Adaptation in Micro-organisms", Third Symp. Soc. Gen. Microbiol. (Cambridge, 1953).
[5] Gale, E. F., and Rodwell, A. W., *J. Gen. Microbiol.*, 3, 127 (1949).
[6] Markov, K. L., and Saev, G. K., *Arch. Mikrobiol.*, 25, 201 (1956); 28, 130 (1957).
[7] Markov, K. L., and Saev, G. K., *Zbl. f. Bakteriol.*, I Orig., 167, 216 (1956). Saev, G. K., and Markov, K. L., *Dok. Akad. Nauk U.S.S.R.*, 111, 1121 (1956).
[8] West, P. M., and Wilson, P. W., *Science*, 88, 334 (1938).
[9] Markov, K. L., and Saev, G. K., *Zbl. f. Bakteriol.*, I Orig., 168, 203 (1957).
[10] Hills, G. M., *Biochem. J.*, 32, 383 (1938).
[11] Smith, G., and Worrel, C., *Arch. Biochem.*, 24, 216 (1949); 28, 1 232 (1950).
[12] Scala, R. A., and Lambooy, J. P., *Arch. Biochem. Biophys.*, 78, 10 (1958).

A Vacuolar System in Cells of *Agrobacterium tumefaciens* as shown by Electron Microscopy of Ultra-thin Sections

ELECTRON microscope studies of ultra-thin sections of the cells of several species of bacteria made by different workers have shown a regular structural pattern which can be summarized as follows: a definite cell wall, a cytoplasmic membrane (Chapman[1]), a granular cytoplasm with one or more round, dense inclusions called chondrioids (Kellenberger *et al.*[2]), and a more or less central core which is irregular in shape and low in density to the electron beam. Comparative studies of stained preparations with the light microscope have led various workers to associate this core with nuclear structures, and it has been called vesicular nucleus, kernvacuole, kernäquivalent, nucleoide, nuclear sites, and nuclear apparatus. Reticulated structures within this core have been considered to be nuclear material, deoxyribonucleic acid or even chromosomes.

Cells of *Agrobacterium tumefaciens* grown on nutrient agar slants for 48 hr. were fixed in potassium permanganate, incorporated into agar blocks, and embedded in methacrylate. Ultra-thin sections were cut with a diamond knife and photographed in the R.C.A. *EMU3B* electron microscope. In the micrographs we have obtained, we have observed some of the structures described above (Fig. 1). However, after removal of the methacrylate with benzene, followed by shadow-casting with palladium, the central core of low electron density is observed as a vacuole crossed by a few strands and with some dense granules protruding from the cytoplasm into it (Fig. 2). Structures that could represent a vacuolar membrane have not been observed.

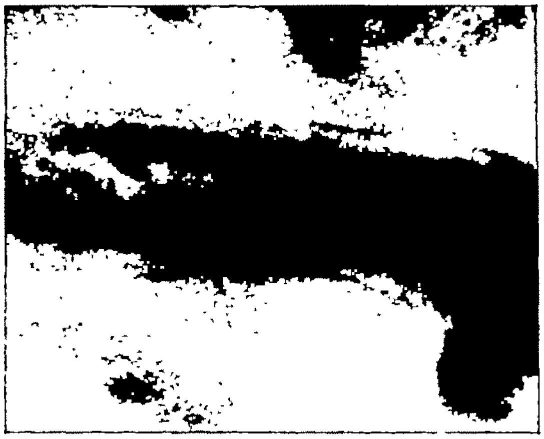


Fig. 1. Cells fixed in 5 per cent potassium permanganate in veronal–acetate buffer, pH 7·5, embedded in methacrylate. (× 42,000)

The presence of a vacuolar system had been observed in other bacteria: Houwink[3] showed in *Halobacterium halobium* a complex vacuolar system not related with the nucleus; and Knaysi[4] working with *Mycobacterium thamnopheos* stated that "the destructive effect of acid hydrolysis . . . is attributed to the presence of vacuoles in the cells of this organism". The empty vacuoles revealed in our work do not seem to correspond to regions with appreciable concentration of deoxyribonucleic acid. Also the absence of a definite membrane limiting these vacuoles, as Birch-Andersen and Maaløe[5] pointed out, gives evidence that the vacuoles with their contents are structures not related with distinct nuclei which are generally separated from the rest of the cell, but probably correspond to the vacuolar systems found in many other vegetative cells.

The work of Knaysi[6] on *Bacillus cereus*, in which he observed the division and fusion of dense granules, indicates that the nuclear sites correspond to areas denser than the cytoplasm, and that some of the so-called cytoplasmic inclusions could be the real sites of the nuclei. Preusser[7], studying ultra-thin sections of *Escherichia coli*, stated that the zones of low electron density within the bacterial cells are products of cellular metabolism and are not comparable with the nuclei of higher organisms. On the other hand, the correspondence observed between the light areas in electron micrographs of ultra-thin sections and the stained nuclear material observed in the light microscope is probably due to the fact that the whole thickness of the bacterial cell is in focus in the light

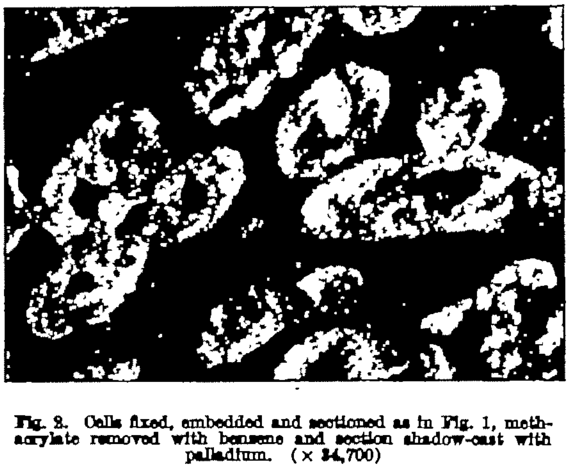


Fig. 2. Cells fixed, embedded and sectioned as in Fig. 1, methacrylate removed with benzene and section shadow-cast with palladium. (× 34,700)

microscope, having been flattened by fixation or drying. It is, therefore, impossible to be certain whether the stained matter which appears within the lighter areas is actually within them or is within the cytoplasm above or below the vacuoles and appears superimposed on them. In any event, the vacuoles observed as clear areas in ultra-thin sections do not correspond to any of the nuclear systems we know at present. In micro-organisms where the location of the real nucleus is known (for example, yeast cells) one notes that the nuclei are not in vacuoles but are embedded in the cytoplasm.

Although only 48-hr. cultures were included in the present work, and although there may be variation between species, we are of the opinion that the central core or zone of low electron density in *A. tumefaciens* represents a vacuolar system and is probably not the site of the bacterial nucleus or nuclear equivalent.

The work reported here was supported in part by a grant to the senior author from the Cancer Research Funds of the University of California while he was a visiting scientist in the Department of Plant Pathology, University of California, Riverside. We wish to acknowledge this support and also the technical assistance of Mr. Philip Dempster.

MIGUEL RUBIO-HUERTOS
Instituto "Jaime Ferran" de Microbiologia,
Madrid.

PAUL R. DESJARDINS
Department of Plant Pathology,
Citrus Experiment Station,
University of California,
Riverside, California.

[1] Chapman, G., *J. Bact.*, 78, 96 (1959).
[2] Kellenberger, E., Ryter, A., and Séchaud, J., *J. Biophys. Biochem. Cytol.*, 4, 671 (1958).
[3] Houwink, A. L., *J. Gen. Microbiol.*, 15, 146 (1956).
[4] Knaysi, G., *J. Bact.*, 74, 12 (1957).
[5] Birch-Andersen, A., and Maaløe, O., *Biochim. Biophys. Acta*, 12, 395 (1953).
[6] Knaysi, G., *J. Bact.*, 69, 117 (1955).
[7] Preusser, H. J., *Arch. Mikrobiol.*, 33, 105 (1959).

Capacity of Extracts from Prestarved *Escherichia coli* to incorporate Thymidine into Deoxyribonucleic Acid

THE ability of a polyauxotroph, *Escherichia coli* strain 15_{T^-} (555–7), to synthesize deoxyribonucleic acid is temporarily lost following a period of incubation in a minimal salts–glucose medium containing thymine but no added amino-acids[1-4]. Moreover, when the starved cells are returned to a medium supplemented with amino-acid, a lag in synthesis of deoxyribonucleic acid is observed[2-4]. The restoration of an active deoxyribonucleic acid synthesizing system in these cells can be prevented by continued suppression of protein synthesis with chloramphenicol[3] or by exposure to X-rays[5]. One possible mechanism considered was that the enzyme or enzymes involved in deoxyribonucleic acid synthesis are lost or destroyed during the starvation period and that chloramphenicol and X-ray exposure prevent re-synthesis or reactivation of these components[3-5].

In a study of incorporation of thymidine labelled with tritium into deoxyribonucleic acid I have determined that polymerase and the kinases[6] responsible for phosphorylation of thymidine are present in the starved cell.

The extracts tested were obtained from cells broken in a French pressure cell. Intact cells and debris were pelleted by centrifugation at 10,000*g* for 20 min. Less than 10 colony-forming cells per mgm. protein were found in the extracts so obtained. The procedure for studying thymidine incorporation into deoxyribonucleic acid was a modified version of that used by Kornberg and collaborators[7,8]. Experiments 1 and 2 were conducted with batches of cells obtained from independent inocula. In the third experiment half an actively growing log-phase culture was used for preparation of the log-phase cell extract and the remaining portion put into medium deficient in amino-acid following harvesting and washing for preparation of the appropriate starved cell extract. Thus, in the latter experiment both cell suspensions were derived from the same culture batch. As can be seen in Table 1, the multi-enzyme system needed for thymidine incorporation was present in extracts obtained either from log-phase cells or cells which had been incubated for 90 min. at 37° C. in minimal medium supplemented with thymine but lacking the required amino-acids arginine, tryptophan and methionine ('starved cells'). These results are in contrast to the impaired *in vivo* deoxyribonucleic acid synthesizing capacity of the starved cells. I am investigating the possibility that thymidine incorporation in the absence of net deoxyribonucleic acid synthesis may occur *in vivo*.

Table 1. INCORPORATION OF THYMIDINE LABELLED WITH TRITIUM INTO DEOXYRIBONUCLEIC ACID

Experiment	Conditions	mμmoles ^{3}H-thymidine incorporated into deoxyribonucleic acid/mgm. protein*
(1) Extract from log phase cells	Complete system†	1·21
	Heated extract	0·01
	Minus adenosine triphosphate and phosphoglyceric acid	0·01
	Minus thymus deoxyribonucleic acid	1·02
(2) Extract from starved cells	Complete system	1·45
	Minus thymus deoxyribonucleic acid	1·35
(3*A*) Extract from log phase cells	Complete system	2·00
	Minus adenosine triphosphate and phosphoglyceric acid	0·02
	Minus the triphosphates of deoxyadenosine, deoxycytidine and deoxyguanosine	0·15
(3*B*) Extract from starved cells	Complete system	1·75
	Minus the triphosphates of deoxyadenosine, deoxycytidine and deoxyguanosine	0·20

* After incubation at 37° C. for 20 min., the reaction vessels were placed in ice and 0·2 ml. of carrier deoxyribonucleic acid (2·5 mgm./ml.) was added. The immediate addition of 0·5 ml. of cold 10 per cent perchloric acid stopped the reaction and precipitated the cold-acid insoluble material. After 10 min. the precipitate was broken up with a glass pestle and washed with a total of 2 ml. of cold distilled water. The precipitate was then centrifuged and the pellet dissolved in 0·2 *N* sodium hydroxide. The solution was reprecipitated with cold perchloric acid. This was repeated twice. The final precipitate was hydrolysed in 1 ml. of 5 per cent trichloracetic acid for 30 min. at 100° C. The hot-acid soluble supernatant was then assayed for radioactivity.

† The complete incubation mixtures (0·30 ml.) contained: 0·02 ml. of glycine buffer (1 *M*, pH 9·2); 0·02 ml. magnesium chloride (0·1 *M*); 0·03 ml. of 2-mercaptoethanol (0·01 *M*); 0·02 ml. each of the triphosphates of deoxyadenosine, deoxyguanosine and deoxycytosine (500 mμmoles/ml.); 0·02 ml. of thymus deoxyribonucleic acid (Sigma Corp.) that had been previously heated at 100° C. for 5 min. (0·5 mgm./ml.); 0·01 ml. of adenosine triphosphate (100 μmoles/ml.); 0·01 ml. of phosphoglyceric acid (0·05 *M*); 0·02 ml. of labelled thymidine (262 mμmoles/ml., 1·54 × 10^5 counts per min. per mμmole on the Packard liquid scintillation counter); extract containing 685 μgm., 585 μgm., 253 μgm., and 282 μgm. protein was added from experiments 1, 2, 3*A* and 3*B* respectively.

That the thymidine was being incorporated into the deoxyribonucleic acid by the multi-enzyme preparation from starved cells was shown by the observation that all the label was associated with the alkali-resistant portion of the cold-acid insoluble material. It is possible that formation of one or more of the necessary deoxyribonucleotides may be blocked in the starved cells. Gros and Gros working with other strains of *E. coli* requiring amino-acid reported the unimpaired capacity of amino-acid starved cells to form mononucleotides[1]. Whether this is true for the deoxyribotides remains to be determined. However, if the presence of thymidine phosphorylating enzymes is indicative of the presence of all enzymes involved in forming the triphosphorylated deoxyriboside substrates necessary for deoxyribonucleic acid synthesis, then I must look elsewhere to explain the discrepancy between the *in vivo* and *in vitro* studies. The possibility of an accumulation of inhibitors during amino-acid deficient growth must be considered. Perhaps there is an unstable protein needed *in vivo* to convert non-priming deoxyribonucleic acid into an active primer. In this work the extracts from both normal and starved cells were found to contain deoxyribonucleic acid capable of serving as primer (Table 1). This may not reflect the true *in vivo* situation since deoxyribonucleases and possibly other enzymes may be activated following rupture of the cell[7,8].

This work is continuing and will be published in more detail elsewhere.

DANIEL BILLEN

Section of Microbiology,
Department of Biology,
University of Texas M. D. Anderson Hospital
and Tumor Institute,
Houston 25, Texas.

[1] Gros, F., and Gros, F., *Exp. Cell Res.*, 14, 104 (1958).

[2] Billen, D., *J. Bacteriol.* (in the press).

[3] Billen, D., *Bact. Proc.* (in the press).

[4] Cowie, D. B., McCarthy, B. J., and Roberts, R. B., Abstracts, Fourth Ann. Meet. Biophys. Soc., 34 (1960).

[5] Billen, D., *Nature*, 184, 174 (1959).

[6] Kornberg, A., Lehman, I. R., and Simms, H. S., *Fed. Proc.*, 15, 291 (1956).

[7] Lehman, I. R., Bessman, M. J., Simms, H. S., and Kornberg, A., *J. Biol. Chem.*, 233, 163 (1958).

[8] Kornberg, A., Zimmerman, S. B., Kornberg, S. R., and Josse, J., *Proc. U.S. Nat. Acad. Sci.*, 45, 772 (1959).

[9] Elson, D., *Biochim. Biophys. Acta*, 36, 372 (1959).

Effect of the Peritoneal Fluid of the Guinea Pig on Strains of Enteric Bacilli

ALTHOUGH the complement-dependent bactericidal system of normal mammalian serum has been actively studied since the early descriptions of Nuttall[1] and Buchner[2], its role in native immunity is a matter of disagreement[3]. Recent reports indicate that strains of Gram-negative enteric bacilli isolated from patients' blood or from burns are ordinarily resistant to this system[4,5]. When equal numbers of a strain of *E. coli* resistant to this bactericidal effect and of one sensitive to it are injected into a rabbit, both strains ordinarily can be cultured from the blood stream 24 hr. following injection; but organisms from the resistant strain are 10–20 times more numerous[6]. There have been reports that strains of enteric bacilli resistant to the action of the complement-dependent system are more virulent for the mouse than are sensitive strains[7,8]. Such observations lead to the belief that bacterial strains sensitive to the action of this system are less likely to cause or maintain an infection than are resistant strains.

During the work on the bactericidal properties of human serum[4], it was noted that pleural or peritoneal transudates from patients with heart failure were active against strains sensitive to serum. This activity was considerably less than that of serum and could be destroyed by heating the transudates at 56° for 30 min.

One method of assessing the role of the complement-dependent system of peritoneal fluid appeared to be the intraperitoneal implantation of chambers containing sensitive and resistant bacterial strains. These chambers were designed to be permeable to body fluids but not to bacterial or mammalian cells[9]. The degree of sensitivity of strains to normal guinea pig and human sera was measured initially by determining the decrease in viable count following exposure of known numbers of bacteria to undiluted serum for 2 hr. at 37°. None of these bacterial strains was killed by heat-inactivated serum. The thirteen strains of enteric bacilli listed in Table 1 were used. Two sensitive strains and two resistant strains were ordinarily used as inocula in the four chambers inserted in each guinea pig.

Table 1. THE RELATIONSHIP OF THE SENSITIVITY OF BACILLARY STRAINS TO THE BACTERICIDAL EFFECT OF NORMAL SERA AND THEIR SURVIVAL IN INTRAPERITONEAL CAPSULES

Bacterial strain		No. bacteria killed/ml. serum in 2 hr.		Growth in intraperitoneal chambers
		Guinea pig	Human	No. times grew/No. trials
Klebsiella	15	160×10^6	160×10^6	0/5
Shigella	141	110×10^6	110×10^6	0/4
E. coli:				
	*A*9	170×10^6	170×10^5	0/4
	128	240×10^4	240×10^4	1/4
	*A*14	170×10^4	170×10^4	0/3
	182	168×10^4	168×10^4	4/14
	31	200×10^3	200×10^3	6/12
	*A*30	1,500	2,100	1/2
	108	140	0	14/15
	*A*13	98	143	2/5
	114	95	0	3/3
	102	54	0	12/15
	*A*29	19	0	3/3

Drum-shaped chambers about 6 mm. deep and 13 mm. in diameter were constructed from lengths of 'Tygon' tubing, the ends of which were covered with 'Millipore' membranes having a pore diameter of 0·45μ (ref. 9). 'Plexiglass' dissolved in ethylene dichloride was used as adhesive. The 'Millipore' membranes were autoclaved and the tubing boiled for 5 min. before the membranes were attached aseptically. Two No. 26 hypodermic needles were inserted through the wall of each chamber. One served as an outlet for air. Usually about 1,000 organisms suspended in physiological saline were injected through the other. The needle holes were sealed with a heated glass rod. Inocula up to 14,000 organisms were used in some experiments; but in any given experiment the numbers were approximately equal. Four of the chambers were then inserted into the peritoneal cavity of a guinea pig. These were removed at 48 or 72 hr. and the number of bacteria in each chamber determined by viable count. Sterility check on the membranes of the chambers at insertion and on removal showed no contamination, and no leakage.

Fluid from the chambers was examined by paper electrophoresis and the major serum fractions were present 24 hr. after the insertion. At 48 hr. the concentration of these fractions as estimated by their electrophoretic curves was about 60 per cent of that of guinea pig serum. Specimens from 40 chambers were examined by phase microscopy, and no mammalian cells were seen.

In every instance except two, the contents of the chambers either were bacteriologically sterile or showed a multiplication of the original inoculum to 1×10^8 to 1×10^9 organisms per chamber. In the two exceptions, the count had been reduced to less than fifty and these two instances are considered in the same category as the sterile ones

Table 1 lists the strains in their order of sensitivity to guinea pig serum *in vitro*. The numbers represent the maximum number of each strain killed by 1 ml. of undiluted serum. Close relationship between sensitivity *in vitro* to human serum and to guinea pig serum is apparent. A similar relationship between sensitivity to human serum and rabbit serum has been shown[8] and leads one to believe that results from experiments in one species may have implications for other species.

The column on the right in Table 1 shows the fate of the strains in the chambers. The very sensitive strains were killed whereas the most resistant strains usually multiplied. Strains of intermediate sensitivity multiplied in some instances but were killed in others. If a strain of intermediate sensitivity multiplied, it did so to the same extent as did resistant strains in the same animal.

These data serve to strengthen the belief that the complement-dependent bactericidal system is of importance in limiting the number of bacterial strains capable of surviving in tissue fluids *in vivo*.

This work was supported by grants from the Lederle Medical Faculty Award and U.S. Public Health Service (*E2755*).

R. J. ROANTREE
L. R. COLLIS

Department of Medical Microbiology,
Stanford University School of
Medicine,
Stanford, California.

[1] Nuttall, G., *Z. Hyg.*, 4, 353 (1888).

[2] Buchner, H., *Zentralblatt Bakt. und Parasitenkunde*, 5, 817 (1889).

[3] Maaløe, O., *Acta Path. et Microbiol.* 25, 237 (1948).

[4] Roantree, R. J., and Rantz, L. A., *J. Clin. Invest.*, 39, 72 (1960).

[5] Lowbury, E. J. L., and Ricketts, C. R., *J. Hyg.* (London), 55, 266 (1957).

[6] Roantree, R. J., and Pappas, N. C., *J. Clin. Invest.*, 39, 82 (1960).

[7] Maaløe, O., *Acta Path. et Microbiol.*, 25, 414 (1948).

[8] Rowley, D., *Brit. J. Exp. Path.*, 35, 528 (1954).

[9] Cutting, W., Cutting, M., and Kato, S., Extrait de Acta Union Internationale contre le Cancer, 15, 870 (1959).

SOIL SCIENCE

Domain or Turbostratic Structure of Clays

IT has been realized for some time that plate-shaped clay particles on drying tend to take up a parallel orientation with respect to one another. Further, Terzaghi[1] has indicated that groups of parallel particles behave as a single particle in suspension and has referred to these groups as 'clay clusters'. Aylmore and Quirk[2], in endeavouring to interpret the swelling of clay-water systems, have defined a 'domain' as a parallel arrangement of crystals. Coal research workers[3] have referred to a similar type of organization as 'turbostratic groups' since the elementary particles are arranged in a parallel fashion in groups and these groups are arranged in turbulent array. The present communication presents evidence for the nature of a domain and discusses the consequence of domain formation in swelling phenomena of clays.

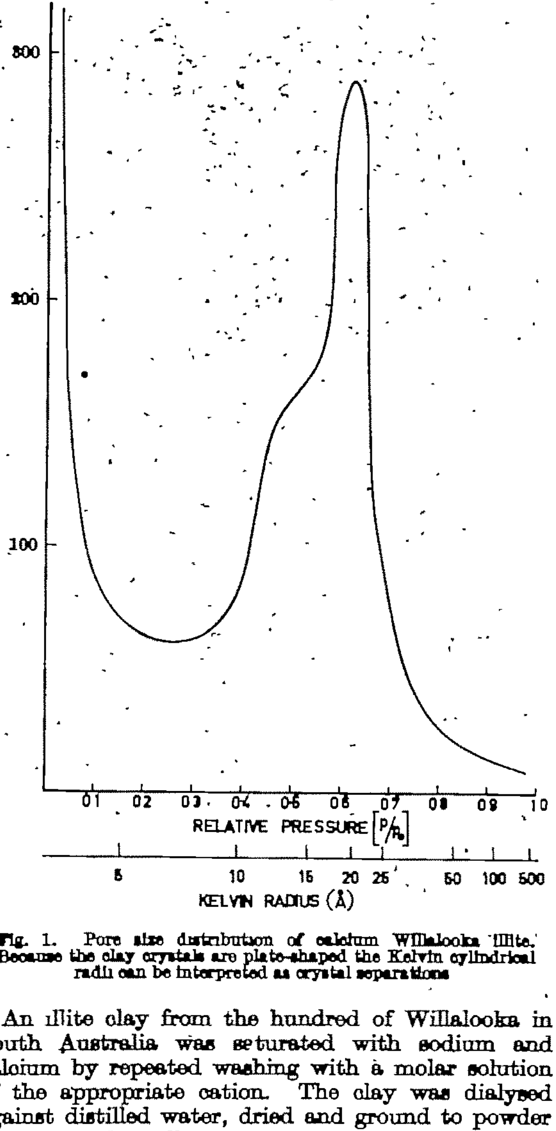


Fig. 1. Pore size distribution of calcium Willalooka illite. Because the clay crystals are plate-shaped the Kelvin cylindrical radii can be interpreted as crystal separations

An illite clay from the hundred of Willalooka in South Australia was saturated with sodium and calcium by repeated washing with a molar solution of the appropriate cation. The clay was dialysed against distilled water, dried and ground to powder which was then allowed to come to equilibrium with a relative vapour pressure of 0·96 before being compressed into cores[4]. These cores were wet up to *pF* 2 and dried in stages to complete desiccation over phosphorus pentoxide. Water and nitrogen isotherms were obtained using these cores. This illite, although low in potassium (potassium oxide, 4 per cent), gives no evidence of interstratification.

A complete adsorption–desorption isotherm of nitrogen was obtained at 78° K. The surface area of the clay calculated by the B.E.T. method was 150 m.²/gm. In Fig. 1 a plot of $dV/d(p/p_0)$ against p/p_0 is shown together with a scale to relate values of p/p_0 to the Kelvin cylindrical pore radius. The clay cores have a porosity of 18·8 c.c./100 gm. and at $p/p_0 = 0{\cdot}80$, 18·6 c.c./100 gm. of pores are filled, indicating that almost the entire porosity is contained in pores less than 42 Å. Kelvin radius. Since the plates of this mineral are 700 Å. across and this is large compared with the plate separation, the calculated Kelvin cylindrical radius can more properly be regarded as a measure of the plate separation. The pore peak in Fig. 1 shows that the clay mass can be regarded as a series of parallel crystals, the

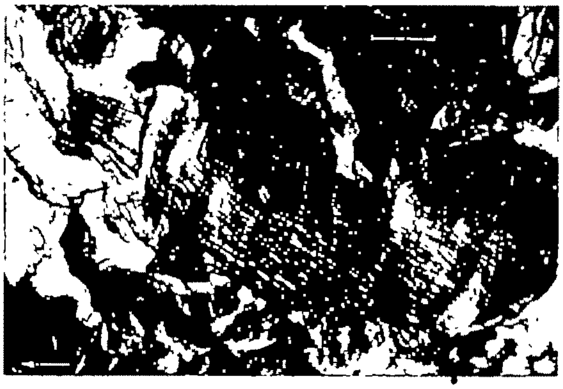


Fig. 2. Electron micrograph of the fracture surface of Willalooka illite core obtained using a replica technique. Arrows indicate the direction of uranium shadowing

separation of which varies between 10 and 30 Å. although closer approach may occur at a few points. This indicates that the pore space of this material is almost exclusively within domains, that is, there is very little interdomain porosity. An electron micrograph of a shadowed replica of the fracture surface of a dry clay core reveals the parallel arrangement of the clay particles and also indicates that there is considerable distortion of the crystals and domain structures undoubtedly caused by stresses set up in drying (Fig. 2).

In Figs. 3 and 4 the solution content–energy curves for sodium and calcium Willalooka illite at varying sodium chloride and calcium chloride concentrations are shown. Since the clay is largely organized on a domain basis it appears permissible to divide the solution content by the specific surface area to obtain a first approximation for the film thickness on the clay surface. When this is done, good agreement between Schofield's theory based on the Gouy–Chapman diffuse double layer and the experimental values for sodium-illite are found for 10^{-1}, 10^{-2} and 10^{-4} *M* sodium chloride concentration.

The remarkable insensitivity of the swelling of the calcium illite to calcium chloride concentration and the appreciable hysteresis in the water content suction curves indicates the non-applicability of diffuse double layer theory to the swelling of this material.

The explanation of the film thickness at *pF* 1 of 30 Å. even for distilled water and the presence of hysteresis lies in the existence of a potential barrier at a plate separation of < 60 Å. and the formation of a gel structure as the result of the relaxation of strains when sufficient liquid is present in the clay matrix. The limited swelling cannot be ascribed to cementing materials; when the sodium illite, swollen in distilled water, is converted to a calcium illite and dried, identical swelling behaviour to the calcium illite prepared directly from the natural material is observed. MacEwan[4] has suggested that coulombic attractive forces exist up to plate separations of 30 Å., at which separation he envisaged the formation of separate double layers by each particle. It seems reasonable to conclude that calcium illite does not overcome this barrier, and that for sodium illite the barrier is overcome, giving rise to high solution contents which are dependent on the sodium chloride concentration. The similarity of this behaviour to that of sodium and calcium montmorillonite[5] is striking and supports the suggestion that a domain structure in some respects resembles a montmorillonite crystal. It is also important to note that on heating to 400° C. the sodium illite swells very little but still retains its exchange capacity of 0·41 m.equiv /gm.

One difficulty in interpreting the water content of a clay in terms of the film thickness developed by the clay particle is that, on wetting, relaxation of strains[6] leads to the formation of a gel structure so that it is difficult to separate that water which is

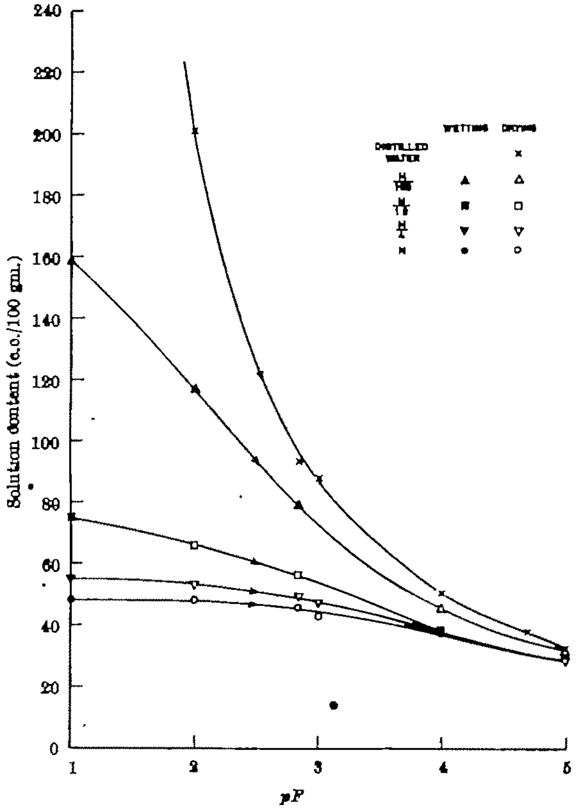


Fig. 3. Solution content–energy curves for sodium Willalooka illite at various electrolyte concentrations (sodium chloride). Note that *pF* indicates only the logarithm of the hydrostatic suction in cm. of water

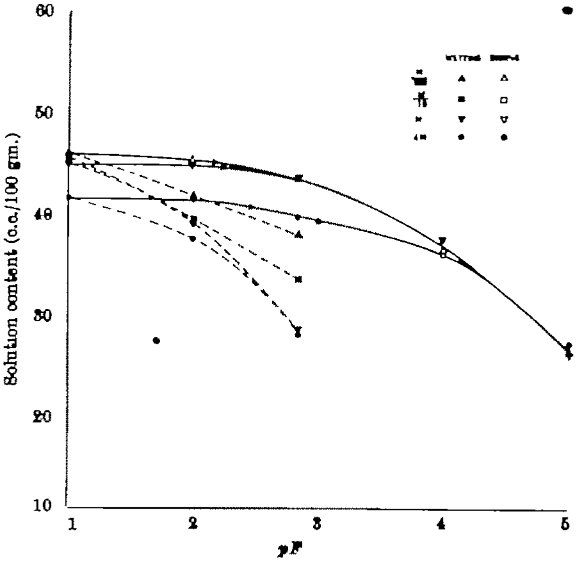


Fig. 4. Solution content–energy curve for calcium Willalooka illite at various electrolyte concentrations (calcium chloride)

directly associated with the clay surfaces from water which is simply enmeshed within the gel structure. Enmeshed water can be regarded in the following way. When a rigid porous material initially filled with liquid dries out under a falling vapour pressure, pores (capillaries) of particular dimensions will empty at a particular vapour pressure. The remaining liquid is held under a hydrostatic suction which is transmitted to the walls but, as each pore empties, stresses on the walls due to this cause will fall to zero. If, however, the material is easily deformed, the suction in the liquid will cause a reduction in the size of the pore, and evaporation will be delayed until a lower vapour pressure is reached, by which time the suction has further increased. The mechanism has been postulated by Barkas[7] for wood-gels, but is clearly applicable to the interpretation of gel structures and hystereses in clay–water systems.

In conclusion, it is necessary to comment on two recent papers which have overlooked, wholly or in part, suggestions put forward at an earlier date by us. Greacen[8], in discussing the swelling of calcium montmorillonite in terms of the critical voids ratio line, has used a surface area of 800 m.^{2}/gm. and has not adequately taken into account the presence of a gel structure. Blackmore and Warkentin[9] have also claimed that their results support the existence of diffuse double layers on the external surface of montmorillonite crystals. However, they too have not considered the possibility that much of the water retained by their clay was enmeshed in a gel structure. Further, Norrish[10] and also Blackmore and Warkentin[9] have noted a collapse of swollen crystals or a condensation of elementary silicate sheets of sodium montmorillonite to give a 19 Å. spacing in the presence of dilute calcium chloride solutions. This situation indicates that attractive forces in calcium clay systems must be such that diffuse double layers do not readily form.

The results discussed here, and those obtained for kaolinites and montmorillonites which will be presented elsewhere[11,12], indicate that diffuse double-layer formation is not of any great significance for the swelling of calcium clays. Diffuse double layers may exist for crystals of calcium clays in a suspension, but this is doubtful in view of the negative adsorption results obtained for an illite[13].

We are indebted to Mr. D. M. Hall, of the Department of Scientific and Industrial Research Dominion Physical Laboratory, for obtaining the electron micrograph.

L. A. G. AYLMORE
J. P. QUIRK

Department of Agricultural Chemistry,
Waite Agricultural Research Institute,
University of Adelaide.

[1] Terzaghi, K., *Geotechnique*, 6, 191 (1956).
[2] Aylmore, L. A. G., and Quirk, J. P., *Nature*, 183, 1752 (1959).
[3] Biscoe, J., and Warren, B. E., *J. App. Phys.*, 13, 364 (1942).
[4] MacEwan, D. M. C., *Nature*, 162, 935 (1948).
[5] Norrish, K., and Quirk, J. P., *Nature*, 173, 255 (1954).
[6] Terzaghi, K., Trans. First Int. Congr. Soil Sci., 4, 127 (1927).
[7] Barkas, W. W., "The Swelling of Wood under Stress" (H.M.S.O., 1948).
[8] Greacen, E. L., *Nature*, 184, 1695 (1959).
[9] Blackmore, A. V., and Warkentin, B. P., *Nature*, 186, 823 (1960).
[10] Norrish, K., *Disc. Farad. Soc.*, 18, 120 (1954).
[11] Quirk, J. P., and Aylmore L. A. G., Seventh Congr. Int. Soil Science Society (1960).
[12] Aylmore, L. A. G., and Quirk, J. P., Ninth National Clay Conf., U.S.A. (1960).
[13] Quirk, J. P., Second Aust. Conf. Soil Sci., Melbourne, Paper No. 26 (1957).

VIROLOGY

Polyphenol Oxidase Activity of *Nicotiana glutinosa* Leaves infected with Tobacco Mosaic Virus

WHEN local necrotic lesions appeared on the leaves of *Nicotiana glutinosa* L. infected with tobacco mosaic virus, but not before, the respiration-rate increased[1]. The same phenomenon was observed on some other host–virus combinations which produced local necrotic lesions[2]. In these cases, it seems that the increased rate of respiration varies with various developmental stages of the necrotic lesions, namely, with degrees of brownish discoloration of leaf tissue due to the virus infection. When the tissues of the tobacco plant are injured, the polyphenol substances are oxidized and then polymerized by polyphenol oxidase[3]. Therefore the polyphenol oxidase activity of leaves bearing necrotic lesions has been compared with that of healthy leaves.

The half-leaves of *N. glutinosa* plants were inoculated mechanically with tobacco mosaic virus and healthy control halves were treated with healthy tobacco leaf sap. Local lesions became visible the second day after inoculation at 20° C. Leaves were harvested on the day following inoculation; when no lesions appeared, the second and the third day after inoculation. Polyphenol oxidase activity was measured in crude enzyme preparations: acetone powder prepared from healthy and infected half-leaves, by the use of Warburg respirometer. The results are expressed by µl. oxygen absorbed by acetone powder (30 mgm. dissolving in solution containing 0·05 *M* phosphate buffer, *p*H 7·0, and 0·2 *M* sucrose) on addition of catechol (0·05 *M*) as a substrate at the rate of once an hour and once every 2 hr. in the case of gallic acid (0·05 *M*). These values have been corrected for autoxidation values and represent the mean value of several experiments. Oxygen consumption in each experiment varied so much according to the leaves chosen or preparative procedure of acetone powder that the standard error of the difference between the values for healthy and infected leaves was calculated (Table 1).

Table 1. POLYPHENOL OXIDASE ACTIVITY OF *N. glutinosa* HALF-LEAVES INOCULATED WITH TOBACCO MOSAIC VIRUS AND OF HEALTHY HALVES

Days after inoculation	Polyphenol oxidase activity Infected	Healthy	Ratio Inf. Healthy	*S.E.*	No. of determinations
Catechol substrate					
1	31·8	31·2	1·02	±1·44	5
2	51·7	35·9	1·44	±1·29	6
3	70·4	43·9	1·60	±6·60	6
Gallic acid substrate					
1	12·1	15·3	0·79	±3·18	5
2	17·5	14·5	1·21	±2·80	6
3	27·1	12·6	2·15	±3·66	6

As shown in Table 1, a considerable increase in activity of polyphenol oxidase was found the third day after inoculation by using either catechol or gallic acid as substrate. In contrast, there was no increase in the activity on the day following inoculation, having no visible lesions, on either substrate. On the second day, when faint black spots had become visible, the ratio of the activity between infected and healthy was 1·44 by using catechol as substrate, and its difference was highly significant, while the difference is not significant at the 5 per cent level in the case of gallic acid although the ratio is 1·21.

In spite of much research, present knowledge of the precise nature of phenol oxidase is limited, and its role in cellular respiration is not as yet clear[4]. It seems, however, that the enhanced activity of polyphenol oxidase plays an important part in browning of plant tissue or hypersensitive defence reaction in both fungal and viral infection[5]. It is unknown whether or not the polyphenol oxidase is a catalyst mediating the final reaction with oxygen in cellular respiration of *N. glutinosa* leaves. The findings, however, that no increase in the activity is detected on the following day after inoculation and the increased rate of the third day is higher than that of the second day were apparently consistent with the results obtained by Yamaguchi and Hirai in the respiration measurement of *N. glutinosa* leaf disks infected with the same virus[1]. Recently, Solymosy *et al.*[5] offered clear-cut evidence that the stimulated activity of phenol oxidase was the immediate cause of lesion formation, by using the technique of administration of compounds capable of reducing quinones or inhibiting lesion formation. This seems to explain the biochemical mechanism of lesion formation. We cannot explain, however, the cause of the parallelism between increased oxygen consumption in infected leaf disks and increased polyphenol oxidase activity during lesion development. This raises the problem of the nature of terminal oxidase in infected tissues.

We are indebted to Prof. Tokuzo Hirai for valuable discussions.

MASATAKE KIKUCHI
AKIRA YAMAGUCHI

Plant Pathology Laboratory,
Faculty of Agriculture,
Nagoya University,
Anzyo, Japan.

[1] Owen, P. C., *Ann. App. Biol.*, 46, 198 (1958). Yamaguchi, A., and Hirai, T., *Phytopath.*, 49, 447 (1959).

[2] Yamaguchi, A., *Virology*, 10, 287 (1960).

[3] Shiroya, M., Shiroya, T., and Hattori, S., *Physiol. Plantarum*, 8, 594 (1955).

[4] Bonner, jun., W. D., *Ann. Rev. Plant Physiol.*, 8, 427 (1957).

[5] Farkas, G. L., and Király, Z., *Phytopathol. Z.*, 31, 251 (1958). Király, Z., and Farkas, G. L., *ibid.*, 34, 341 (1959). Solymosy, F., Farkas, G. L., and Király, Z., *Nature*, 184, 706 (1959). Uritani, I., and Akazawa, T., "Plant Path.", 1, 349 (Academic Press, New York, 1959).

Direct Infra-Red Spectral Analysis of the Cucumber Mosaic Virus Infection Process

INFRA-RED spectroscopy may provide a means of following biochemical changes which occur in tissues as a result of virus infection, if induced spectral changes can be detected and related to the structure of the absorbing compounds.

The upper surfaces of fully expanded cotyledons of cucumber seedlings were dusted with 'Carborundum' and inoculated with a small sponge rubber pad moistened with tissue homogenates of tobacco plants infected with cucumber mosaic virus. Identically grown control plants in separate pots were dusted with 'Carborundum' and rubbed with virus-free buffer in the same manner. Control and virus-inoculated plants were held in a growth chamber with a 16-hr. day at 28° C. and an 8-hr. night at 20° C.

Lower epidermis was stripped from three infected and from three normal plants at daily intervals following inoculation. Adhesive 'Cellophane' tape was punched with a $\frac{1}{4}$-in. circular paper-punch and then placed in contact with the epidermis. The tape was peeled from the mesophyll tissue carrying an intact epidermal layer covering the punched-out area. The tissues were allowed to dry in the normal laboratory atmosphere of about 20–30 per cent humidity and were analysed 24–48 hr. later with a Perkin Elmer model 21 infra-red spectrophotometer. The spectrum of a normal lower epidermis from a cucumber cotyledon plotted against air in the reference beam is shown in Fig. 1.

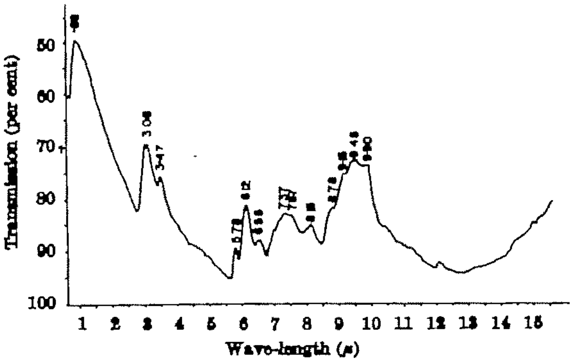


Fig. 1. Infra-red transmission through dried, normal cucumber cotyledon lower epidermis. Wave-lengths of principal peaks are identified

The analytical method used for detecting virus-induced changes was differential double-beam analysis with normal epidermal specimens in the reference beam and virus-infected epidermal specimens in the sample beam. The instrument then plotted the difference between the infected and normal specimens at all wave-lengths from 1 to 15μ. The recorder pen was adjusted to near mid-scale on the chart paper so that induced excesses and deficiencies could both be recorded as deviations from the I_0 (base line) of the instrument. These deviations were plotted linearly from I_0 in terms of percentage of the transmission of the normal tissue. Each of the infected tissues was compared with each of the normal tissues collected at the same time. The recorded spectral curves of each day's analyses were superimposed to give maximum coincidence of points. Median values were drawn for the superimposed curves and were plotted as values representative of the daily virus-induced changes. The daily median values plotted from two successive experiments were remarkably similar, indicating that the analytical method was reproducible. The results from both experiments are combined in Fig. 2 to show the progressive changes induced by the virus infection in the tissues as detected by the methods used.

Interpretation of the results presented in Fig. 2 is complicated by the numerous cellular reactions occurring within epidermal cells during the infection. Synthesis of virus nucleic acid and protein is probably accompanied by degradative reactions. Translocation of carbohydrates and possibly amino-acids, purines and pyrimidines to the halophytic epidermal cells may be altered by the changed rates of utilization of these compounds in cells infected by virus. Virus formation and side reactions may produce accumulated intermediate or end products that are not used in producing virus. The spectrophotometric changes

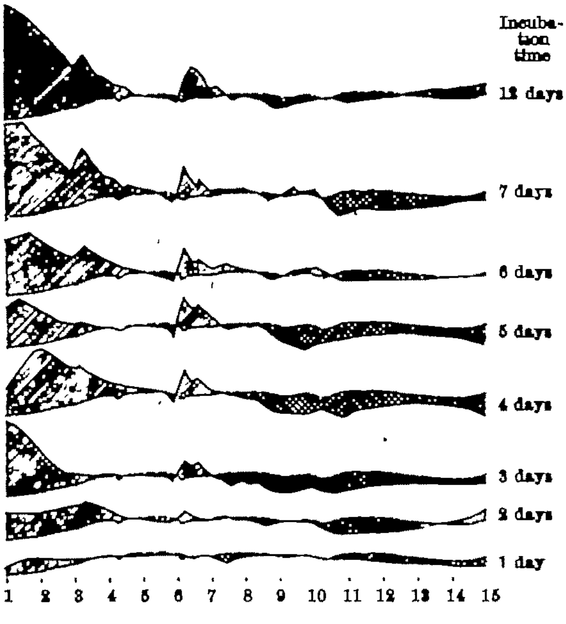


Fig. 2. Progressive changes in infra-red absorption of lower epidermis of cucumber cotyledons induced by the cucumber mosaic virus infection process (averaged values of two experiments). Full line, graphically determined median value for comparisons of three virus-infected with three normal epidermal strips; broken line, I_0 (base-line of the instrument); dark shading, greater than normal absorption; light shading, less than normal absorption

observed during the course of an infection represent the resultant effects that all the above processes have in adding to or decreasing the total number of chemical bonds that are responsible for absorption at each wave-length.

Increased spectral absorption in the infected tissues reflects an increased accumulation of certain chemical bonds that may be the result of increased translocation or of synthesis. A decreased spectral absorption in the infected tissues reflects losses of certain chemical bonds probably as a result of degradation reactions or perhaps by translocation.

The peptide linkage is known to give rise to strong absorption bands at 6·1 and 6·5μ (ref. 1). Because increased absorption at 6·5μ did not occur until the third day, it appears that a significant increase in peptide linkages did not occur until this time. The absorption at this wave-length continued to increase on the fourth and fifth days, but fell to a lower level on the sixth and seventh days. It is probable that this increase in peptide linkages reflects a comparable increase in proteins.

Nucleic acids and proteins both absorb strongly in the 3- and 6-μ ranges. It is possible that the absorption seen at these wave-lengths on the second day is caused by increases in nucleic acids. Nucleic acids also absorb strongly in the 9–9·5μ range[2]. On the second day there is a slight excess in this spectral region. On the third, fourth and fifth days marked deficiencies occur in this range and then on the sixth and seventh days excessive absorption occurs again. It is interesting to note that the absorption in the 9–9·5μ region appears to vary inversely with the absorption at 6·5μ. The results suggest that a cyclic variation has occurred in which nucleic acids build up and then fall during a period in which proteins are increased. Then when protein-levels fall on the sixth and seventh days nucleic acid-levels rise.

The relation of nucleic acid to protein synthesis is not well understood. Perhaps a comparison with studies of nucleic acid synthesis in virus-infected bacterial cells is noteworthy. An exponential increase of protein, ribonucleic acid and deoxyribonucleic acid occurs in a logarithmically growing population of bacterial cells. However, at the time of the inoculation of *E. coli* with T_2 bacteriophage the synthesis of bacterial components stops quickly and the cellular machinery is devoted to the synthesis of viral protein and viral deoxyribonucleic acid[3]. Astrachan and Volkin[4] have shown with tracer studies that a burst of synthesis of ribonucleic acid occurs before the formation of virus proteins. It is postulated that the synthesis of ribonucleic acid is a necessary prerequisite for the formation of the proteins essential to virus formation.

The results in Fig. 2 suggest that other reactions are occurring, but no attempt will be made at the present time to postulate these. Experiments are now in progress in which this type of analysis is being applied to the study of the earliest detectable events in the infection process.

The work reported in this communication was supported, in part, by research grant No. *AT*(11–1)-80 Proj. 3 from the United States Atomic Energy Commission.

G. W. COCHRAN
G. W. WELKIE
J. L. CHIDESTER

Department of Botany and Plant Pathology,
Utah State University,
Logan,
Utah.

[1] Blout, E. R., and Mellors, R. C., *Science*, 110, 137 (1949).

[2] Fraser, R. D. B., and Chayen, J., *Exp. Cell Res.*, 3, 492 (1952).

[3] Kornberg, A., "Rev. Mod. Phys.", 31, 200 (1959).

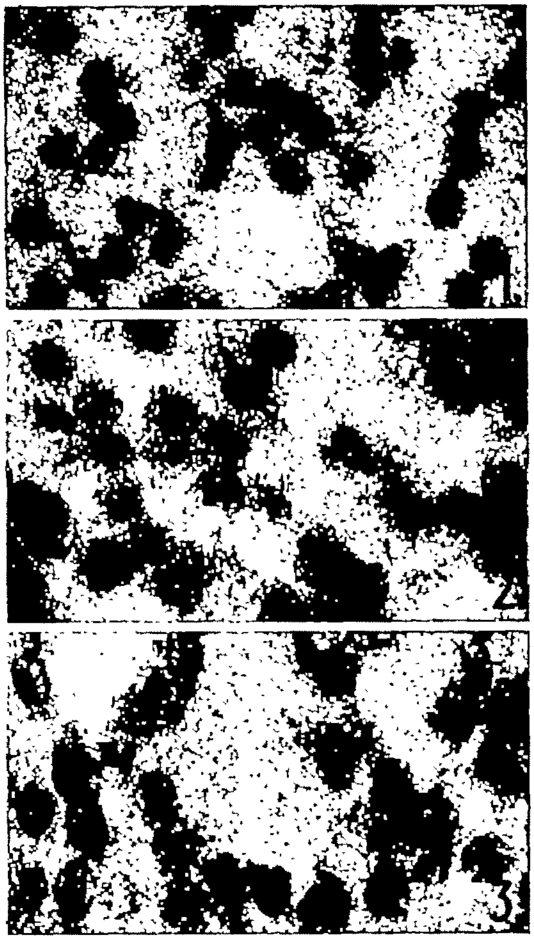
[4] Astrachan, L., and Volkin, E., *Biochim. Biophys. Acta*, 29, 536 (1958).

Site and Nature of Adenovirus Nucleic Acid

THE effects of specific nuclease digestion on the morphology of the Rous virus, as observed with the electron microscope, established recently that this agent's nucleoid contained a substantial amount of ribonucleic acid[1,2]; the type of nucleic acid was confirmed at the same time by cytochemical studies[3].

Similar methods have now been used with type 5 adenovirus. The virus was grown in HeLa cell cultures[3], and particles were isolated from them by a fluorocarbon separation technique[4,5] followed by high-speed centrifugation. Samples of the particle-containing zones of the resulting pellets were used for the work and were first sectioned for electron microscopy in order to check their homogeneity[6]. Biological tests were combined with these experiments and served to indicate the viral nature of the particles[6].

Thereafter, other samples of pellets containing the virus were treated with nucleases following fixation with potassium permanganate[7], a fixative known to permit subsequent digestion of nucleic acids by such enzymes[8]. The nucleases were applied in many ways; but specific changes in virus morphology were only



Figs. 1–3. Electron micrographs of thin sections of permanganate-fixed adenovirus particles treated in various ways. All the particles were exposed to a preliminary incubation at 37° C. for 2 hr. in buffer at *p*H 9 containing 30 per cent alcohol, and show some degree of swelling as compared to examples prepared directly. × 75,000

Fig 1. Control particles given a second incubation in 30 per cent alcohol containing 0·003 *M* magnesium chloride; the dense nucleoids are very evident

Fig. 2. Particles which had been exposed to ribonuclease at *p*H 7 (1 mgm. per ml.) during a second incubation in 30 per cent alcohol. No change has taken place in the density of the nucleoids

Fig. 3. Particles treated with deoxyribonuclease (1 mgm. per ml.) and 0 003 *M* magnesium chloride in 30 per cent alcohol during a second incubation. The nucleoids have been digested

observed after the following procedure. Samples of virus fixed in iced permanganate were placed in iced 30 per cent alcohol and brought to room temperature; they were then incubated for 2 hr. at 37° C. in Michaelis veronal buffer at *p*H 9 containing 30 per cent alcohol. After this the samples were divided into three groups and were incubated again in 30 per cent alcohol containing respectively 1 mgm. per ml. ribonuclease at *p*H 7, the same quantity of deoxyribonuclease together with magnesium chloride at a concentration of 0·003 *M* or, as a control, a similar concentration of the salt but no enzyme. At the end of this second incubation all the samples were dehydrated, embedded in *n*-butyl methacrylate and sectioned for electron microscopy.

Exposure to the alkaline buffer caused some degree of non-specific swelling of all particles as compared with examples prepared directly, while in the control preparations treated with enzyme-free medium after the buffer, no other structural change was seen (Fig. 1). A similar lack of change was found in particles treated with ribonuclease during the second incubation, the density of the nucleoids being well preserved (Fig. 2). In marked contrast, the nucleoids were digested from particles incubated with deoxyribonuclease after alkaline buffer (Fig. 3). The effect of the buffer was probably to degrade the outer coat of the particles in the manner already reported for mild alkalis[8,9], so allowing subsequent penetration by deoxyribonuclease.

These results demonstrate that the adenovirus contains much deoxyribonucleic acid, thus substantiating earlier inferential evidence[10], and also establish the location of this material in the nucleoid. A full account of this work will be given elsewhere[11] together with the confirmatory results of concomitant fluorescence microscopy tests for nucleic acids[12,13].

M. A. Epstein
S. J. Holt
Bland Sutton Institute of Pathology and
Courtauld Institute of Biochemistry,
Middlesex Hospital Medical School, London, W.1.

[1] Epstein, M. A., *Nature*, 181, 1808 (1958).

[2] Epstein, M. A., and Holt, S. J., *Brit. J. Cancer*, 12, 363 (1958).

[3] Pereira, H. G., and Kelly, B., *J. Gen. Microbiol.*, 17, 517 (1957).

[4] Gessler, A. E., Bender, C. E., and Parkinson, M. C., *Trans. N.Y. Acad. Sci.*, 18, 701 (1956).

[5] Epstein, M. A., *Brit. J. Exp. Path.*, 39, 436 (1958).

[6] Epstein, M. A., and Powell, A. K., *Brit. J. Exp. Path.* (in the press).

[7] Luft, J. H., *J. Biophys. Biochem. Cytol.*, 2, 799 (1956).

[8] Fraenkel-Conrat, H., and Williams, R. C., *Proc. U.S. Nat. Acad. Sci.*, 41, 690 (1955).

[9] Schramm, G., Schumacher, G., and Zillig, W., *Z. Naturforsch.*, 10b, 481 (1955).

[10] Bloch, D. P., Morgan, C., Godman, G. C., Howe, C., and Rose, H. M., *J. Biophys. Biochem. Cytol.*, 3, 1 (1957).

[11] Epstein, M. A., Holt, S. J., and Powell, A. K., *Brit. J. Exp. Path.* (in the press).

[12] Armstrong, J. A., *Exp. Cell Res.*, 11, 60 (1956).

[13] Bertalanffy, L. von, and Bickis, I., *J. Histochem. Cytochem.*, 4, 431 (1956).

ARCHÆOLOGY

The Enkomi Silver Cup

In *Nature* of May 28, p. 676, reference is made to a nielloed silver cup of 1400 B.C. from Enkomi, Cyprus. To encounter a nielloed article of such an early date would indeed be a discovery of importance, since, so far as we are aware, no one has proved the use of niello as a means of decoration before the second century A.D. (ref. 1). There is, however, no evidence for the presence of niello on this cup, as we were able to demonstrate at the time the cup was being restored. The paper dealing with this[2] shows clearly that the only basis the author had for assuming the powdery material surrounding the gold ornamentation to be niello was that it was black.

It will be apparent, therefore, that the Enkomi cup should be made available for further scientific study; but in the meantime we should like to point out that the only conclusion that can be arrived at from the evidence reported in the paper[2] is that the Enkomi silver cup was inlaid not with niello, but with copper. It is pertinent to remark that, when last seen by us, the handle of the cup still retained some of its copper inlay.

G. F. Claringbull
A. A. Moss
British Museum (Natural History),
London, S.W.7. July 4.

[1] Moss, A. A., *J. Int. Inst. Preserv. Museum Objects*, 1, 49 (1953).

[2] Plenderleith, H. J., technical report in C. F. A. Schaeffer's "Enkomi-Alasia", 381 (Paris, 1952).

THAT the Enkomi silver cup exhibits many fascinating points of technique no one will deny. The suggestion that the black is derived from an inlay of copper is interesting, especially coming from the Department of Mineralogy of the British Museum (Natural History), and it is clear that such a copper-inlay technique would be likely to facilitate manufacture; but, in the absence of the inlays, its presence would be difficult and might even be impossible to prove. The cap at the extremity of the 'wish-bone' handle, referred to above, was scraped and the freshly exposed surface appeared coppery, but whether due to inlay or to staining of the silver alloy (that is, by niello) was not determined. Dr. Claringbull, who examined scrapings by spectrograph, could detect silver, copper and gold only. It is admitted that to obtain a *representative* sample of the black material in question from the bowl, without causing damage, was found to be most difficult. A further examination by X-ray diffraction of a second tiny specimen that was submitted yielded nothing fresh.

The features that led me to consider the Enkomi cup had been decorated with niello may be summarized: black patterns lustrous or splendent and enamel-like; where damaged, brittle and in one case appearing as a charcoal-like powdery stain subsisting from antiquity in contact with massive copper chlorides and carbonates; where undamaged, forming a perfect tracery of shiny jet-black mass-and-line ornament in a groundwork of bright metallic silver; the perfection of line and lustre survived immersion for 20 min. in commercial formic acid (1 : 2 parts water, by vol.), at boiling temperature, without any sign of loss. The gold-foil patterns that had been applied to this black material were in no way deformed, as one might have expected them to be, had they been mounted on copper inlays that would certainly have become swollen by oxidation during 2,000 years of burial. The cavities cut in the silver to contain the black decoration, where undamaged, were filled flush with the surface contour and the black material did not appear to have increased in bulk. If the results of the X-ray crystallographic examination were considered to be in doubt because of the possible inadequacy of the sample, the above observations—difficult to explain otherwise—had to be taken as straw in the wind suggesting the use of niello.

The weak point in the argument for niello is that although chlorides were present in quantity in the incrustation, no trace of sulphides could be detected. For this reason I agree that the case must be taken to be not proven as regards the presence of stromeyerite and acanthite; and, having regard to the importance of the matter, I would agree further that a re-examination is desirable. I suggest, however, that as we have now a new theory, some preliminary work should be done on black lustrous copper minerals (as exemplified, for example, in Tang mirrors) to determine how far the black compounds can survive treatment with hot formic acid without losing lustre, shape or quality, before contemplating further operations on the cup itself.

HAROLD J. PLENDERLEITH

International Centre for the
Study of the Preservation and
Restoration of Cultural Property,
Rome.

MISCELLANY

Cost of Scientific Periodical Publications

I AM writing with reference to the paragraph under the above heading which appeared in *Nature* of April 9, p. 124.

The periodicals mentioned are not similar in matter per page, since some of them contain considerable amounts of what is classed as 'difficult' setting by printers, and this has an appreciable effect on production costs. While it may be broadly true to say that a reduction in price leads to increased circulation, the optimum circulation obviously depends on several other factors; for example, the number of people engaged in research in a particular field. The journal which has the backing of a scientific society is in an advantageous position in that it has a guaranteed circulation to members of that society, as well as a subsidy in most cases.

The figures quoted in the table are approximately correct for 'library subscription rates' of the Pergamon Press journals mentioned, although, on the basis of the volumes completed on 1959 subscriptions, the price of *Physics and Chemistry of Solids* is 3·7*d.* per page (not 4·1*d.*), and that of *Reactor Science* is 8·2*d.* per page (not 8·9*d.*). However, the table as published is not the whole story so far as Pergamon Press subscription prices are concerned. Pergamon Press, in order to ensure maximum dissemination and to encourage individual scientists to own their own journals, have a specially low subscription price for private individuals, and the effect of comparing these subscription rates against the journals published by other publishers listed in the table is as follows:

Title	Source	Publisher	Price per page
Tetrahedron	U.K.	Pergamon Press	0·7*d.*
Journal of Inorganic and Nuclear Chemistry	U.K.	Pergamon Press	0·9
Journal of the Chemical Society	U.K.	Chemical Society	1·0
Physics and Chemistry of Solids	U.K.	Pergamon Press	1·0
Chemical Reviews	U.S.A.	American Chemical Society	1·2
Journal of Soil Science	U.K.	Oxford University Press	1·3
Chemical Engineering Science	U.K.	Pergamon Press	1·4
Information and Control	U.S.A.	Academic Press	2·0
Philosophical Magazine	U.K.	Taylor and Francis	2·2
Biochemie	Holland		2·25
Fuel	U.K.	Butterworth	2·5
Journal of Electronics	U.K.	Taylor and Francis	2·8
Chemical Abstracts	U.S.A.	American Chemical Society	3·0
Reactor Science	U.K.	Pergamon Press	4·1

Since this note was written, an amicable and constructive meeting has taken place between representatives of the Pergamon Press and the Standing Conference of National and University Libraries and the Library Association; the latter, although they now have a better appreciation of the reason for the Pergamon Press price differential policy, nevertheless still object to the fact that libraries should have to pay the higher, multi-user price.

I. R. MAXWELL

Pergamon Press, Ltd.,
Headington Hill Hall,
Oxford.

FORTHCOMING EVENTS

Monday, September 19

INSTITUTE OF METAL FINISHING (at the Northampton College of Technology, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. D. R. Weiner: "Decorative and Electronic Applications of Gold Plating".

Tuesday, September 20

SOCIETY FOR ANALYTICAL CHEMISTRY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 11 a.m.—Meeting on "The Chemist and Food Quality".

Wednesday, September 21—Friday, September 23

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (in the William Beveridge Hall, Senate House, and the Assembly Hall, Institute of Education, University of London), at 9.30 a.m. daily—Symposium on "High Temperature Resistance and Thermal Degradation of Polymers".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PRINCIPAL (graduate, or equivalent qualification, with teaching, administrative and industrial experience) OF HACKNEY TECHNICAL COLLEGE, London, E.8—Education Officer (FE3a/T/2066/9), London County Council, County Hall, London, S.E.1 (September 23).

RESEARCH ASSISTANT (with experience of research work in physical chemistry or physics and preferably with a Ph.D. degree in one of these subjects) IN THE DEPARTMENT OF CHEMISTRY, to continue work on a programme, under the general direction of Dr. S. J. Gregg, on the reaction of gases with metals at elevated temperatures. The techniques include measurement of the sorption of gases and the use of the vacuum microbalance and of radioactive tracers; special attention is paid to the part played by the film of reaction product—The Secretary, The University, Exeter (September 24).

RESEARCH FELLOW (preferably with experience in rocket or satellite instrumentation) IN PHYSICS, for research on primary cosmic rays using instruments carried in artificial earth satellites—The Secretary and Registrar, The University, Southampton (September 28).

ASSISTANT ANALYST (science graduate with some training in biochemical methods), in an experimental cytology unit working mainly on neurobiological problems—The Professor of Pathology, School of Medicine, Leeds 1 (September 30).

BACTERIOLOGIST, Assistant Experimental Officer grade (with a pass degree with bacteriology as main or subsidiary subject, or equivalent qualification), in the Humber Laboratory, Kingston-upon-Hull, to assist in research on bacteriological aspects of handling, processing and preservation of fish and fish products, together with certain fundamental studies of marine microbiology—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G323/0A (September 30).

HEAD (with high academic and professional qualifications in mechanical or electrical engineering together with appropriate industrial, teaching and administrative experience) OF THE ENGINEERING DEPARTMENT—The Registrar, Flintshire Technical College, Connah's Quay, near Chester (September 30).

SENIOR RESEARCH FELLOW IN PHYSICS at the University of New England, Armidale, N.S.W., to take part in a research programme to study the action of very powerful beams of gyro-waves on the ionosphere—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (September 30).

RESEARCH FELLOW IN PHYSICS at the University of Tasmania, for work with a group which is active in the field of intensity variations and associated solar-terrestrial phenomena, using counting techniques developed for the I.G.Y.—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (September 30).

LECTURER IN PHARMACOLOGY in the Department of Pharmacology and Therapeutics—Joint Clerk to the University Court, Queen's College, Dundee (October 1).

VETERINARY SURGEON (preferably a recent graduate with some practical experience and an interest in the application of chemical methods to the investigation of animal diseases) in the Agricultural Research Council's Experimental Pathology Department, Institute of Animal Physiology, to assist the Clinical Pathologist—The Secretary, Institute of Animal Physiology, Babraham, Cambridge (October 1).

LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Secretary, The University, Aberdeen (October 3).

SCIENTIFIC ASSISTANT, for the maintenance of physical instruments, including spectrophotometers and radiochemistry equipment—Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (October 8).

JUNIOR RESEARCH FELLOW or RESEARCH FELLOW IN THE DEPARTMENT OF BOTANY, University College, Ibadan, Nigeria, for research into the biology of the parasite Striga—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (October 10).

ASSISTANT LECTURER (with special qualifications in physical chemistry) IN PHYSICAL CHEMISTRY—The Registrar, The University, Manchester 13 (October 15).

LECTURER IN PHYSIOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 15).

PRINCIPAL (with high academic qualifications and appropriate educational and administrative experience)—R. H. Currell, F.C.A., Northern Polytechnic, Holloway, London, N 7 (October 15)

PROFESSOR AND HEAD (with academic qualifications and research or development experience appropriate to a postgraduate department studying gas turbines, jet propulsion engines and rockets, with an increasing emphasis on high temperature problems and nuclear power) OF THE DEPARTMENT OF AIRCRAFT PROPULSION—The Principal, The College of Aeronautics, Cranfield, Bletchley, Bucks (October 15).

RESEARCH CHEMIST or BIOCHEMIST (honours graduate in science or agricultural science) IN THE DAIRY RESEARCH SECTION, Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia, to take part in an expanded programme of research on dairy manufacture—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2 (October 15).

SENIOR LECTURER and LECTURER IN MATHEMATICS at the University of the Witwatersrand, Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 15).

SENIOR LECTURER (with an honours degree, and preferably a higher degree in electrical engineering with specialization in electronics) IN ELECTRICAL ENGINEERING at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, October 15).

SENIOR RESEARCH ASSISTANT, and EXPERIMENTAL OFFICERS (2), to work under the direction of Prof. G. Gee on the physical properties of high polymers—Prof. G. Gee, Department of Chemistry, The University of Manchester, Oxford Road, Manchester 13 (October 15).

CHAIR OF MEDICAL RADIOBIOLOGY in St. Bartholomew's Hospital Medical College—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 20).

SENIOR NUFFIELD RESEARCH FELLOW (graduate in either medicine or science, and with several years research experience) IN THE DEPARTMENT OF MICROBIOLOGY—The Registrar, University of Adelaide, Adelaide, South Australia (October 20).

DIRECTOR (with a sound scientific training and with the ability to co-operate with scientific personnel, the administrators and the occupiers of the tussock and mountain lands) OF THE TUSSOCK GRASSLANDS AND MOUNTAIN LANDS INSTITUTE, Canterbury Agricultural College, Lincoln, New Zealand—Mr. H. G. Hunt, Registrar, Lincoln College, Christchurch, New Zealand (October 22).

LECTURER (with an honours degree in philosophy and experience in teaching and research) IN CHARGE OF THE TEACHING OF PHILOSOPHY at the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Kuala Lumpur and London, October 22).

CHAIR OF MATHEMATICS—The Registrar, The University, Hull (October 31).

FOUNDATION CHAIR OF NUCLEAR ENGINEERING in the University of New South Wales, Kensington, New South Wales, Australia—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (Australia, October 31).

SENIOR LECTURER IN PHYSICS at the Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 31).

SENIOR LECTURER or LECTURER (with an honours or higher degree in science or engineering and with teaching and research experience in the fields of the physics of solids, the mechanics of solids or solid state chemistry) IN ENGINEERING MATERIALS at the University of Melbourne, for duties including lectures and supervision of laboratory classes for second and fourth year engineering students who are required to study engineering materials on the basis of solid state physics and chemistry—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 14).

PROFESSOR AND HEAD OF THE DEPARTMENT OF AGRICULTURAL ECONOMICS AND PROVINCIAL AGRICULTURAL ECONOMIST—The Registrar, The University, Nottingham (December 1).

ASSISTANT PROFESSOR (preferably with an interest in anaesthesia) OF PHARMACOLOGY—Prof. J. G. Aldous, Department of Pharmacology, Dalhousie University, Halifax, N.S., Canada.

ASSISTANT PROFESSOR (with Ph.D. or M.B. degree) IN PHARMACOLOGY—Prof. M. F. Murnaghan, University of Ottawa, Ottawa, Ontario, Canada.

ASSISTANT PROFESSOR or ASSOCIATE PROFESSOR (PHYSIOLOGIST, with an M.D. or Ph.D. degree and capable of independent research) IN THE DEPARTMENT OF PHYSIOLOGY—Prof. M. Bernak, University of Ottawa, Ottawa, Canada.

CHAIR OF AGRICULTURE in the Faculty of Agriculture, University College of the West Indies, St. Augustine, Trinidad—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

GEOLOGIST (with a degree in geology, general experience in geology and geophysics and a knowledge of the occurrence of ground water) with the Government of Kenya, for duties including the location of sites for water boring, geological mapping with special reference to occurrence of ground water and general investigations connected with engineering problems—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.112/7/044/01.

INTERNATIONAL WOOL SECRETARIAT RESEARCH FELLOW (with a degree in physics or physical chemistry, and with some research experience), to undertake work on the structure of protein fibres generally and wool in particular—Dr. F. Happey, Head of the Department of Textile Industries, Bradford Institute of Technology, Bradford.

LECTURER (with an honours degree in chemical engineering or corporate member of the Institution of Chemical Engineers, with experience in research and in the operation and supervision of full-scale chemical plant) IN CHEMICAL ENGINEERING—The Registrar, The University, Nottingham.

LECTURER (with a good honours degree and practical experience, with an interest in fluid motion and its technical applications) IN FLUID MECHANICS—Prof. C. M. White, Imperial College of Science and Technology, London, S.W.7.

LECTURER (with qualifications in mineralogy and petrology and an active interest in pre-cambrian rocks and ore deposits) IN GEOLOGY at the University of Khartoum—The Registrar, University of Khartoum, care of Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

MASTER TO TEACH PHYSICS: and a MASTER TO TEACH BIOLOGY—The Head Master, King's College School, Wimbledon, London, S.W.19.

PLANT PATHOLOGIST (with a good honours degree in a biological science, with postgraduate experience in research or advisory work in plant pathology) in Tanganyika, for research and specialist advisory services in plant pathology—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/08/C1.

PRINCIPAL (male, with appropriate qualifications and experience) OF THE DUDLEY AND STAFFORDSHIRE TECHNICAL COLLEGE—The Chief Education Officer, Education Offices, 3 St. James's Road, Dudley, Worcs.

RESEARCH ASSISTANT (with at least two years electronics experience) AT THE NUFFIELD RADIO-ASTRONOMY LABORATORIES, Jodrell Bank, for development and construction of low noise parametric amplifiers for use with a 250-ft. radio telescope—The Director, Nuffield Radio-Astronomy Laboratories, Jodrell Bank, near Macclesfield, Cheshire (October 10).

RESEARCH FELLOW (Ph.D. standard in chemistry or physics and with a sound knowledge of electronics), and a RESEARCH STUDENT (to read for a higher degree in chemistry), for research on new developments of nuclear magnetic resonance spectroscopy—The Secretary, Department of Chemistry, King's College, Strand, London, W.C.2.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research: Building Research Station. Factory Building Studies No. 6: Noise in Factories. By A. G. Aldersey-Williams. Pp. iv+26. (London: H.M. Stationery Office, 1960.) 3s. 6d. net. [206

Air Ministry: Meteorological Office. Averages of Earth Temperature for the British Isles. Pp. ii+159. (M.O. 665.) (London: H.M. Stationery Office, 1960.) 10s. net. [206

Department of Scientific and Industrial Research. Report of the Warren Spring Laboratory 1959: Report of the Warren Spring Laboratory Steering Committee for the period 1st July 1958 to 31st December 1959, and the Report of the Director of the Warren Spring Laboratory for 1959. Pp. iv+27+4 plates. (London: H.M. Stationery Office, 1960.) 3s. net. [206

National Union of Teachers. The Universities and the Teaching Profession. By Sir Charles Morris. Pp. 15. Willing the Means. By Sir Ronald Gould. Pp. 11. The Crucial Factor: The Supply and Training of Teachers, 1960–1970. By H. L. Russell. Pp. 10. (Addresses delivered at the Annual Conference of the National Union of Teachers at Blackpool.) (London: National Union of Teachers, 1960.) [17

Committee of the Privy Council for Agricultural Research. Report of the Agricultural Research Council for the year 1958–59. Pp. vii+213. (Cmnd. 1069.) (London: H.M. Stationery Office, 1960.) 9s. net. [17

Building Research Station Digest, No. 135 (June 1960). The Permanent Supplementary Artificial Lighting of Interiors (PSALI). Pp. 7. (London: H.M. Stationery Office, 1960.) 4d. [57

Chelsea College of Science and Technology. Prospectus, Session 1960–61. Pp. 35. (London: Chelsea College of Science and Technology, 1960.) [57

Aluminium Development Association. Information Bulletin No. 18. Working Aluminium in Shipyards. Second edition. Pp. 60. (London: Aluminium Development Association, 1960.) 2s. [57

English Electric Valve Company, Ltd. Voltage Stabilisers and Reference Tubes. Pp. 64. Valve Replacement Index. Pp. 8. V.H.F. Transmitting Tetrode for F.M. and Television Service 9kW Output at 216 Mc/s. Pp. 8. (Chelmsford: English Electric Valve Co., Ltd., 1960.) [57

The Diffusion of Knowledge. By Dr. Michael Grant. (Foundation Oration, 17 March 1960.) Pp. 15. (London: University of London Goldsmiths' College, 1960.) [57

Peace at the Last: a Survey of Terminal Care in the United Kingdom. By H. L. Glyn Hughes. (A Report to the Calouste Gulbenkian Foundation.) Pp. 64. (London: Calouste Gulbenkian Foundation, United Kingdom and British Commonwealth Branch, 1960.) 5s. [57

Institution of Electronics, Northern Division. Catalogue of the Fifteenth Annual Electronics and Instruments Exhibition and Convention, 1960, held in the College of Science and Technology, Manchester 1. Pp. xx+120+28. (Rochdale: W. Birtwistle, Honorary General Secretary, 78 Shaw Road, 1960.) [57

Other Countries

Durban Museum Novitates. Vol. 5, Part 19 (15th April 1960): A New Species of Pipistrelle Bat (*Chiroptera*: *Pipistrellus*) from South Israel. By David L. Harrison. Pp. 261–267 (2 plates). 1s. 6d. net. Vol. 5, Part 20 (30th April 1960): A New Race of the Flat-Headed Bat *Platymops Barbatogularis* Harrison from Kenya Colony, with observations on the Anatomy of the Gular Sac and Genitalia. By David L. Harrison and J. D. L. Fleetwood. Pp. 269–284 (5 plates). 3s. net. Vol. 6, Part 1 (30th April 1960): Geographical Variation in the South African Populations of the Golden-Breasted Bunting *Emberiza flaviventris* Stephens. By P. A. Clancey and J. M. Winterbottom. Pp. 1–11. 2s. net. (Durban: Durban Museum, 1960.) [276

Year-Book of the Institute of Nutrition, Budapest, 1959. Pp. vi+62. (Budapest: Institute of Nutrition, 1960.) [276

Union of South Africa: Department of Commerce and Industries—Division of Fisheries. Twenty-ninth Annual Report for the period 1st April, 1957, to 31st March, 1958. (Reprint from *Commerce and Industry*, November, 1959.) Pp. 160. (Pretoria: Government Printer, 1960.) [276

South African Council for Scientific and Industrial Research: National Building Research Institute. The Grouting of Prestressed Cable Ducts. By V. R. Boardman. (Paper presented to the International Congress on Prestressed Concrete, Johannesburg, October, 1959.) Pp. 24. (Pretoria: South African Prestressed Concrete Development Group, South African Council for Scientific and Industrial Research.) [276

Analytical Biochemistry: an International Journal, Vol. 1, No. 1 (June 1960). Edited by Alvin Nason. Pp. 95. Volume 1 (6 issues), 1960—15 dollars. (New York and London: Academic Press, Inc., 1960.) [306

Instituto de Zootecnia, Rio de Janeiro. Publicacao No. 25: Algumas Pesquisas da Associacao de Sinais na Pelagem Equina. Por Prof. Raul Briquet, Jr. Pp. 8. Publicacao No. 29: Introducao Geral ao Melhoramento Genetico das Populaxoes (com aplicacao aos problemas zootécnicos). Por Prof. Raul Briquet, Jr. Pp. 57. Série Monograficas, No. 1: Genética da Pelagem do Cavalo. Por Prof. Raul Briquet, Jr. Pp. 117. (Rio de Janeiro: Instituto de Zootecnia, Ministeiro da Agricultura, 1959.) [306

Canada: Department of Mines and Technical Surveys. Publications of the Dominion Astrophysical Observatory, Victoria, B.C. Vol. 10, No. 26: Apsidal Motion in the Spectroscopic Binary H.R. 8800. By R. M. Petrie. Pp. 459–466. 25 cents. Vol. 11, No. 4: The Inner Chromosphere of the K-Type Component of 31 Cygni as observed at the 1951 Eclipse. By K. O. Wright. Pp. 77–141. 25 cents. Vol. 11, No. 6: Shock Waves in the Atmosphere of the δCephei Star BW Vulpeculae. By G. J. Odgers and R. S. Kushwaha. Pp. 185–200. 25 cents. Vol. 11, No. 7. The Automatic Guider of the Dominion Astrophysical Observatory. By P. E. Argyle. Pp. 201–208+plate 7. 25 cents. Vol. 11, No. 8: A study of the Wolf-Rayet Stars H.D. 192103 and H.D. 192163. By Anne N. Underhill. Pp. 209–234+plate 8. (Ottawa: Queen's Printer, 1960.) [306

Metropolitan Life Insurance Company. *Statistical Bulletin*, Vol. 41 (May 1960): Marriages Increase in 1959. Mortality of Overweights with Impairments. Claim Payments at All-Time High in 1959. Fatal Injuries in Competitive Sports. Pp. 12. (New York: Metropolitan Life Insurance Company, 1960.) [17

Population Reference Bureau, Inc. *Population Bulletin*, Vol. 16, No. 4 (June 1960). Growth of American Families. Pp. 65–88. (Washington, D.C.: Population Reference Bureau, Inc., 1960.) 50 cents. [17

The Climate of Canada. By C. C. Boughner and M. K. Thomas. Pp. 74. (Reprinted from *The Canada Year Book*, 1959 and 1960.) (Toronto: Meteorological Branch, Air Services, Department of Transport, 1960.) [17

Bulletin of the Florida State Museum, Biological Sciences. Vol. 5, No. 4: Middle-American Poeciliid Fishes of the Genus *Xiphophorus*. By D. E. Rosen. Pp. 57–242. (Gainesville: Florida State Museum, 1960.) 2.80 dollars. [57

Parliament of the Commonwealth of Australia. Eleventh Annual Report of the Commonwealth Scientific and Industrial Research Organization for the year 1958–1959. Pp. 181. (Canberra: Commonwealth Government Printer, 1960.) [57

United States Department of the Interior: Fish and Wildlife Service. Statistical Digest No. 49: Fishery Statistics of the United States, 1958. By E. A. Power. Pp. ii+424. (Washington, D.C.: Government Printing Office, 1960.) 2 dollars. [57

United States Department of the Interior: Fish and Wildlife Service. Bureau of Commercial Fisheries. Statistical Digest No. 48: Statistics of the Alaska Herring Fishery, 1878–1956. By Bernard E. Skud, Henry M. Sakuda and Gerald M. Reid. Pp. iv+21. (Washington, D.C.: Government Printing Office, 1960.) 25 cents. [57

Commercial Outboarder, Vol. 1, No. 1 (Spring, 1960). Pp. 4. (Nassau, Bahamas: Outboard Marine International, S.A., 1960.) [57

Northern Rhodesia. Ministry of Land and Natural Resources. Annual Report of the Department of Water Affairs for the year 1959. Pp. 7. (Lusaka: Government Printer, 1960.) 1s. [57

Occasional Papers of the California Academy of Sciences. No. 27 (June 15, 1960): The Generic Allocation of *Hypsiglena slevini* Tanner (Serpentes: Colubridae). By Alan E. Leviton and Wilmer W. Tanner. Pp. 7. (San Francisco: California Academy of Sciences, 1960.) [57

Reports of the Botanical Survey of India. Year 1949/50. Pp. 10+3 plates. Year 1950/51. Pp. 10+3 plates. Year 1951/52. Pp. 8. Year 1952/53. Pp. 11. Year 1953/54. Pp. 11. Year 1954/55. Pp. 13. Year 1955/56. Pp. 24+5 plates. (Calcutta: Botanical Survey of India.) [57

State of Illinois: Department of Registration and Education. Natural History Survey Division. Biological Notes No. 41: Hawks and Owls: Population Trends from Illinois Christmas Counts. By Richard R. Graber and Jack B. Mills. Pp. 24. Biological Notes, No. 42: Winter Foods of the Bobwhite in Southern Illinois. By Harlow B. Mills. Pp. 35. (Urbana, Ill.: State of Illinois, Department of Registration and Education, History Survey Division, 1960.) [57

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

Pure Chemistry Library,
SCIENCE COLLEGE,
92, Upper Circular Road.
CALCUTTA

LIBRARY
9.11.60
SCIENCE COLLEGE

RESOURCES FOR ATOMIC ENERGY AND SPACE RESEARCH

THE subject of space research has already been discussed three times in the House of Commons during the past two sessions: on a motion by Mr. G. de Freitas in April 1959; on one by Mr. F. V. Corfield last February; and on a motion by Mr. G. de Freitas again on July 29. Between the second and third debates, on April 24, the Parliamentary and Scientific Committee was addressed by Sir Edward Bullard, Prof. W. R. Hawthorne, Sir Robert Cockburn and Dr. D. Taylor, and the question of space research was discussed with particular reference to the national benefits that could be expected to accrue from it. The Government's decision to discontinue *Blue Streak* as a military weapon has kept public, as well as scientific, interest in Britain focused on the subject, but in the meantime the announcement that the nuclear power programme is to be retarded has emphasized the comparative limitations of Britain's scientific and technological resources, and the critical character of decisions regarding the allocation of those resources as between one field and another.

There is, in fact, reason for believing that the proposals for space research are now much more realistic, and less likely to distort the general balance of effort in scientific and technological research. Lord Hailsham should be assured of strong and authoritative support in resisting any unrealistic proposals, and the Parliamentary debates and discussions on space research are, in fact, appropriately considered against the background revealed in the White Paper on the nuclear power programme published in June*. It might be noted that the retardation therein outlined was not foreshadowed in the usual White Paper on Capital Investment in the Coal, Electricity and Gas Industries† published two months earlier.

This earlier White Paper put the estimated capital expenditure by the electricity supply industry in England and Wales during 1958–60 at £308·2 million, of which £120·5 million was for conventional and £58·0 million for nuclear stations, compared with £275·4 million, £107·5 million and £46·0 million, respectively, approved for 1960–61; in addition, £6·4 million was spent on nuclear fuel in 1959–60 and £9·6 million is expected to be spent in 1960–61. Most of the expenditure on nuclear power stations in 1959–60 represented progress payments on main constructional works at the first four stations in the programme, and the White Paper notes that payments still to be made for those stations are likely to fall due earlier than had been estimated previously: increased expenditure under these contracts in 1960–61 will be offset by reductions in later years.

The White Paper on the nuclear power programme states that five nuclear power stations are being built and two more have been approved under the programme; the earlier stations will come into operation in 1961 and all seven should be in operation by 1966, with a total output capacity of about 3,000 megawatts. To reach the capacity of 5,000–6,000 MW. by the end of 1966, adopted in 1957 as the basis of the revised programme, exceptionally large orders for nuclear capacity would have to be placed during the next two years for commissioning in 1965 and 1966, and in the meantime the need on the grounds of fuel supply for a sharp and immediate acceleration in the rate of ordering capacity has passed. Accordingly, in consultation with the Atomic Energy Authority, the English and Scottish Electricity Authorities have re-examined the programme with the Government, in the light also of the latest estimates of nuclear and conventional costs and the future availability of primary fuels.

Although the cost of electricity from the first nuclear power stations to be commissioned next year will be rather higher than earlier estimates, the costs of later stations are following closely the downward trend foreseen in 1957, and while, for stations designed to-day, conventional power costs are about 25 per cent less than nuclear costs in the United Kingdom, the Government is advised that, in spite of the unexpected fall in the costs of conventional power from new stations, nuclear generation for base-load purposes is likely to become cheaper than conventional generation by about 1970. While there is a present world surplus of coal and oil, in the long run we shall need increasing supplies of nuclear power, and to secure this we must continue to build nuclear stations on an adequate scale.

The White Paper records the Government's decision to continue for the time being to place orders for nuclear stations at the rate of roughly one every year; and as the capacity of individual stations is likely to increase, this should provide about 5,000 MW. of capacity in 1968. Compared with the 1957 programme and allowing for more conventional stations, this will reduce by some £90 million the cost of power stations to be commissioned during the next seven years and there will be some loss to the Atomic Energy Authority. At any time there should be five or six stations in various stages of development, and it is claimed that this proposed rate of ordering should maintain fully the rate of development of nuclear technology in Britain and sustain a nuclear plant industry capable of competing for overseas business and of expanding to meet the higher level of the future needs of Britain itself.

The Minister of Power was closely questioned about the revised programme in the House of Commons on June 27; but he added nothing substantial to what was contained in the White Paper, apart from stating that for calculating depreciation the life of nuclear power stations was taken as twenty years, though it might be longer, and when they reached the end of their useful lives they would be dismantled, except the reactors, which would be sealed up, and new stations might be built on the same site. On July 28, replying for the Minister for Science, Sir David Eccles said that the slowing down of the nuclear power programme would result in the Authority carrying large stocks of uranium, and it was estimated that the annual interest on the capital locked up in the additional stocks might amount to several million pounds: present estimates suggest that the Authority's current and prospective supplies of uranium would last about ten years. Apart from this, it seems sensible to defer part of the programme rather than run the risk of erecting costly and uneconomic power stations, though there must be some question whether the retarding of construction may hinder the development of more efficient types of reactor.

---

* Ministry of Power. The Nuclear Power Programme. Pp. 4. (Cmnd. 1083.) (London: H.M. Stationery Office, 1960.) 4*d.* net.

† Ministry of Power. Capital Investment in the Coal, Electricity and Gas Industries. Pp. 4. (Cmnd. 993.) (London: H.M. Stationery Office, 1960.) 6*d.* net.

Sir Christopher Hinton scarcely seems to support this view. Discussing, in one of the Royal Society tercentenary lectures (see p. 1064 of this issue), the technical problems which must be solved to reduce the cost of nuclear power to an economically competitive level, Sir Christopher noted that at present the cost of electricity produced by nuclear power plants is 25 per cent higher than that produced by conventional coal- or oil-fired power plants, but that it is expected to drop below that of conventional power before 1970. He then suggested that it would be interesting to speculate on the cost of conventional power generation if it attracted as much research and development as its nuclear rival.

Here, of course, Sir Christopher touched on the essential difficulty that confronts anyone who carries the responsibility for allocating Britain's precious resources of scientific and technological man-power; and Mr. Aubrey Jones, the former Minister of Supply, has even implied that this is the essential reason for establishing a Ministry for Science. As he sees it, the main task of the Minister for Science should be to find a substitute for the technological role which armaments have hitherto played in a free society, with all that that implies in the allocation of resources, the stimulation of research and the fashioning of appropriate relations between industry and government. Mr. Aubrey Jones maintains further that the Minister must operate primarily on the side of demand, that he must seek ideas from industry, and avoid the dispersal of resources, concentrating them on a few major problems, and in particular he urged that the Department of Scientific and Industrial Research and the National Research Development Corporation should be brought into a closer relation and under the same authority—that of the Minister for Science.

The importance of a reasonable balance in the distribution of the resources of Britain is enhanced rather than otherwise by the interaction of different technologies which may be involved in such a field as that of nuclear power, to which Sir Christopher Hinton also alluded in the lecture already noted. Sir Christopher had emphasized that the heat-cycle temperatures in nuclear power plants are lower than the steam temperatures in conventional plants because of the combined effect of the inherent design of a nuclear reactor and the difficulty of finding materials which can stand up to irradiation. If comparable temperatures could be reached in a nuclear plant, Sir Christopher said that nuclear power would already be cheaper than conventional power. Here lie the major problems facing nuclear scientists and engineers at present, and little further advance can be expected, he said, until a new canning material is used for the fuel elements.

The annual reports of the Atomic Energy Authority have frequently indicated the benefits which other technologies have drawn from Britain's programme in nuclear energy, though those benefits are of themselves no justification for disproportionate expenditure of energy in any one field, and they are reasons for some information being published as to the expenditure on research and development by the Authority rather than otherwise. The essential lesson is the imperative need for effective co-ordination, in research and development generally as in fuel and power policy; and if either the Minister for Science or the Minister of Power lacks the authority or resources to formulate and execute such policies, he should not hesitate to approach Parliament for the necessary powers. That undoubtedly is a priority if Britain is to embark in space research on any considerable scale, and in the debate on July 29 Vice-Admiral J. H. Hallett very rightly stressed the need to re-examine the methods by which development contracts of the magnitude required in such programmes are co-ordinated and financed.

Although there are obviously still large problems of administration in research and development which demand some fresh thinking by the Minister for Science, it is no less important that we should be clear before embarking on any large programme of space research as to exactly what benefits the country may derive from such an effort. It is one thing to support projects such as those for which the Department of Scientific and Industrial Research announced last July the allocation of £184,540 to sixteen research groups in British universities for the development of instruments in rockets and satellites; it is quite another to contemplate a programme of space research demanding financial support on a scale comparable with that given to the rest of science. As Prof. Fred Hoyle has emphasized, space research is only a fragment of astronomy, and astronomy itself is only a fragment of science.

In opening the debate on July 29, Mr. G. de Freitas put national prestige as the chief argument for space research and development; but it is difficult to take this argument too seriously. Prof. Hoyle has also questioned whether we are likely to lose any able young scientists even if we do not embark on a space research programme. The really important question is that discussed before the Parliamentary and Scientific Committee and, directly connected with the expected benefits from such a programme, namely, what is a reasonable level of effort in this field. On the scientific side, Sir Edward Bullard referred to the importance of a better knowledge of the high atmosphere for the transmission of radio-waves, to the new opportunities space research offers for investigation of the charged particles in space and for astronomical observations outside the atmosphere. The present programme, he said, is costing about £100,000–£150,000 a year, and he thought this might rise to about £200,000, which is the same order of magnitude as the Department of Scientific and Industrial Research's grant to universities outside nuclear science.

Prof. W. R. Hawthorne, however, urged a programme involving expenditure of £100 to £200 million over the next ten years on launching space satellites and probes, and justified his claim on the ground of advances anticipated in control devices, communications and power, as well as in structures and mechanical engineering. He thought, for example, that the impetus given by the jet engine to research and development in combustion was likely to be repeated as engineers tackled the problems of rocket combustion, and similarly in connexion with the transmitters and receivers designed for space research to detect weak signals in a background of noise would be invaluable to industry in the next decade. Beyond this, however, Prof. Hawthorne argued that failure to support a serious space project would reduce the number of innovations we develop, innovations which might be of material advantage to industry as a whole, and it would also reduce the resources of skill and experience on which our designers could draw. Innovation, he insisted, is a product of imagination, skill and chance, and without entering on any discussion of the relation between discovery and innovation, he strongly urged the importance of an environment which fosters innovation, such as a space project should provide, in the education of the engineer.

Sir Robert Cockburn said that, of possible applications of satellites, only their use for long-range communications, in reconnaissance and in navigation could yet be considered in detail, and Dr. Denis Taylor stressed more particularly the stimulus space research could bring to instrumentation and to continental telephone and radio communication. In the discussion, Mr. A. Albu questioned whether engineering and scientific achievements could not be maintained more cheaply by spending money in some of the industries. Prof. Hawthorne admitted that it is difficult to explain the working of the intellectual stimulus and, as he also said, the Department of Scientific and Industrial Research had long been seeking to introduce science into British industry, but with only partial success. He agreed with Lord Halsbury as to the need for understanding why industrial design teams and others behave as they do, and the discussion certainly focused attention on the critical importance to Britain of such understanding for the proper deployment of our limited scientific resources.

Something of this discussion was reflected in the debate in the House of Commons on July 29. Mr. de Freitas, asserting that for speech, and later for television, satellites offered a far greater capacity and economy than ordinary terrestrial radio or cables, quoted opinion from the telecommunications industry that while for the first three years a telephone call to Australia might cost £1 a min., within four years a profit would be made at 10*s*. a min., and within twenty years anywhere in the world could be reached at 6*d*. a min. and be highly profitable. It is estimated that this could be achieved for an outlay of £6 million in the first year and a total of £80 million over forty years, and the system should have an income of £3·7 million in the first year, rising to more than £50 million in twenty years.

Mr. de Freitas also referred to the use of these satellites, for navigation and weather forecasting; but while, in replying on the debate, the Parliamentary Secretary to the Ministry of Aviation, Mr. A. G. E. Rippon, agreed that great scientific, technological and commercial benefits might be expected to result from space research, he pointed out that scientists themselves are divided on the question, and he again stressed the importance of considering the possibilities of international co-operation in this field. The debate had concentrated on the question of the development of *Blue Streak* as a satellite launcher, but on this Mr. Rippon had nothing to add to what the Minister of Aviation, Mr. Duncan Sandys, had told the House on June 20. Mr. Sandys said then that he was keenly aware of the potentialities of a British space research programme, but that he was not yet in a position to announce any decision. He also said that the French and German Governments appeared to be considerably interested in the idea of co-operation, but that before taking any decision the Government would consult the Australian Government.

Mr. de Freitas did not repeat what he had said in replying on the debate on February 22 about the British contribution to various space research programmes. Since the decision to abandon *Blue Streak* as a military weapon was announced, work had continued on those parts of the project which are necessary to its adaptation as a space satellite launcher and there was no evidence to show that these important design teams were splitting up, though he appreciated that excessive delay in reaching a decision could have adverse effects. Meanwhile, work on the technical problems associated with a future space programme had confirmed that a launcher could be developed from our abandoned military project capable of putting into orbit an array of satellites, and the design studies indicated that at least three types of satellite could be launched.

Although Mr. Rippon did not go into details of the scientific programme which could thus be carried out, his references to telecommunications, meteorology and to the stimulus of new technology and innovation suggested that the Government has already been considerably impressed by what was said before the Parliamentary and Scientific Committee, the memorandum from the British Interplanetary Society and other representations. Equally it would appear that the Government is concerned to maintain the balance of the research effort of Britain and avoid the distortion which Prof. Hoyle and others fear. Some scientists like Sir William Slater and Dame Kathleen Lonsdale fear that space research will divert skilled man-power from more important fields of research; but while Sir Frederick Brundrett suggests that a programme of space research should normally run with a military programme for the development of liquid-fuelled rockets and thus, like Prof. Hoyle, appears to question whether the successful development of a satellite relay system really lies within the range of a *Black Knight–Blue Streak* programme, Prof. Hoyle seems to be alone in doubting whether sufficient sound ideas for space research have yet been advanced to prevent the decline in standards which tends to result if too much money chases too few ideas.

There seems little reason to doubt that the Advisory Council on Scientific Policy took the right line in its annual report for 1958–59, from which Mr. Rippon quoted in the debate on February 22. British science and technology have contributed, and will continue to contribute, valuable results in space research, but these contributions should be made in specific directions appropriate to our special skills and they should be part of an internationally based approach. There does not indeed appear to be any reason on financial grounds or those of scientific and technical man-power why Britain should not afford such a programme; but a sound decision will be reached much more readily when the results of the design-studies recommended by the Advisory Council are available.

Meanwhile, the importance of a close assessment of the distribution of Britain's effort in research and development, including that of the universities as well as of Government and industry, is obvious, and this should be receiving the urgent attention of the Minister for Science. Moreover, it should not be forgotten that while Mr. Rippon rightly stressed the need to consider carefully all possibilities of international co-operation in space research, a report last March by Mr. D. Wilgress on co-operation in the field of scientific and technical research to the Organization for European Economic Co-operation strongly urged the need for more co-operation, particularly in fundamental research. Still more recently, industrial leaders like Viscount Chandos and Dr. Solvay have urged the need for more co-operation in fundamental research within particular industries, again on the ground of avoiding waste of limited resources, and especially of trained man-power. The Government is right in refusing to be rushed into any hasty or premature decision as to entering or not on a programme of space research; but it is for the Minister for Science to make sure that all the relevant factors are taken into account, including the interaction of different technologies on one another and the functioning of innovation and invention. Not all these factors can, it is true, be estimated with any accuracy; and there is sound reason for putting some further studies in hand. If the results will not be available in time to guide the decision regarding space research, they should assist similar decisions which are bound to recur from time to time in an age of advancing technology.

SEMICONDUCTORS AND TRANSISTORS

Les Semiconducteurs

Par Prof. P. Aigrain et F. Englert. (Monographies Dunod.) Pp. x+203. (Paris: Dunod, 1958.) 980 francs.

Les Semiconducteurs Électroniques

Introduction à la Physique des Redresseurs et des Transistors. Par Dr. E. Spenke. Traduit par L. Godefroy. Pp. xx+349. (Paris: Dunod, 1959.) 5,600 francs.

The Properties, Physics, and Design of Semiconductor Devices

By John N. Shive. (The Bell Telephone Laboratories Series.) Pp. xxi+487. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1959.) 73*s*.

Transistors

By A. C. Gillie. Pp. xvi+262. (London: Prentice-Hall International, Inc., 1959.) 42*s*.

The Junction Transistor and its Applications

Edited by E. Wolfendale. Pp. viii+394. (London: Heywood and Co., Ltd., 1958.) 84*s*. net.

THE subject of semiconductors was understandably not popular with authors of books during the period when the two semiconductors in common use, copper oxide and selenium, and rectifying contacts made to them, were proving such severe tests of the theories of the solid state then being developed. Industry found it necessary to use empirical methods to improve these materials for use in rectifiers, thereby, as it happened, tending to increase the difficulty of closing the gap between theory and practice.

The whole outlook of the subject was ultimately changed, not by the resolution of the difficulties which made the subject so obscure, but by rapid advances following comparable observations of materials more amenable to scientific investigation. Germanium in particular proved to be a semiconductor well suited to study by physicists; the discovery of transistor action and its explanation in terms of minority carriers acted as a great new stimulus, and the refinements made to the methods of preparing germanium, and later silicon, with very small, but controlled, amounts of desirable impurities quickly increased confidence in quantitative measurements. New electrical properties of semiconductors were discovered and fitted into the expanded theory, and its adequate explanation of the behaviour of p-n junctions was one of its greatest successes. To-day therefore, despite some difficulties which the subject has run into in its newer fields and in some details, the basis of the subject is well established and the problems facing authors of books on the subject are an over-abundance of original and review papers and the rapidity of advance. In addition, the readers have changed; few continue to regard the subject as a test of the powers of quantum mechanics, for it has had important reactions on the basic theories and is big enough to demand specialized treatment. Most readers will be content if the specialized treatment is only sufficiently rigorous to contain the more important basic physical effects, and will expect a compact picture of the positive achievements and applications of the subject which has spread into several branches of science.

Prof. Aigrain and his co-author make little concession to these readers in so far as they assume that a study of quantum mechanics will already have been made—even if many details have been forgotten—and that frequent recourse to fundamentals is essential. They begin with a highly condensed account of the role of electrons in solids, largely in mathematical terms and divorced from physical quantities directly observable, into which they then fit a few practical findings. The bare outlines of the properties of junctions and transistors follow, expressions still being quoted rather than deduced, and the book ends on a lower intellectual note, with summaries of the preparation of transistor-quality germanium and silicon and of some photoelectric and thermo-electric applications. The merits of this short book as a summary of the formal theory for those readers already well acquainted with the subject are likely to be its greatest demerits for others.

The second edition of Spenke's book was translated into English last year by staff of the Radio Corporation of America, who made some useful additions; the French translation, which seems a little less free by comparison, includes the addition describing junction capacitance. The book is in two overlapping parts. The first four chapters form one part and take us from band theory to the physical mechanisms of transistors; mathematics and wave-mechanical ideas take second place to descriptive language, but the author avoids over-simplification. The second part is intended for the physicist who requires a more comprehensive analysis of the physical processes responsible for the properties of semiconductors. It reveals the more successful work of the period 1930–40, made despite the difficulty of experimental confirmation, though it may over-emphasize some at the expense of more recent findings.

Shive, too, though writing for readers with little prior knowledge, divides his book into two distinct parts. The first, once again, is very descriptive, both of semiconductors and of the chief devices made from them—thermistors, point-contact diodes, rectifiers using copper oxide and selenium, photocells and junction transistors. A scientist in a non-physical field could benefit equally with any newcomer. The second part begins by inquiring more deeply into the physics of semiconductors, largely in terms of particle models, with occasional reference to wave and quantum mechanics; some over-simplifications may have crept in, but the chief points are well put. The key points of junction theory are presented without frills, and the book concludes with chapters on thermoelectricity, the Hall effect and the processes used to make junctions. The whole is worth study by those who teach the subject as well as by those seeking a broad understanding which is, however, more than superficial.

Despite the fair number of books on transistors now available, it is still difficult to say how best the subject can be presented, either for beginners or for experienced designers of devices and circuits. If reasons are to be given for the electrical properties, some recourse to physics is necessary; but if they are not, a statement of the properties and their translation into analytic form can prove an adequate starting point for a book on applications. Gillie's attempt, aimed at a non-analytic introduction to the device and its elementary circuits, is not badly planned, but must be very nearly completely discounted because of the numerous errors and misleading statements early on. Thus he talks of the velocity of current, confuses resistance and resistivity, asserts, with the emphasis of italics, that pure germanium is an insulator, seems to imply that acceptors increase the conductivity of a semiconductor, because the electrons from the valence band filling the acceptor-levels then require less energy to be excited to the conduction band and states that hole-electron pairs can be more easily created in n-type material. The two chapters on the junction transistor can be recommended to the newcomer without serious reservation, provided he has other sources to refer to at the same time.

On the other hand, Wolfendale and the contributors to his book have produced something worth the serious attention of electronic engineers. The opening chapter, of some length, on transistor physics is specially noteworthy, for, from a simple beginning, it develops analytically all the main electrical properties of the uniform-base transistor; an extension to graded-base units would be valuable in any second edition. Several of the later chapters are of the standard expected in a good designers' hand-book, and all have some merit. Continuity is sometimes a little lacking, and some parts are treated in much more detail than others; but there are no inconsistencies and few misleading statements. The book was written before the idea was advanced that the charges stored in the base and in depletion layers furnished a basis for predicting the behaviour of transistors as switching elements; but it does illustrate the difficulties of finding a single representation for a transistor adequate for all applications.

J. R. TILLMAN

COMMUNICATIONS AND ELECTRONICS DICTIONARIES

Elsevier's Telecommunication Dictionary in Six Languages

English/American—French—Spanish—Italian—German—Dutch. Compiled and arranged on an English Alphabetical Base by A. Visser. Pp. viii+1011. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1960.) 147*s*.

Swedish Supplement to Elsevier's Dictionary of Electronics and Waveguides

By W. E. Clason. Pp. iv+43. (Amsterdam: Elsevier Publishing Company; London: D. Van Nostrand Company, Ltd., 1960.) 20*s*.

THE first volume is a very welcome addition to the series of multilingual dictionaries published by the Elsevier organization. Its compilation is more than justified by the enormous progress that has taken place in the field of communications, both line and radio, in the past one or two decades. This volume has been compiled by Mr. A. Visser, who retired a few years ago from the position of librarian and chief of the documentation section of the Netherlands Postal and Telecommunication Services. The basis of the book is the listing of all terms used in the telecommunication world arranged in alphabetical order in the English language. Below each term is given the equivalent word or phrase in French, Spanish, Italian, Dutch and German in that order. In many cases it has been necessary to give alternative words or phrases in interpretation of the basic English term or phrase. No definitions of the terms are given, but, in a large proportion of cases, the terms are sufficiently self-explanatory for the technical reader.

Following the basic section, alphabetical lists are given in each of the other five languages, each word being indexed as a reference to the basic table, so that the user can find the corresponding term in English, and all the equivalents in the other languages.

As with former volumes in this series, the production of the book is excellent. In spite of its size—more than one thousand pages—it is convenient to use, with the familiar semi-flexible binding, and a thumb-index to the different languages. All engineers and scientists engaged in the field of telecommunications will find this a most useful work of reference and aid to the reading of foreign literature.

A dictionary on similar lines to that referred to above but dealing with the field of electronics and waveguides was published by the same company in 1957 (see *Nature*, 181, 801; 1958). To the language section of that volume has now been added a Swedish supplement. This is arranged in two parts: the first being an alphabetical list of terms in this language; while the second comprises a re-arrangement of the same terms in the numerical order corresponding to the numbered basic English section of the main dictionary. The publication of this supplement thus extends the former volume to be a complete work of reference in seven languages to all terms in use in the technique of electronics and waveguides.

R. L. Smith-Rose

PROBABILITY AND PHYSICS

Probability and Related Topics in Physical Sciences
By Mark Kac. With special lectures by G. E. Uhlenbeck, A. R. Hibbs and Balth. van der Pol. (Lectures in Applied Mathematics, Vol. 1.) Pp. xiii+266. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 43*s*.

THIS book, which is based on a course of lectures given in 1957, makes no claims to be a text-book; but it contains a wealth of material underlining the established place of probability technique in modern physics. Prof. Kac's enviable skill in analysis is somewhat naturally displayed to the full in many of the problems discussed, so that, while the mathematics always remain his servant, his book may in consequence appeal rather more to mathematicians than to physicists.

There are four chapters and four appendixes. Chapter I explains the nature of probabilistic reasoning, and includes discussion of the Maxwell velocity distribution in the theory of ideal gases and of the number of real roots in polynomial equations with random coefficients. Chapter 2 deals with "Some Tools and Techniques of Probability Theory", illustrated mainly by reference to various random walk problems. The longest chapter (3) is on "Probability in Classical Statistical Mechanics", and the first appendix by G. E. Uhlenbeck on 'the Boltzmann equation' should be read together with this chapter. Uhlenbeck's appendix gives a very clear survey of the various models, microscopic and macroscopic, mechanical (deterministic) and stochastic, that exist and the relations between them. In Chapter 3 itself, the fundamental problems and paradoxes of statistical mechanics are considered by reference to the Ehrenfest urn example, by the use of the so-called 'master equation' which represents a stochastic simplification of the exact Boltzmann equation, and by a modern account of Smoluchowski's brilliant theory of fluctuations.

The final chapter (4) is on "Integration in Function Spaces and Some Applications", and discusses the recent technique of path integrals introduced into quantum mechanics by Feynman and having analogues in the theory of stochastic processes. There is a relevant appendix (2) on quantum mechanics by A. R. Hibbs, recalling some of the special peculiarities of probability in this domain. The final appendixes (3 and 4) by B. van der Pol, on "Smoothing and Unsmoothing", and "The Finite Difference Analogy of the Periodic Wave-equation" and the "Potential Equation" respectively, are not directly related to the rest of the volume, which ends with some interesting historical notes and a bibliography.

One important topic omitted from this book is information theory; this might be explained by Prof. Kac's concentration on problems closely connected with his own researches. It might also be argued that this theory is more related to communication engineering than to physics: but more fundamentally its bearing on the concept of entropy and on theories of measurement has yet to be fully clarified. On the subject-matter of Chapter 4, the mathematical connexion between the Feynman integral and analogous integrals in stochastic process theory is stated clearly enough, but on a deeper physical level the differences seem puzzling and remain rather a challenge. I was also somewhat surprised not to find a more explicit discussion of the important class of probability problems associated with such work as Onsager's on the two-dimensional Ising model, to which a very fleeting allusion is made in the bibliography (p. 261). However, even this last comment can scarcely be a criticism of the book under review, when it is recalled that the author's intention was to indicate the scope and value of probability theory, and part, but by no means all, of its rapidly increasing range in physics.

M. S. Bartlett

ADVANCES IN GEOPHYSICS

Advances in Geophysics
Edited by H. E. Landsberg and J. Van Mieghem. Vol. 4: Pp. x+456. 12 dollars; 86*s*. Vol. 5: Pp. x+325. 10 dollars; 80*s*. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1958.)

IN these volumes, as in past issues, geophysics is interpreted in the widest sense with perhaps a greater emphasis on pure geophysics than prospecting geophysics. If it is the editorial policy that the subjects selected for review reflect the state of research among the Earth sciences, it would appear that meteorology and upper atmosphere physics lead the field, for almost half the articles in the volumes under review concern these subjects. The International Geophysical Year stimulated research in all branches of geophysics as Gerson's article "Polar Years to I.G.Y." (Volume 5) illustrates, and it is to be hoped that future issues of "Advances in Geophysics" will take account of this activity, particularly in the fields of geomagnetism and seismology.

In reviewing the organization and achievements of the First Polar Year, Second Polar Year and the International Geophysical Year, Gerson remarks on the accumulation of "mountains of undigested data". The institution of world data centres by the organizers of the International Geophysical Year to co-ordinate and standardize the accumulated data makes it all the more imperative that geophysicists should be trained in computer programming methods in order to assimilate this data. Any student in this field is well advised to read Holloway's review on "Smoothing and Filtering of Time Series and Space Fields" (Volume 4).

Hirvonen, in "The Size and Shape of the Earth" (Volume 5), describes recent advances in geodetic surveying and also discusses the application of Stokes's formula to determining the geoid. Those minute oscillations of the Earth's crust due to Earth tides are reviewed by Melchior in "Earth Tides" (Volume 4). The remarkable sensitivity of the horizontal pendulums, extensometers and gravity meters (which the author describes) is exemplified in the attempt during the International Geophysical Year to detect the change in Love's numbers with tidal periods attributed to motions in the fluid core. While Earth tides can be dealt with largely by static theory, ocean tides demand a dynamic theory. The theoretical and empirical study of tides in uniform and actual oceans is reviewed in Volume 5 by Doodson.

On microseisms, the late B. Gutenberg (Volume 5) emphasizes the difficulties inherent in a branch of seismology which deals with dispersed sources involving energy transfer from wind–water–Earth and propagation by surface and channel waves.

Junge, in "Atmospheric Chemistry" (Volume 4), reviews recent research on aerosols and trace gases. Among other trace gases the role of carbon dioxide in the heat budget of the Earth is discussed. In "The Physics of Cloud Modification", Volume 5, the entire history of cloud-seeding techniques is outlined by MacDonald together with a discussion on condensation and precipitation processes in clouds.

Further afield, Watanabe (Volume 5) gives an extensive account of ultra-violet absorption cross-sections and absorption processes in the ionized regions. Rocket and satellite studies have also contributed to the revolution now taking place in theories of magnetic storms which have a direct bearing on theories of the aurora. Chamberlain (Volume 4) reviews these theories, discussing at length the Chapman–Ferraro theory of storms since this remains the most rigorous treatment that takes account of auroræ.

Lapaz (Volume 4) provides the first extensive account of "The Effects of Meteorites upon the Earth" discussing not merely the composition, trajectories, etc., of meteorites but also the probability of their striking densely populated areas.

These two books maintain the high standards of previous issues and deserve a place on most geophysicists' bookshelves.

S. H. HALL

BIOLOGY OF POLLUTION

The Effects of Pollution on Living Material

Edited by W. B. Yapp. (Symposia of the Institute of Biology, No. 8.) Pp. xii+154. (London: The Institute of Biology, 1959.) 25s.

The Biology of Polluted Waters

By H. B. N. Hynes. Pp. xiv+202+2 plates. (Liverpool: Liverpool University Press, 1960.) 25s. net.

The Church Army Press is perhaps partly to blame for the style of the Eighth Symposium of the Institute of Biology "The Effects of Pollution on Living Material". Although expensive the quality of production, paper and printing is poor and while this may have been specific to my copy the contents must be general. After two good introductory contributions the symposium lapses into a stage for mere repertory and is saved only by the last chapters on pollution, in its widest sense, by radioactive materials. Although at present mostly fall-out, some contribution to radioactive pollution is made by nuclear power stations and general radioactive waste disposal from hospitals and industry for which there is still no national scheme. With radioactive pollution at its present level, such effects as an eventual increase of 5,300 in the number of blind persons in Great Britain may be expected. It seems, however, that, except for tritium and carbon-14, both soft beta emitters, cobalt-60 with a half-life of 5 years is the longest-lived nuclide in fall-out. Improvement would therefore be quite rapid if bomb testing was to stop.

While the chemist interested in water has for a long while been well equipped with books on pollution, biologists have hitherto had probably only one recent book, namely "Aspects of River Pollution" by Dr. L. Klein, to draw upon. That work is primarily a reference book, while "The Biology of Polluted Waters", by Dr. Hynes, in which frequent reference is made to Dr. Klein's book, provides for the first time an introductory text for any biologist sufficiently interested in pollution to be intrigued by the striking cover. In the preface and throughout the book Dr. Hynes emphasizes the essentially biological nature of pollution and the incongruity of the older chemical approach. Mr. F. T. K. Pentelow too, who wrote the introduction, criticized some of the river boards for expecting the chemists on their staffs to understand and tackle alone problems so essentially biological.

Having experienced the difficulty of communication with chemists who are often unfamiliar with biological concepts, the author has provided a kind of picture vocabulary to help the non-biologist reader, but it is doubtful whether this simple device will in fact bridge the gap between the worlds of the chemist and the biologist.

To most people pollution has a definite connotation; but perfectly natural phenomena, such as the autumn fall of leaves or a sudden summer shower, may deplete the dissolved oxygen in a river enough to be catastrophic for the inhabitants. Similarly, pollution of lakes may merely hasten the natural hydrosere from oligotrophic to eutrophic condition. Where then is the border-line between natural and polluted water? Only complete understanding of the biology of a whole waterway can justly answer this question in any particular case, yet, as the author points out, still too little is known for this often to be possible. Perhaps the best basis for a general judgment on the condition of a river is given by Turing cited by Hynes. "Fish are a very useful barometer of the real state of purity of a water. No river should be considered as in a satisfactory condition unless fish will live and thrive in it".

In short, the book sums up the work of the Water Pollution Research Laboratory, the Freshwater Biological Association and authorities in Europe and the United States, in a comprehensive and above all eminently readable way. G. C. WARE

NORTH AFRICAN PREHISTORY

The Stone Age in Northern Africa

By C. B. M. McBurney. (Pelican Book No. A342.) Pp. 288+24 plates. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1960.) 6*s*.

DR. McBURNEY is among the half-dozen prehistorians who are really competent to write about the early prehistory of North Africa. Over a series of years he has visited much of the area and has himself made there important excavations. His book, therefore, can be confidently recommended to all students of the subject.

As a lecturer and teacher in the University of Cambridge who has travelled widely, he brings to bear on the problems of North Africa a wide knowledge of prehistory elsewhere, and seeks to fit his special area into the pattern of the Stone Age world. Thus he begins his book with 60 pages on "The Present Stage of Prehistoric Studies"—a chapter which will be appreciated both by his less- and more-instructed readers, and which presents the problem of North Africa in relation to the neighbouring areas of Europe, western Asia and Africa south of the Sahara. He then discusses the physical and climatic problems of his own region. Climatic changes in the past have profoundly affected the possibility of habitation during prehistoric times. Prior to the last pluvial period (Gamblian) the spine of the Sahara could be traversed from south to north, but afterwards such movements were, to say the least, difficult on account of the absolute desert conditions which set in.

Next come three chapters which perhaps are the meat of the book and which deal, in order, with "The Earliest times of Man in North Africa", "The Middle Palæolithic" and "The Blade Industries and the Spread of *Homo sapiens*". In the first of these it is splendid to be given, with proper recognition of its importance, an account of the work of Arambourg and his finds of early Acheulean human remains at Ternifine (Palikao). To English readers such an account has not hitherto been readily available. Villafranchian faunal assemblages used as date-giving fossils are discussed and there are comparative faunal tables and some, perhaps not enough, text figures of varying excellence of some of the implements found. In the Middle Palæolithic chapter the author has much excavated material to discuss and many problems, and can draw on the work of Miss Caton Thompson again and again. There is a charming account of his own finding of a hunter's encampment site near the Wadi Derna in Cyrenaica, with a list of the animals eaten there, and where the typology of the finds brings to mind the industrial tradition of the lower Levalloiso-Mousterian of Palestine. In the "Blade Industries" chapter his own excavations have again helped the writer. The problems are more than ever complicated as he admits, but as a working hypothesis he offers a series of dates starting at 15,000 B.C. with the appearance of the earliest Oranian in the Maghreb as a result of Gravettian influence or immigration from south-west Europe into a Levalloisean area until 5000 B.C., when the Upper Capsian seems to come to the end of its sway and Levantine influences are apparent. A final chapter on the Neolithic period, which gives a picture of a surprisingly uniform cattle-breeding (but sheepless and goatless) economy extending from the Atlantic to the Nile, includes a short account of less than 15 pages of the North African rock-shelter art and about the same number of pages of illustrations, principally, I fancy, taken from Frobenius. On this matter, of course, a great deal more could be written, but the survey will be found useful to students. It is in a connexion like this that one must regret that owing to the economic problems of to-day such a fundamental study as this book could not have appeared in a larger format. So much which the author has touched on could have been usefully expanded. Nevertheless we now have, together with the complementary volumes in the series by Desmond Clark and Sonia Cole, three authoritative works on the prehistory of the continent of Africa.

M. C. BURKITT

EXISTENTIAL PSYCHIATRY

The Divided Self

A Study of Sanity and Madness. By Dr. R. D. Laing. Pp. 240. (London: Tavistock Publications, 1960.) 25*s*. net.

THIS book will be of interest to those who are orientated towards philosophy, but others may find it difficult going. The author is obviously widely read in existential and other modern philosophical theories and has attempted to apply them to understanding psychiatry—particularly schizoid personalities and schizophrenia.

The main weakness of the book is that it does not develop a coherent system, but uses the existential ideas to explain some patients' symptoms without giving a satisfactory scheme which is applicable in other cases. In some instances he sets up 'Aunt Sallies' only to knock them over. For example, he complains that "the current technical vocabulary currently used splits up man verbally". By this presumably he means that one speaks of the ego, super-ego and id and so on. Yet this does not split up man verbally unless one regards an engineer who talks of the cylinder, piston, connecting rod and crank-shaft as splitting up an engine verbally. They are merely descriptive terms, and he still regards it as a whole engine.

The author puts forward a number of interesting mechanisms in schizophrenia, for example, engulfment, implosion, petrification, and depersonalization. He believes that the 'inner self' undergoes various changes in this disease and can be 'phantasicized' or 'volatilized'; it can become unreal, or impoverished, empty, dead, or split; it can be more and more charged with hatred, fear and envy.

The author complains that psychiatric theory has not changed since Kraepelin (although Freud changed a good deal), and perhaps he has laid the foundations of a system which he may be able to develop further in other books. CLIFFORD ALLEN

Safety in Mines Research Establishment Bibliography, 1960

Compiled by E. B. Smith. Second edition. Pp. viii+177. (Sheffield: Ministry of Power, Safety in Mines Research Establishment, 1960.) 17*s.* 6*d.*

THE organization known since 1950 as the Safety in Mines Research Establishment of the Ministry of Power has operated in one form or another since 1908. It has made noteworthy contributions to knowledge not only of the immediate problems of safety in mines connected with dusts, ventilation, inflammable gases, explosions, roof control, methods of working, lighting, health of the miner, electrical hazards, materials used in mining, and so forth, but also of fundamental scientific knowledge to a whole wide range of subjects which affect mining and mining conditions. These include physics of liquids and of fine particles, gas flow, ignition and combustion of gases and solids, flame propagation and explosions, metallurgy, coal constitution, palæobotany, medical science, etc.; this list is not exhaustive, but is a selection to show the breadth of interest of the Establishment as a whole. There are, in fact, more than 1,500 entries in this comprehensive bibliography (which supersedes the Safety in Mines Research Establishment Bibliography, 1921–52, and includes publications up to the end of 1959, as well as references to international conference papers translated and published by the Establishment).

The scope of the Establishment is wide because problems of safety in mines touch almost every science and technology. The bibliography, therefore, will be of interest to workers engaged in many fields of pure and applied science. It is well arranged and well presented for its price; but what a pity that it is stapled in such a way that the sharp ends of the staples can scratch—and in the case of one copy already have scratched—the surface of a polished table.

S. G. WARD

South African Animal Life

Results of the Lund University Expedition in 1950–1951, Vol. 6. Edited by Bertil Hanström, Per Brinck and Gustav Rudebeck. Pp. 553. (Stockholm: Almqvist and Wiksell, 1959.) 75 Sw. kr.

A CONTINUATION of what has now become a well-known series, this sixth volume follows the style of its predecessors. Like them, it is particularly pleasant to use because the various type-faces are well-chosen and attractive, and combine to make the text most readable. The crown octavo pages are bound in such a way that the volume stays open without trouble. A consistent editorial policy makes all papers present equivalent information: synonymy; systematic notes; descriptions of new genera and species; detailed and general distribution. The volume as a whole is rather lightly illustrated, though some papers have good figures.

This sixth volume includes accounts of the following groups of animals, as they were represented in the collections made by the Lund University Expedition during 1950–1951: Hirudinea (I. Sciacchitano); Diplopoda, Penicillata (B. Condé); Collembola (J. Paclt); Coleoptera, Scarabaeidae-Hopliini (H. Schein); Bostrychidae (J. M. Vrydagh); Erotylidae (H. Philipp); Endomychidae (H. F. Strohecker); Colydiidae (R. D. Pope); Monommidae (H. Freude); Cerambycidae (F. F. Tippmann); Chrysomelidae I (G. E. Bryant); Chrysomelidae II (J. Bechyné); Curculionidae, part (G. A. K. Marshall); Curculionidae-Brachycerinae (E. Haaf); Neuroptera, Plannipennia II (B. Tjeder); Diptera, Culicidae (J. Muspratt); Ceratopogonidae (B. de Meillon); Mydaidae (M. Bequaert); Stratiomyiidae (E. Lindner); Phoridae (E. M. Beyer); Dorilaidae (Pipunculidae) (D. E. Hardy); Chloropidae (C. W. Sabrosky); Hippoboscidae (J. Bequaert); Streblidae (B. Jobling); Calliphoridae (F. Zumpt); Hymenoptera, Ichneumonidae (P. L. G. Benoit); Gasteruptionidae (J. J. Pasteels); Megalyridae (K. J. Heqvist); Sapygidae (P. L. G. Benoit); Pompylidae (G. Arnold); Amphibia (R. F. Inger).

There is a contents page, but this volume is not separately indexed.

H. OLDROYD

Les Observatoires Astronomiques et les Astronomes

Par Fernand Rigaux. Pp. ii+452. (Bruxelles: Observatoire Royal de Belgique, 1959.) n.p.

THIS is a new edition of a work which appeared originally in 1931 and has been very useful as a reference book. Many astronomers must have regretted frequently that the only supplement was made in 1936, so that the work was no longer of any use. It gives the names of the astronomers in all the principal observatories, and a brief description of the instruments to be found in them, and in addition it gives the addresses of retired observatory astronomers, university professors and lecturers interested in astronomy, and indeed of prominent amateur astronomers.

While the Royal Observatory of Belgium, and Fernand Rigaux in particular, are to be congratulated on the production of a new edition, it is impossible not to regret the fact that the information which now appears is four years out of date, at least so far as several British observatories are concerned that I have checked in detail. One might also suggest that a formidable book of 452 pages is not really necessary to convey the information. It is possible to criticize the lay-out, which seems to be very wasteful of space.

I would be heartily in favour of bringing out this reference book more frequently in a handier and cheaper form.

R. v. d. R. WOOLLEY

The Faith of a Physicist

By Dr. H. E. Huntley. Pp. 159+4 plates. (London: Geoffrey Bles, Ltd., 1960.) 16*s.* net.

IN a foreword to this book, Prof. C. A. Coulson commends it "as an honest attempt to help others to see the present status and future possibilities of science. In its simple and direct style it can hardly fail to instruct and to encourage its readers".

It is desirable that writers with a special knowledge of one branch of science should, on occasion, relate their scientific outlook to their attitude towards the Christian faith. This the author, lately professor of physics in the University College of Ghana, has done. In the first chapter, "The Status of Science", Prof. Huntley maintains that science "is not only more than technology; it is more also than a social force of unprecedented power. *Science is a revelation and its study is a religious activity*". Successive chapters expand this theme in relation to such subjects as education, beauty as revealed in Nature and the stature of man.

A feature of the book is the number of literary quotations which the author uses to illustrate his argument.

H. D. ANTHONY

EVOLUTION OF NUCLEAR POWER PLANT DESIGN*

By SIR CHRISTOPHER HINTON, K.B.E., F.R.S.

MOST applied research is expensive, and applied research and development on atomic energy is so expensive that expenditure should be justified either by the needs of defence or by the expectation of a satisfactory return in the industrial field. The foundations of the atomic energy industry were paid for with defence funds; the research, development and engineering of the fuel-element manufacturing plant at Springfields, the diffusion enrichment plant at Capenhurst and the Windscale reactors and chemical separation plant were done to produce plutonium and uranium-235 for defence. Even the Calder Hall reactors were built primarily for the production of plutonium, and generated electric power as a by-product. The possibility of using this experience in the industrial field had been seen from the first, and progress into this field had been planned. But now that we have advanced into it, little of the further research and development which are necessary can reasonably be charged to a defence budget; they must be justified by immediate or prospective savings as compared with alternative industrial techniques which are available or are likely to be available.

When the British nuclear power programme was first launched in 1955, it was estimated that (in the first stages of development) the cost of nuclear and conventional power would be equal at about 0·6*d.* per unit of electricity. Since then there have been three important changes; because of rapid development in that field, the cost of conventional power has fallen by more than 10 per cent; for technical and commercial reasons the credit allowed for by-product plutonium (which it is hoped to use as fuel in reactors of advanced types) was drastically reduced; interest rates (which had been taken at 4 per cent) have risen, and this rise reacts against nuclear power with its high capital cost. The result of these changes is that nuclear power from the plants which are now being ordered will cost about 25 per cent more than from the best conventional plants built concurrently and operated under similar load conditions.

That a difference of this sort was likely was known at the time when the nuclear programme was expanded in 1957; the expansion was justified by the immediate anxiety about fuel supplies in Britain at that time, by the fact that forecasts then made of fuel available for electricity generation suggested that the ceiling would be reached by 1965, and by the fact that (because the nuclear power industry was new) important reductions in cost could be expected. Since then both the short- and the long-term positions in regard to coal supplies have changed; there is a present surplus of steam coal, not only in Britain but also in many overseas countries; the long-term forecast of supplies of coal for steam-raising suggests that (without a nuclear programme) supplies could meet demand until about 1970. In these changed circumstances the nuclear programme was revised in June 1960, but the reduced programme can only be justified if it gives promise that it will give cheaper power than can be obtained from conventional fuels at a reasonable date in the future. If it gives that promise, as indeed it does, a programme involving the construction of many successive power stations, each of which will be less economical than conventional stations built concurrently, is justified, because research, development and large-scale construction and industrial use must move forward hand in hand; research in such a field is not effective if it moves too far in advance of application.

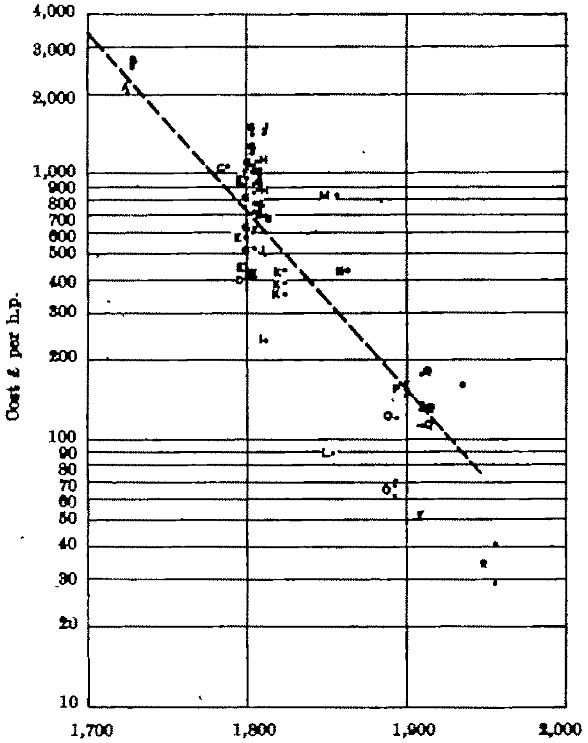
The cost of power from every form of prime mover has fallen as, with the passage of time, it has been possible to achieve higher top temperatures in the heat-cycle used by that prime mover. When the first industrial reactors were built at Windscale, the heat of fission was wasted because it was not possible to recover it at a high enough temperature. In the Calder Hall reactors the heat was recovered at a temperature just high enough for use; but even in the industrial reactors which are being built to-day, the top temperature of about 380° C. which is being achieved in the steam-cycle is at a level which was common in conventional steam-power plant practice twenty-five years ago. Nuclear power can thus be made cheaper by achieving higher temperatures in the heat-cycle; types of reactor which do not give promise of these high temperatures are only of passing interest or of interest only in specialized fields of application.

But advances in technology bringing down the cost of power generation are still taking place in the conventional field, so that the point at which the cost of nuclear power breaks even with, and then falls below, the cost of conventional power is determined by the convergence of two falling curves of cost. Before we look at the prospects in the nuclear field, it is worth while to examine the trend in conventional power plants.

The downward trend in capital cost of steam-power plants extends back to the earliest days of the steam engine (Fig. 1). The scatter of points on which the curve is based is naturally wide because plants have (at each date) been built of different sizes and for different conditions, but the trend is clear. In this period the top temperature in the steam-cycle has risen from 100° C. to 570° C. or, in some present-day pioneering plants, even higher. It would be wrong to suggest that the continuing fall in capital cost is due only to continued ability to achieve higher top temperatures in the heat-cycle, but the advance to higher temperatures is the backbone of the development. The use of higher top temperatures was naturally accompanied by the use of higher steam pressures; these made the use of boilers and turbines of higher capacity both possible and desirable. The use of these sets of larger capacity (as in all prime movers) brought down the capital cost per unit of output to an extent which outweighed the higher cost of the special materials of construction used to withstand the higher temperatures. The use of higher

---

* Royal Society Tercentenary Lecture, delivered on July 20.



1954 equivalent capital cost of steam power stations, £ per h.p.

Fig. 1

temperatures and the practicability (provided by the use of higher pressures) of using re-heat, increased thermal efficiencies and combined with the reduced capital cost to reduce the cost of generation.

To project this trend into the future we have to take into consideration other factors in design (such as transport of components to site) and in operation, such as the size and stiffness of interconnexion of the British electricity grid system.

Before we can use the forecast of capital cost and efficiency prepared in this way to predict the future cost of conventional power, we must also forecast the cost of coal. It is interesting to find that this forecast of future coal costs, depending as it does on competition from oil and nuclear fuels, on social habits, economic conditions and on Government policy, is far more uncertain than the forecasts of capital cost and thermal efficiency either in the conventional or the nuclear fields, great as are the uncertainties in both of them.

When these predicted coal costs are applied to stations having the capital costs which are forecast, we find that the cost of conventional power in future years will be as shown in Fig. 2. It is with these costs that nuclear power must compete.

Atomic energy does no more than provide a third fuel (alternative to coal and oil) which can be used in steam-power plants generating electricity. If, with this fuel, we could achieve the same top temperatures in the heat-cycle that are achieved with conventional fuels, nuclear power could to-day be cheaper than conventional power. That we cannot do so is obviously not due to difficulties in the boilers or turbines; it is due entirely to problems within the reactor. In descending order of difficulty these problems are concerned with the fuel elements, the moderator, the control of reactivity and the materials of engineering construction.

The top temperature achieved in the heat-cycle in nuclear power plants of the type favoured in the United Kingdom is determined by the bulk outlet temperature of the coolant gas from the reactor, and this is determined by the temperature tolerable in the hottest fuel element. The upward trend of the achievable temperature is shown in Fig. 3. In the Windscale reactors—built to a tight time-schedule for the production of plutonium for defence purposes—it was the temperature limitation in the fuel elements that made power production impracticable. For ease of manufacture and for nuclear economy, the fuel elements were 17 in. diameter rods of cast uranium enclosed in aluminium cans; the use of magnesium as a canning material was rejected partly because an early and inaccurate determination made its neutron absorption cross-section appear unattractive, but ultimately because of risk of fire in the reactor. When arrangements for manufacture were well advanced, the danger arising from formation of UAl_3 by interaction between can and metal was realized and dealt with by oxidizing the surface of the uranium bar and coating it and the inside of the can with colloidal graphite. This solution was satisfactory only for the modest conditions of the Windscale reactor, where the maximum surface temperature of the can was 300° C. and where (because of considerations connected with weapon design) the maximum irradiation of the fuel elements was less than 500 MW. days/tonne. Even at these low irradiations, the intercrystalline movement (due to heat-cycling a material in which the coefficients of expansion are greatly different in different crystallographic direc-

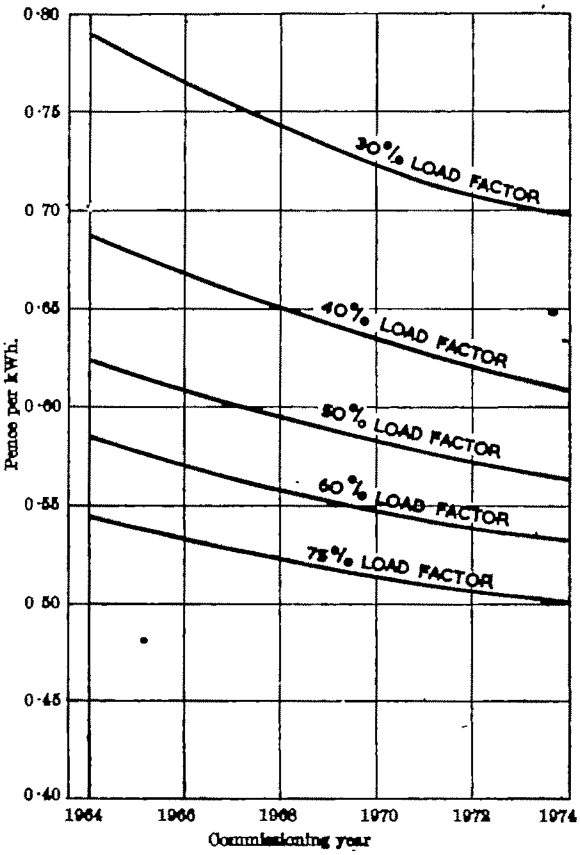


Fig. 2. Forecast of cost of electrical power from coal-fired stations at various load factors

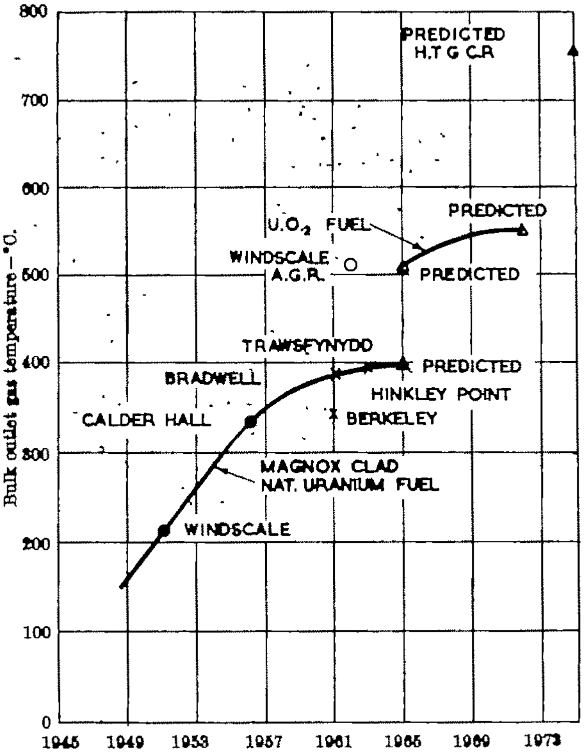


Fig. 3. The trend of outlet gas temperatures in British industrial reactors

tions and due to dimensional changes within single crystals caused by neutron irradiation) caused surface wrinkling which was liable to break down the barrier of colloidal graphite and permit metallic contact, formation of UAl_3 and can failure. Wrinkling was controlled by heat treatment to produce a fine random grain size; but the danger of the UAl_3 reaction, which increases with temperature, prevented advances while aluminium was used as a canning material.

It was the development of magnesium alloys containing small quantities of beryllium, calcium and aluminium to reduce the possibility of rapid oxidation and fire in the reactor which made the use of magnesium as a canning material practicable, and enabled us to reach outlet-gas temperatures which made power generation possible. But this magnesium alloy (magnox) has its disadvantages and limitations: at the operating temperatures in the cooler part of the reactor, it has a low elongation to fracture with low rates of deformation (a defect that can be minimized by careful design) and worse, it melts at about 640° C. Present reactor practice gives maximum surface temperatures of cans of 450° C. with possibilities of higher temperatures, so that little advance can be expected until change is made to another canning material.

Two alternatives are available to make the use of higher temperatures possible; stainless steel—cheap in itself but expensive overall because its high neutron cross-section makes enrichment of the fuel necessary—and beryllium, which gives economy of neutrons but it is an expensive metal.

The research by the Atomic Energy Authority on beryllium has been most ably done. When its development programme was started, little was known about the fabrication of beryllium; forming and joining techniques had to be found to give components of adequate strength and ductility. Techniques of consolidation and fabrication have been developed to the point where thin-walled tubes, rod, and forgings can be consistently produced to the close dimensional tolerances which are necessary. The mechanical properties of the fabricated metal are not the same in different directions (for example, the ductility of extruded metal is greatest in the direction of extrusion and is much smaller at right angles to this direction), and this has necessitated work to determine the metallurgical structure of the fabricated metal, with the view of optimizing the mechanical properties.

The high reactivity of the metal at elevated temperatures complicates the problem of joining, and it is necessary to use arc welding in argon or helium of high purity in order to achieve the desired results; as little as 0·05 per cent of oxygen in the welding atmosphere is sufficient to make the weld unsound. At high temperatures, beryllium is attacked by most metals and by carbon dioxide, and it is possible that this reaction may limit its operating temperature in reactors cooled with carbon dioxide to not much above 600° C. Energetic neutrons react with the nuclei of beryllium to form helium atoms within the crystal lattice, and these affect the mechanical properties of the metal and may limit its useful life in a reactor; an irradiation programme has been arranged to examine the problem and the first results are reasonably encouraging.

Further expansion in beryllium production will reduce the price, but it will always be expensive. Because of its high toxicity, great care is necessary in handling it; but experience shows that neither the scale nor the type of operation need be limited provided that the fabrication plant is properly designed. The problem of the poor ductility remains; but recent work suggests that the ductility is closely associated with impurities, and that this fault may be resolved by control of composition and by heat treatment.

Though the use of stainless steel or beryllium as a canning material opens the way to the use of higher temperatures, it means that in either case the cost per tonne of fuel elements will be far higher than with magnox. This increase must be offset by using higher ratings and by achieving higher burn-ups, both of which requirements force us away from the use of metallic uranium as a fuel.

In present practice the uranium centre temperature in the hottest fuel element is 590° C. Higher ratings necessarily mean higher temperature gradients, and when these are imposed on the higher temperatures of the surface of the cans that we must achieve, they bring conditions into the range where the phase change of the uranium will certainly cause trouble.

In reactors using metallic uranium fuel elements, we are hoping to achieve an average burn-up of 3,000 MW. days/tonne of fuel. It is improbable that figures much in excess of this will be achieved because (apart from distortion caused by crystalline movement due to irradiation and heat cycling) there is a volume increase due to the formation of fission products some of which are gases which can coalesce and cause swelling.

We thus find that to achieve the higher temperatures required, we are forced to use beryllium or stainless steel as a canning material; either course increases the cost of fuel elements. This must be compensated for by achieving higher ratings and higher burn-ups, and this can only be done by using uranium in ceramic form as our fuel.

Let us now consider the problems of the moderator. Graphite was used in the early stages of the U.K. project because we had no alternative. It has continued in use because it still seems to give the greatest economy in capital and operating costs; but its chemistry and physics under reactor conditions are still incompletely understood and it still presents a problem.

Reactor graphite does not oxidize quickly in carbon dioxide at temperatures below about 600–650° C. in the absence of radiation. In a pile, however, the carbon dioxide undergoes radiolysis with the production of active species which readily oxidize the graphite. This reaction causes a loss of graphite, with a consequent reduction of mechanical strength and moderating power; furthermore, carbon removed by oxidation may be deposited in the cooling circuit. The rate of reaction increases with the energy absorbed by the gas and thus with the gamma-ray flux and the gas pressure, and might, unless checked, become an embarrassment in advanced systems.

Studies of the reaction mechanism and methods of limiting the reaction-rate are being developed. One possible solution is to add to the coolant a gaseous inhibitor which will react preferentially with the active species. Carbon monoxide has proved to be effective, though it is possible that the benefit which has been observed is not caused by an inhibiting effect on the active species but by deposition of carbon produced by the radiolysis of carbon monoxide. A second possibility of reducing the attack depends on experimental evidence that most of the loss of weight is due to reactions on the internal surface of the graphite. It is probable that formation of active species occurs within the graphite pores (which constitute about 25 per cent of the volume of reactor graphite) so that the rate of reaction should be reduced by the sealing of these pores.

The physics problems of graphite result from the displacement of carbon atoms by fast neutrons having energy greater than the bond-energy in the crystal.

The first main effect is that the displaced atoms represent an accumulation of energy in the crystal; raising the temperature of the graphite partly anneals this damage, with liberation of the stored energy as heat. At low irradiation temperatures the energy stored in graphite can be considerable, and the Windscale reactors were periodically annealed in order to release this energy under controlled conditions. As the temperature of irradiation of graphite is raised, so the net damage to the graphite decreases, since under thermal activation a larger proportion of the displaced atoms return immediately to the vacant sites. The problem can be dealt with in practical reactor design by using moderator temperatures which, while sufficiently high to reduce the stored energy to tolerable levels, are well below the temperatures at which the chemical reaction between graphite and carbon dioxide becomes serious.

The second main effect is a change in the dimensions of the graphite blocks under irradiation. Displacement of carbon atoms causes the inter-planar spacing of the layers in the graphite crystal to increase and the layers themselves to contract slightly. These changes are integrated over the block (in which there is a preferred orientation of crystals) to give an increase in its transverse dimensions and a small shrinkage in the longitudinal direction. As with stored energy, the magnitude of this effect increases with the dose of radiation and decreases with rise of temperature. At temperatures of more than about 300° C., there is a second dimensional effect which, as yet, is not well understood and which gives rise to a contraction in both directions, possibly due to a closer packing of the crystallites. It is clear that there is still much research to be done on graphite under advanced reactor conditions.

Next in our descending order of difficulty as we advance in reactor technology were the problems of reactor stability and control, which become more acute when higher ratings and burn-ups are used. The basic reason for using gas-cooled instead of liquid-cooled reactors in 1946 was that they could not become instantaneously supercritical, and the large safety distances required by the original Hanford reactors were unnecessary. Operating experience showed that, with the low burn-ups used at Windscale, the reactors had a negative temperature coefficient and were, in fact, self-regulating. At higher burn-ups, however, the build-up of plutonium in the reactor reverses that part of the temperature coefficient which is associated with the graphite. This complicates the analysis, but the overall effect is that control must be by movement of the control rods, and care must be taken to see that departure from normality cannot be too rapid to be corrected with absolute certainty. The problem of xenon poisoning becomes more acute at higher ratings; it may cause oscillatory disturbances (which would be aggravated by the effects of build-up of plutonium), and it can also make it difficult to re-start the reactor after a shut-down. It is fortunate that the temperature coefficient of the fuel element remains negative and that it is strong enough to give an effective stabilizing influence in rapid transients.

Last and least in our order of difficulty were the problems of engineering construction, and these are mainly connected with the pressure system. The large pressure shells which are at present used in reaction construction demand thicknesses of plate so great as to minimize the opportunity for rolling and cross-rolling in fabrication, and there must be a danger of persistence of casting defects and coarse grain in the steel. Welding these thick plates is not easy and the problem of brittle fracture (which is increased by neutron irradiation) demands close attention in design, fabrication and operation. These problems are reduced by the use of higher fuel-element ratings because the dimensions of the pressure vessel for given heat-output are reduced. The use of higher bulk-gas outlet temperatures would give rise to other difficulties if the pressure shell were exposed to these temperatures, but designs can be evolved to avoid this.

It is this history and this present state of knowledge and development that has led the Atomic Energy Authority to the design of the advanced graphite reactor that is being built at Windscale as a prototype for the next logical step forward in technology. It is designed to achieve a bulk outlet gas-temperature of 510° C.; the gas flow is so arranged that the pressure shell is not exposed to this temperature but only to gas at a temperature of 320° C. which has passed through the heat exchangers. The design of the fuel elements is such that either beryllium or stainless steel can be used for canning, with uranium oxide fuel. The arrangement of the graphite moderator is conventional; the graphite loss due to corrosion during the life of the reactor is calculated to be tolerable, but more work is needed to check this point and to develop satisfactory conditions.

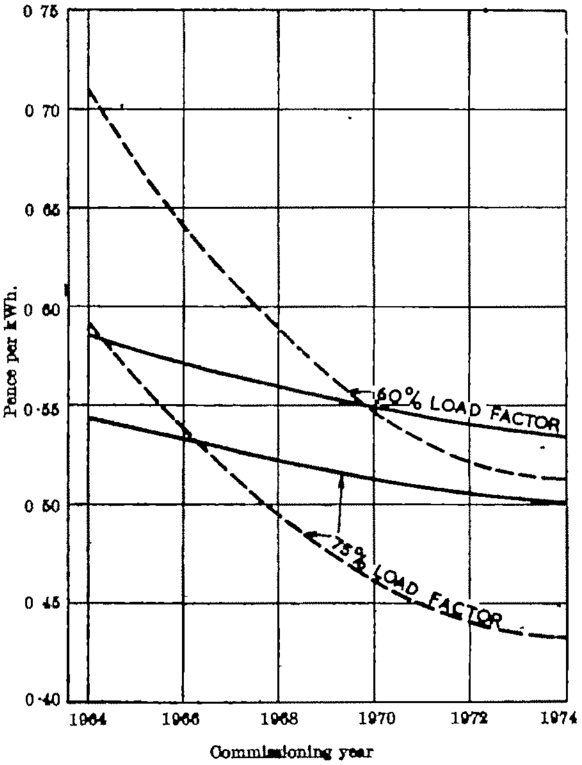


Fig. 4. Forecast of nuclear and conventional power costs in Great Britain. ---, Nuclear plant; ———, conventional coal-fired plant

It is estimated that the capital cost of the first industrial plant of the advanced graphite reactor type will be between £95 and £80 per kW. sent out, and that they will generate power at a cost of between 0·55*d*. and 0·50*d*. per unit or perhaps a little less at a load factor of 75 per cent; these cost brackets are naturally wide at a time when much development remains to be done.

The advanced graphite reactor represents the next logical step forward in British reactor practice; but, just as nuclear power finds strong competition from conventional power in establishing its new technology, so the new advanced graphite reactor must meet competition from the better established reactors of the Calder type in the early stages of its development. The advanced graphite reactor starts with the advantage of being able to achieve higher temperatures in its heat-cycle than are possible in magnox reactors, but in its race to supersede them it is competing with a technology which has advanced rapidly and is capable of further advance. Let us then look at the industrial progress of the magnox reactors with which the advanced graphite reactor competes.

The downward trend in cost of the nuclear power plants which are being built by the Central Electricity Generating Board in Britain can be closely estimated, and is shown in Table 1.

Table 1

Station	Capacity (MW sent out)	Cost (£/kW. sent out)
Berkeley	275 (2 reactors)	160
Bradwell	300 ,,	150
Hinkley Point	500 ,,	133
Trawsfynydd	500 ,,	128
Dungeness	550 ,,	110

This downward trend arises from the growing familiarity of the nuclear power industry with the problems of nuclear plant design and construction and from better overall optimization of design. It is difficult to separate these influences when considering individual designs, but from the general picture presented by the nuclear stations now being constructed three distinct lines of advance may be seen. These are, first, an increase of pressure in the gas circuit, secondly, improved utilization of the volume of the pressure vessel and, thirdly, increase in temperature of fuel elements and coolant.

A higher gas pressure leads to improved heat transfer from the fuel elements (allowing more power to be removed for a given fuel temperature limitation) and reduces the power required by the gas circulators. The higher the pressure, therefore, the greater the power that may be drawn from a given reactor. The coolant gas pressures for the Central Electricity Generating Board stations and for Calder are shown in Table 2, together with the pressure vessel dimensions and plate thickness.

Table 2

Station	Coolant pressure (lb./sq. in.)	Shape of vessel	Size of vessel	Thickness of plate
Calder	100	—	—	2 in.
Berkeley	125	cylinder	80 ft. high × 50 ft. diam.	3 in
Bradwell	132	sphere	67 ft. diam.	3 in. (some 4 in.)
Hinkley Point	185	sphere	67 ft. diam	3 in.
Trawsfynydd	239	sphere	61 ft. diam.	3½ in.
Dungeness	268	sphere	62 ft. diam.	4 in. (some 4½ in.)

This marked increase in pressure is due to the use of thicker plate for the pressure vessel and to the use of internal insulation in the hot-top domes. The effect of this latter advance in design is shown in a comparison between the system pressures of Bradwell and Hinkley Point, which have vessels of the same diameter and plate thickness. The greatly increased pressure at Hinkley Point is the direct result of internally insulating the top of the vessel, thus reducing its temperature and allowing a higher design stress. The increase in plate thickness follows naturally from the growing experience of welding and testing thick plate. This experience may be expected to lead to consideration of even thicker plate in the future.

Directly connected with this is the choice of shape of vessel—cylinder or sphere. As the reactor itself is of cylindrical shape, it fits most conveniently into a cylindrical pressure vessel and uses the volume of the vessel to the best advantage. Unfortunately, the allowable pressure in the cylinder is less than that for a sphere of the same diameter and plate thickness, and there is therefore a contest between utilization of volume and pressure in the system. The 'reactor cylinder' which has to be fitted into the pressure vessel includes the core itself, a cylindrical space above it which is needed to manœuvre the fuel-handling gear, and the heavy structure needed for the support of the core. Considerable design effort has been put into this structure to reduce its size and give a better shape, and hence a better utilization factor. How successful these efforts have been may be seen in Table 3.

This table clearly shows the better utilization possible with a cylindrical vessel and the considerable

Table 3

Station	Utilization factor (vol. of core/vol. of pressure vessel)	Shape of vessel
Berkeley	0·437	cylinder
Bradwell	0·313	sphere
Hinkley Point	0·406	sphere
Trawsfynydd	0·419	sphere
Dungeness	0·442	sphere

improvements that have been made in volume utilization in the spherical vessel.

The upward trend in temperature-levels is the result of better understanding of the heat-transfer process and better optimization of station design to make best use of this in terms of plant efficiencies. As the systematic and random variations in fuel-element temperatures become better understood, it becomes possible to design for operation nearer the limit set by the properties of the fuel-element materials. In short, the 'margin of ignorance' is being reduced and used to advantage. This is reflected in higher gas temperatures and improved steam conditions, as shown in Table 4; it must be remembered, however, that there is little more to be gained in this direction.

Table 4

Station	Gas inlet temp. (deg. C.)	Gas outlet temp. (deg. C.)	High-pressure steam conds. (lb./sq. in./deg C.)	Low-pressure steam conds. (lb./sq. in./deg. C.)
Calder	140	336	195/313	48/177
Berkeley	160	345	306/322	62/322
Bradwell	180	390	755/373	195/373
Hinkley Point	180	374	650/363	180/354
Trawsfynydd	202	399	962/382	304/368
Dungeness	250	410	1,403/393	575/395

All these developments help the nuclear station designer to move in the direction of obtaining more power from a given size of reactor and therefore to achieve a lower capital cost per kW. We may assess the results of his efforts in terms of reactor heat generated per unit volume of core. These 'heat densities' are set out in Table 5; they show clearly that the rate of development has been high.

Table 5

Station	Heat density kW./cu. ft. of core	kW./cu. ft. of pressure vessel
Berkeley	10·21	4·46
Bradwell	10·77	3·37
Hinkley Point	15·09	6·13
Trawsfynydd	17·46	7·31
Dungeness	15·37	6·73

There can be little doubt that it would be possible to obtain 500 MW. of electrical power from a reactor of the Calder Hall type, using a pressure shell of about 70 ft. diameter with plate thickness about 4 in. At a time when the only operating experience is from the Calder Hall reactors with a capacity of 35 MW. electrical power, one shrinks from carrying the extrapolation in size so far, yet reactors with this capacity must be built in order to get the best results from the advanced graphite reactor and for comparative purposes a 500-MW. Calder type reactor should be considered. Using Calder Hall reactors of this size and assuming economies which can obviously be made in layout and general engineering of the stations, the capital cost should come down to about £100 kW., which should give a generating cost of around 0·52*d*. a unit.

The initial generating cost estimated for the advanced graphite reactor shows little, if any, immediate advantage over the Calder reactor developed in this way, yet all logic and history tells one that it is necessary to move forward to the type which gives a prospect of using higher temperatures. It is probable that, in these circumstances, there will be a period in which the two types overlap, and orders for advanced graphite reactor stations will be interspersed between orders for Calder type stations until ultimately the more technically advanced graphite reactor shows a clear advantage in operating cost over the older type. This would conform with practice in the conventional field, where advance to higher steam conditions has never implied that all new power plants used the most advanced conditions.

Based on these forecasts of development in design and downward trend of capital charges, estimates of fuel-element prices and operating charges, the cost of nuclear power has been forecast and is shown in Fig. 4. This figure also shows the forecast cost of conventional power and indicates that costs should break even between 1966 and 1970, depending on the load factor at which it is possible to operate.

It is disquieting, however, to compare the research and development effort which is devoted to bringing down costs in the two fields. In the conventional field, the available figures suggest that research and development costs are of the order of 5 per cent of the capital value of power plants built. Information is not available to determine the corresponding figure in the nuclear field but, if it is assumed that the cost of the nuclear sections (that is, the cost of the reactors and heat exchangers but excluding turbo-alternators and other conventional items) of the nuclear power plants built for the Central Electricity Generating Board in the years during 1965–75 is rather less than £50 million per annum, it seems improbable that research and development costs, if effort is maintained at its present level, are likely to be less than 30 per cent.

That research and development costs can be so high is easily understood when one considers the advanced gas-cooled reactor. It is probable that by the time the advanced graphite reactor goes into use, research and development expenditure on the development of the Windscale prototype will have been of the order of £30 million, and this is only one part of the effort required. It is unquestionably the logical step forward in British reactor technology, yet it is possible that the number of power stations built by the Generating Board to use this type of reactor will be less than ten.

By the mid-1970's, advance to higher temperatures and higher ratings is likely to make the introduction of another thermal reactor necessary. (This article does not consider fast-reactor development because it is felt that it is at present ancillary to the development of thermal reactors.) In the absence of developments which cannot at present be foreseen, it appears that we are reaching the limit of temperature and neutron intensity at which graphite can be used as an irreplaceable moderator, and that we shall be forced to types of reactor which make replacement or reconditioning of the moderator possible.

The high-temperature gas-cooled reactor which is at present in the project stage at Winfrith Heath (as a joint venture with other European countries) is an effort to meet the problem by using the graphite as the canning material for the fuel; it is thus replaced as the fuel elements are changed. Using enriched uranium in ceramic form in a semi-homogeneous system (which is capable of breeding), this reactor should, if it is successful, make it possible to achieve temperatures exceeding 1,000° C. in the heat cycle.

If such a system, using a replaceable graphite moderator, cannot be evolved, the alternative would be to use heavy water as a moderator, so that radiation damage can be repaired or removed during circulation. At that stage it would probably be convenient to use steam instead of carbon dioxide as a coolant. American reactor development has generally been on the lines of water-moderation and cooling. As they make their way towards higher temperatures in the heat-cycle, they will probably be forced to use steam cooling instead of water cooling. If this happens and if British development takes the line suggested, the two streams of development, starting so far apart, will have flowed logically together.

Meanwhile, we are faced with the fact that if the present rate of technological progress in the nuclear field is to continue, there appears to be little prospect that research and development costs will fall; they are likely to remain at about 30 per cent of capital expenditure.

For how long can the electricity industry justify this? The rate of advance in the nuclear field was determined initially by effort which was part of, and was justified by, the defence programme. Remembering that the demand for electricity has a doubling period of ten years, that the total fuel requirements of the Generating Board (expressed as coal equivalent) are now 54 million tons a year and will rise to 90 million tons a year by 1970, and remembering that it is improbable that sufficient British-mined coal would be available to meet the Board's total fuel requirement by some date in the 1970's, it appears reasonable to aim at continuing the high rate of advance of nuclear technology to the point where nuclear power breaks even in cost with conventional power; we shall then have freedom to manœuvre in a three-fuel economy. After that date, which is not remote, it is surely reasonable to think that research on reactor technology should be justified by savings which can be expected to arise from its industrial application. It is interesting to speculate how much the downward trend in the cost of conventional power could be increased if it could attract as great a research and development effort as its nuclear rival. There is no suggestion that it should attract such expenditure, but it is suggested that re-deployment of research and development resources must be carefully considered and that this consideration will probably demand a changed distribution in a few years time.

It is possible that there is, to-day, a danger that the deployment of research effort can be distorted by development work directed to defence and paid for by defence funds. Although work in the defence field may be directed to a few major projects, the ancillary work is widespread; for example, the development of nuclear weapons has demanded and fostered intensive and expensive research in ion exchange, solvent extraction, fluorine chemistry, vacuum technology, the metallurgy of a wide range of metals, the development of high-speed digital computers and other things. All these developments find industrial applications, so that the 'hot-house' growth of technology in the defence field affects the rate of development in many industrial fields where application is possible. When this happens only in the limited time of a war, the effect is beneficial; when peace returns, the injection of defence technology into industrial practice is a useful stimulus. But since 1946 conditions have been such that a war-time rate of development has continued in defence and its many ancillary fields, and one wonders whether the injection of these developments into the industrial field has not over-stimulated some industries in a way that makes it hard to live with them, while diverting effort from others. To avoid this would be difficult; but, as the emphasis of defence development moves from one field to another (and, one hopes, is ultimately relaxed overall), it is possible and desirable to examine the rate of advance which has been induced, and to ensure that it is adjusted to what is economically justifiable and that it does not continue by pure habit at a rate which is artificially high.

FOOD AND ANIMAL PRODUCTION

A SESSION on "Food and Animal Production Overseas", arranged by Section M (Agriculture) of the British Association, was held in Cardiff on September 2.

Mr. J. H. Anderson, of the National Agricultural Advisory Service, presented a rather gloomy picture of the present position of "Food Production Problems of the Middle East"—low rainfall, uncertain time of onset of the spring rains and, when it did come in quantity, the flooding of large areas and soil erosion.

For example, it had been calculated that in Iraq some 170 million tons of soil was carried down in the Tigris every year. Soil destruction by arable cultivations only and by over-grazing are leading to a worsening of the position. The average size of the holdings is small; for example, 90 per cent of the farms in Egypt cover less than 3 acres. In many cases these provide only enough food for the occupiers and none to supply the rapidly growing urban population. Throughout the area higher education tends to be directed to law rather than to technical training for the agricultural advisory or even medical services, there being only about two medical practitioners for every 3,000 inhabitants. He proceeded, however, under various headings, to describe what is being attempted and what is further needed to improve these conditions. Except for Egypt, better land and water-use is required: afforestation is wanted on the mountains. In Syria some 30,000 trees, in addition to windbreaks, are being planted to hold the water. In the discussion afterwards, it was mentioned that very deep ploughing with tractors, rather than the present shallow cultivation with wooden ploughs, would allow the water to sink in rather than run off or evaporate. Mr. Anderson also pointed out that it is increase in yield per acre which is required rather than increase in cultivated area. For this purpose nitrogenous fertilizers are one of the chief requirements, but the cost of importation is too great; Iraq is, however, setting up a nitrogen plant. Except for Turkey, Israel and Egypt, new improved varieties of crops with better yielding capacity are also required. Throughout the whole area, locust destruction is needed. Much more irrigation is required; great advances are being made in Israel, where it is hoped by 1975 to double the present area and triple the crop output. One problem with irrigation is increase in the salinity of the soil, some 70 per cent of the irrigated area in Iraq being more or less affected by this: research is needed in desalinating.

Livestock improvement is also wanted; except for Israel and Egypt, from cattle and buffaloes respectively, milk is in poor supply. To produce this, more feed from arable cultivation is necessary. In the other countries, the browsing goat is a useful source of milk supply. The need for tractors is great, but development in this respect is slow owing to the cheapness of labour. However, as pointed out in the discussion, tractors are necessary for deep ploughing on hard soil before the rains come. As in most places, a better system of agricultural credit should be made available to effect these improvements. Methods of helping the small farmer to accumulate capital were mentioned in the discussion on the paper by Mr. B. N. Chatterjee. Much could be done to improve food production in this area if the advisory services for farmers could be raised to a higher level and their personnel better trained.

Dr. J. Griffiths Davies, of the Australian Institute of Agricultural Science, gave an account of "Pasture Development of Tropical Australia". In the northern area the rainfall is a summer one, which ranges from 10 to 180 in. as one passes from the southern to northern tropics and from central to coastal areas. In general, the soil is poor and suffers from deficiency of nitrogen, calcium, phosphate and potash, as well as many of the trace elements too. Throughout most of the area cattle rather than sheep are the main product. Slides were shown of typical primitive vegetation areas and the methods used for their improvement. In areas of long dead grass, burning allows the young green shoots at the base to become available to cattle. In the acacia country, the bush is pulled over by chains between powerful tractors, piled, burnt and grass seed, such as that of Buffel and Rhodes grass, sown. One of the features of grass growth in tropical areas is the very rapid and luxuriant growth which occurs in the wet season; this, with the onset of the dry season, develops fibre and is low in protein and energy value for feeding purposes. During the discussion which followed, it was suggested that under such conditions the grass should be cut frequently during the wet season and made into silage for feeding during the dry season.

One of the main limiting factors for growth of grass throughout the tropical parts of Australia is the supply of nitrogen in the soil, and it is one of the most costly to apply, being about £39 per ton. Whereas in the south of Australia the application of phosphates and seeding with subterranean, strawberry or white clover supplies nitrogen for the grass, there are at present no suitable legumes for this in the northern areas; search for these is now in progress. Throughout the tropics, legumes, such as cow peas, etc., have been found for arable culture, but none suitable for incorporating into grassland has yet been used. Slides of some species which might prove suitable were shown; one came from Brazil and another from Guatemala. Various requirements are necessary in addition to their capacity for fixing nitrogen—a perennial character, palatability and non-toxicity for cattle. In addition to finding suitable species, there is also the problem of finding the right strain of organism to inoculate the seed. Slides were shown to illustrate the very large differences which exist in the growth of the legume due to this factor.

The importance of the problem is seen in the fact that there are some 90 million acres of poor soil in tropical Australia on which such legumes could be incorporated into the grassland.

Mr. B. N. Chatterjee, of the Department of Agriculture, Bihar, in his paper on "Animal Production and Fodder Resources in India", described the five main agricultural zones, conditioned mainly by rainfall and altitude, and compared the vast differences which exist between the level of nutrition of the people there and in the United Kingdom. Typical examples of some of the breeds of zebu cattle were shown. The two dairy breeds, the Sindhi and Sahiwal, are small, both in size and numbers, but they give reasonable quantities of milk. Some dual-purpose work-milk types exist, but for the most part the breeds in India are specialized for draught purposes. Buffaloes supply much more milk than cattle and their milk contains some 7·5 per cent of fat. Goats, too, are used widely as sources of milk and meat supplies.

Three main systems of animal husbandry exist. The State breeding farms form the main and practically the only source of livestock improvement. As was pointed out in the discussion, these are not large enough or numerous enough for the work that needs to be done in improving the milk yields of their cattle. The village farms, which are very small, provide little more than draft bullocks and barely enough milk for their own needs. Thirdly, there are the nomadic herdsmen, mainly with sheep and goats which are folded on crop residues and graze marginal land. For the most part, feed for animals is supplied from crop residues, many of which contain large quantities of fibre. The village grazing areas are overstocked and provide more exercise than nutrition. The growing of fodder crops and the making of silage for the dry season are badly needed, while the killing of the older cattle in necessary to allow of a higher nutritive level for those which have a productive value.

In the discussion which followed, it was pointed out that not only would the production of more milk in the villages and its collection by organizations in nearby towns such as that existing in Poona, be of advantage to the nutrition of the urban population, but also the weekly income derived from it would keep the villager out of debt, so that when his crop came to be harvested it would be his and not the moneylenders. Moreover, if more milk were consumed, it would have a sparing action on the need for cereals, and so some land could be released to grow fodder crops, after which the yields of cereals would be higher. In pig-feeding experiments in England, it has been shown that it requires some 5 lb. of cereals to produce 1 lb. live weight, whereas when a little animal protein such as milk is added, this is reduced to about 4 lb. The question of whether the essential amino-acids in animal protein could be added to extracted leaf protein is at present out of the question, owing to the high cost of the synthesized products.

During the course of the discussion, Prof. J. Grossman from Brazil gave a short illustrated account of the agricultural zones there. The projects for irrigation in the highly populated areas were mentioned. The grassland areas in the south with a 60-in. rainfall could, with phosphates and clovers, produce suitable feed for cattle. While in the far south European breeds of cattle can be kept, farther north it is necessary to use zebu cattle. Recently, however, improved beef types which are tolerant of heat, such as the new Santa Gertrudis breed from Texas, have been introduced.

JOHN HAMMOND

GROWTH BY CELL DIVISION IN INSECT TISSUE CULTURE

By DR. B. M. JONES and I. CUNNINGHAM
Department of Zoology, University of Edinburgh

THE cultivation of insect tissues and cells, first attempted about fifty years ago[1], has been an unexpectedly difficult problem[2-4]. A method for the routine production of insect cultures in a medium that can be easily prepared, and the provision of adequate evidence of growth by cell division taking place in them as in vertebrate cultures, has not hitherto been available[4]. The delay in devising such a method arises largely from pioneer work having to rely on knowledge of the requirements that favour the growth of vertebrate tissue in culture[5]. Recently, however, encouraging results have been obtained in maintaining insect tissue in a physiological solution based on the composition of insect hæmolymph[6,7], which differs profoundly from that of the blood of vertebrates[8-11].

The purpose of this article is to describe briefly the results of an investigation undertaken to try to devise a method of producing insect tissue cultures in a routine fashion, and to evaluate in particular the extent and nature of growth by cell division in the cultures obtained. The work is based on the use of diapause pupæ of the silkmoth, *Philosamia advena*, as a source of ovarian tissue for explants, and of hæmolymph for inclusion in the culture medium. It so happens that development in these pupæ is arrested for about six months extending from the autumn to the early summer, a period that can be lengthened if need be by storing the pupæ continuously at 25° C. (ref. 12). The pupæ, in providing tissue in a more or less uniform state over such a long period, thus favour the design of a method of producing insect tissue cultures as required. So does the use of a medium that can be prepared easily. The one employed in the present work consisted essentially of salts, sugars and organic acids, based on previous work[6], lactalbumin hydrolysate ('Difco'), *TC* yeastolate ('Difco'), and pupal hæmolymph. The latter was preheated before it was added to the medium[6]. The usual precautions were taken in preparing hanging-drop cultures to ensure freedom from contamination. Streptomycin and penicillin were also added to the medium at 100 I.U. and 50 I.U. per ml., respectively (Table 1).

Table 1. COMPOSITION OF THE MEDIUM FOR THE CULTIVATION OF OVARIAN TISSUE OF THE DIAPAUSE PUPA OF THE SILKMOTH *Philosamia advena*

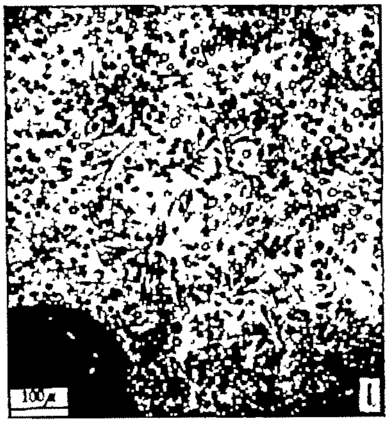
		Mgm./ 100 ml.			Mgm./ 100 ml.
A.	NaH_2PO_4	110	*D.*	Malic acid	60
	$MgCl_2.6H_2O$	300		Ketoglutaric acid	35
	$MgSO_4.7H_2O$	370		Succinic acid	6
	KCl	300		Fumaric acid	5.5
B.	$CaCl_2$	80	*E.*	*TC* yeastolate ('Difco')	100
C.	Glucose	70			
	Fructose	40	*F.*	Lactalbumin ('Difco')	1,000
	Sucrose	40			

The salts were dissolved in 30 ml. water; calcium chloride in 7 ml. water; sugars in 10 ml. water; organic acids in 5 ml. water and neutralized with potassium hydroxide. Lactalbumin was dissolved by autoclaving at 10 lb. pressure for 10 min. in 35 ml. water; *TC* yeastolate in 5 ml. water. The solutions were mixed, adding the calcium chloride last. *p*H was adjusted to 6.35 with 10 per cent potassium hydroxide, and then pre-treated hæmolymph was added, and finally antibiotics. See text for further information.

In the preparations incubated at 25° C., cells began to migrate from the explants on about the third day, and from the fourth to ninth days the cellular outgrowths spread extensively over the surface of the coverglass (Fig. 1). The medium was changed every fifth day. The cultures remained healthy for up to four weeks, and in appearance they resembled primary chick fibroblast cultures.

To permit an estimation of growth by cell division in the outgrowths, and to ascertain the nature of the cells involved, a technique was devised for making permanent stained preparations of cultures *in situ*. Adhesion of the explants and the outgrowths to the coverglass, an important requirement for carrying it out successfully, was greatly favoured by the presence of 10 per cent hæmolymph in the medium, and by inverting the culture chambers during incubation.

Examination of such preparations revealed that several kinds of cells originating from the different



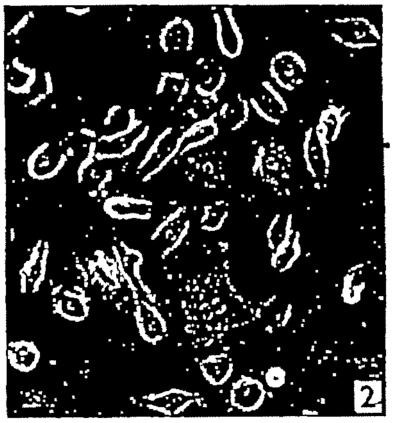
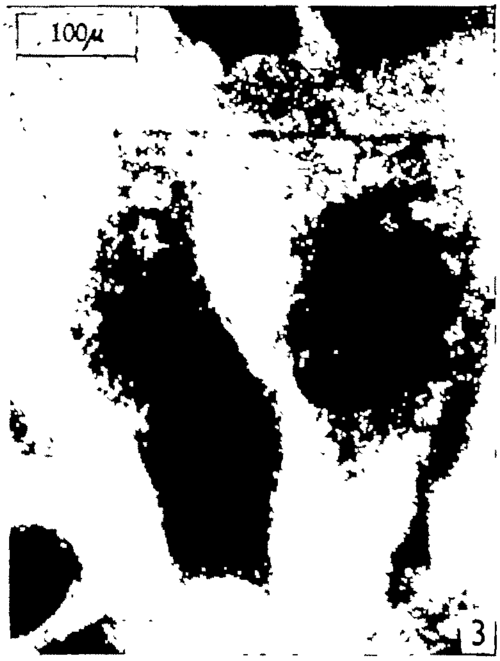
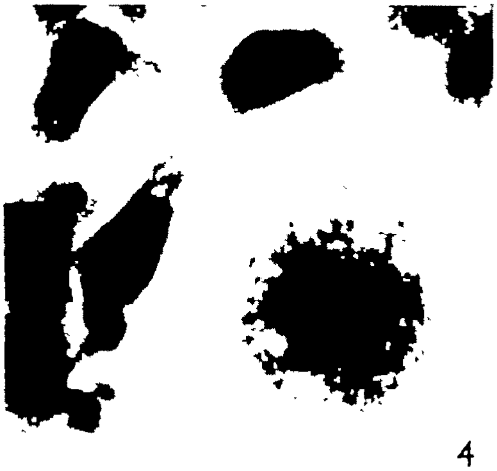


Fig. 1. Inner region of cellular outgrowth, eighth day *in vitro*

Fig. 2. Relatively large vacuolated cells derived from the ovariole sheath and other cells mostly from the intermediate layer of the ovariole present in cellular outgrowth, ninth day *in vitro*, phase contrast

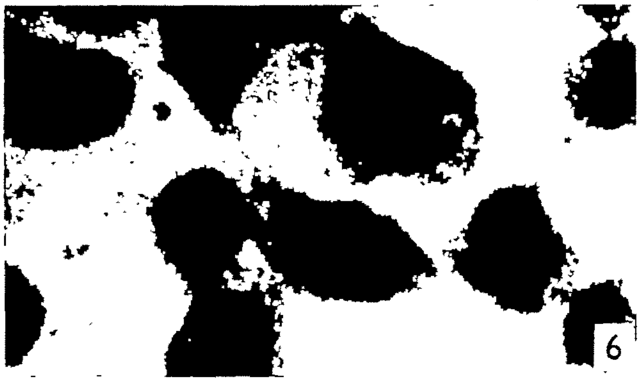


3

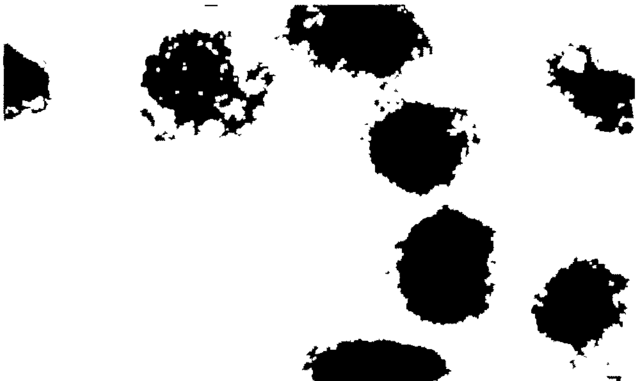


4

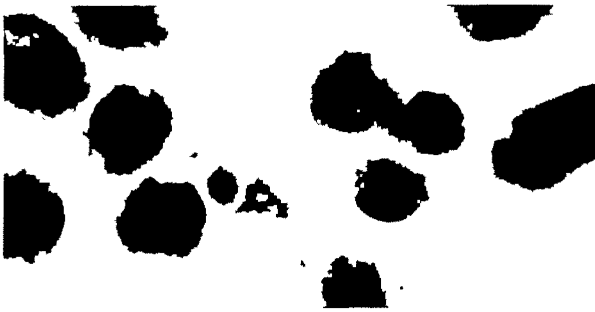
5



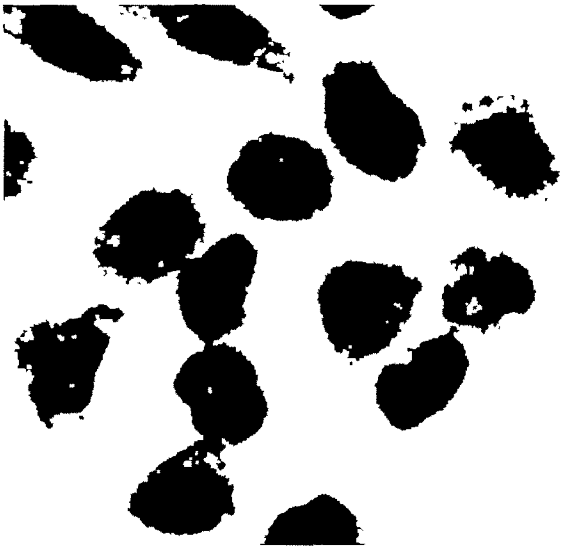
6



7



8



9

Fig. 3. Prophase in ovariole sheath cell in cellular outgrowth stained with Erhlich's hæmatoxylin *in situ*, 9 days. Fig. 4. Metaphase in same kind of cell in outgrowth, 9 days. Fig. 5. Late anaphase, 9 days. Fig. 6. Metaphase, 12 days. Fig. 7. Early anaphase, 12 days. Fig. 8. Telophases displayed by cells derived from the intermediate layer of the ovariole, 9 days. Fig. 9. Cells of intermediate layer in outgrowth almost completely divided, 9 days. (The number of days refers to age of culture)

regions of the ovary, long ago described in detail[13], were present in the outgrowths, those of the ovariole sheath and of the intermediate layer of the ovariole tubule being predominant (Fig. 2). It was less easy to be certain of the presence of cells of the inner follicle layer; but it is likely that these cells only escape into the medium when their bounding membrane is impaired in the explant. Occasionally, the extremely large nurse cells wandered out into the cellular field. Brush-like extensions composed of cells derived from the connective tissue cap, which encloses the distal portions of the ovariole tubules, and epithelial sheets formed by cells of the ovariole sheath, often appeared in the cultures prior to the migration of discrete cells. It has been suggested that hæmocytes might be present in the outgrowths[14], and it would be interesting to learn to what extent they are involved.

Mitosis in the outgrowths was mainly confined to the cells of the ovariole sheath, and those of the intermediate layer. These cells, scattered in the cellular field, displayed mitosis at all stages (Figs. 3–9). In cultures 5–6 days old the mean mitotic index was 1·0 per cent, in those of 8–9 days 0·5 per cent, 12 days 0·3 per cent, and 21 days less than 0·3 per cent. From an estimated mitotic index of 0·5 per cent over a period of 12 days, and also from the fact that cells in culture took 30 min. to divide, one may infer that the cells that were capable of mitosis produced several generations during this period. Mitosis in cultures three weeks old also supported the conclusion that growth by cell division was progressive and therefore resembled that which takes place in primary cultures of vertebrate tissue.

It is hoped to publish the details of this work, which was made possible by a grant from the Agricultural Research Council, elsewhere in due course. We thank Prof. Michael Swann for helpful discussions, Dr. Honor Fell for the interest she has shown in this work, Dr. John Campbell for taking photographs of mitotic figures in our preparations, and also Mr. Dennis Cremer for his help in the photography.

[1] Goldschmidt, R., *Proc. U.S. Nat. Acad. Sci.*, 1, 220 (1915).

[2] Hartzell, A., Proc. Int. Congr. Entomol., Tenth Congr., Montreal, 2, 319 (1958).

[3] Day, M. F., and Grace, T. D. C., "Ann. Rev. Entomol.", 4, 17 (1959).

[4] Martignoni, M. E., *Experientia*, 16, 125 (1960).

[5] Trager, W., *J. Exp. Med.*, 61, 501 (1935).

[6] Wyatt, S. S., *J. Gen. Physiol.*, 39, 841 (1956).

[7] Grace, T. D. C., *Austral. J. Biol. Sci.*, 11, 407 (1958).

[8] Buck, J. B., "Insect Physiology", 147, edit. Roeder, K. D. (New York, John Wiley and Sons, 1953).

[9] Sarlet, H., Duchateau, G., and Florkin, M., *Arch. Int. Physiol.*, 60, 105 (1952).

[10] Wyatt, G. R., Loughheed, T. C., and Wyatt, S. S., *J. Gen. Physiol.*, 39, 853 (1956).

[11] Wyatt, G. R., and Kalf, G. F., *J. Gen. Physiol.*, 40, 833 (1957).

[12] Van der Kloot, W. G., *Biol. Bull.*, 109, 276 (1955).

[13] Schneider, K., *Arch. Zellforsch.*, 14, 79 (1915).

[14] Wigglesworth, V. B., "Ann. Rev. Entomol.", 4, 1 (1959).

OBITUARIES

Prof. H. Moore

EMERITUS PROF. HARRY MOORE died on August 5 at the age of seventy-two. He was educated at Belle Vue School, Bradford, and the Royal College of Science, London, where he was afterwards demonstrator, and then lecturer, in physics at King's College, London, during 1908–15. During this period he published papers on the ionization produced by X-rays in various materials.

He was a very capable craftsman and he turned this talent to very good war-time use when during 1915–18 he was co-manager of the Munitions Training Department at King's College, London. There followed a short period as technical officer to the Training Department of the Ministry of Labour, but in 1919 he joined Sir Herbert Jackson in the newly formed British Scientific Instrument Research Association. It was here that his interest in glass was first aroused, and he was responsible with Jackson for a programme of research, particularly on optical glasses, which had originally been sponsored by a war-time Committee for Glass Research of the Institute of Chemistry. In 1933 he followed Sir Herbert Jackson as director of research of the British Scientific Instrument Research Association, a post which he held for four years, and in 1937 became director of the Research Laboratories then being set up by Pilkington Brothers, Ltd., in St. Helens. This post he held from 1937 until 1945, and during this time he became very active in circles concerned with glass technology, serving as president of the Society of Glass Technology during 1944–46.

Moore was appointed to the chair of glass technology in the University of Sheffield when W. E. S. Turner retired. The Department was set up in 1915 with the function of teaching in the subject of glass technology and with carrying out investigations and research on problems connected with industry. It was governed by a body known as the Glass Delegacy, the members of which were about equally divided between the University and industry. This unique arrangement had functioned extremely well during the period in which Turner held the chair, and while the number of University students was small. After the Second World War, the growth of the Department's teaching work and the demands on its time by industrial inquiries soon convinced Moore that some change in its structure would eventually be needed, and when he retired in 1955 the Delegacy, under the chairmanship of Dr. L. H. A. Pilkington, had just completed arrangements for the setting up of the new British Glass Industry Research Association. These arrangements left the University Department free to carry out teaching and research exactly as a normal university department.

In addition to the duties of his chair, Prof. Moore had been dean of the Faculty of Engineering for the three years, 1948–51. While head of the Department of Glass Technology, Moore's chief research work was concerned with the colours of glass and particularly those due to iron; a fascinating problem which, apart from its technological importance, for iron is an ever-present impurity in all raw materials used for glass making, has great scientific interest.

Shortly after Moore retired, the Society of Glass Technology found itself without an editor, and he allowed himself to be persuaded to step into the breach. Once having been persuaded, he threw himself into the task with characteristic energy and attention to detail for a period of eighteen months. Towards the end of this period, however, he seemed to realize that he was no longer a young man, and after a short period in hospital, he and Mrs. Moore decided to move south and, as he himself put it, "to rusticate completely". In September 1958 they moved to Arundel, where his younger son had been living for a year or so. The move was a success and it is pleasant to think that he and Mrs. Moore had two years of quiet retirement together.

The University of Sheffield and the glass industry will always be conscious of the great debt it owes to Harry Moore for his energetic leadership and wise guidance of the Department of Glass Technology at a critical period of development and decision.

R. W. Douglas

Walter Baade

With the death on June 26 of Walter Baade, astronomy loses a truly outstanding figure.

Some thirty years ago, it was generally expected that Baade would succeed to the directorship of one of the major German observatories. But this was not to be. In 1932, at the suggestion of Edwin Hubble, Baade was offered a two-year fellowship at the Mt. Wilson Observatory. His knowledge of astronomy proved so comprehensive, and his telescopic technique so perfect, that this temporary arrangement soon became permanent. Baade remained a staff member of the Mt. Wilson and Palomar Observatories until retirement two years ago.

At the time of his emigration, Baade was perhaps best known for his work on Cepheid variables. 'Baade's criterion' is still spoken of in the subject.

In a short space, only the briefest mention can be made of his outstanding contributions. There was work on supernovæ, first with Zwicky, then with Minkowski. Baade's supremacy as an observer was widely acclaimed after his brilliant resolution in 1944 of stars in the nucleus of the Andromeda Nebula. In his contribution to the dedication of the 200-in. Palomar telescope, he clearly foresaw the great contribution that the colour-magnitude diagrams of star clusters would make to the understanding of stellar evolution. Perhaps his most famous piece of work was his re-assessment, some ten years ago, of the distance scale of the universe. Outstanding in recent years has been the optical identification, in collaboration with Minkowski, of cosmic radio sources.

Almost every one of Baade's papers turned out to have far-reaching consequences ; and much has died with him.

Fred Hoyle

NEWS and VIEWS

Biochemistry at Leicester : Prof. Hans L. Kornberg

Dr. Hans L. Kornberg, who has been appointed to the newly established chair of biochemistry at the University of Leicester, has distinguished himself especially by a series of papers on the metabolism of simple carbon compounds in micro-organisms. He has made major contributions to the elucidation of the pathways leading from acetate and more highly oxidized carbon compounds to cell constituents when such compounds serve as the sole source of carbon. Dr. Kornberg was educated at Queen Elizabeth Grammar School, Wakefield, and the University of Sheffield. He started his postgraduate career in the Department of Biochemistry at the University of Sheffield in 1949 after graduating in the Honours School of Chemistry. In 1953 he was awarded a Commonwealth Fund fellowship, which he spent in the laboratories of Dr. E. Racker of Yale University and the Public Health Research Institute of the City of New York, and of Dr. M. Calvin at the University of California. Since 1955 he has been a member of the staff of the Medical Research Council Unit for Research in Cell Metabolism at the Department of Biochemistry, Oxford, where he has headed a very active research group including many visitors from overseas.

Botany at St. Andrews : Prof. J. A. Macdonald

Dr. J. A. Macdonald has been appointed professor of botany at the University of St. Andrews in succession to Prof. J. H. Burnett, who is taking the chair of botany at King's College, Newcastle-on-Tyne (see *Nature*, 186, 1016 ; 1960). The appointment of Dr. J. A. Macdonald, who is at present senior lecturer in the Department of Botany at St. Andrews, will bring pleasure to a wide circle of botanists, not least to those in Scotland. His appointment ensures the continued happy development of the department, and the Botanic Garden, much of which was initiated by him during 1950–55 as acting head of the department. Born at Dingwall, Dr. Macdonald was educated successively at Paisley, Inverness Royal Academy and the University of Edinburgh. He obtained the B.Sc. (Agric.) with honours in botany in 1931, and the Ph.D. in 1935. He was then appointed lecturer in botany at St. Andrews and senior lecturer in 1953 ; in 1947 he was awarded the Sykes Gold Medal for his D.Sc. thesis. Elected Fellow of the Royal Society of Edinburgh in 1940, he has served on the Council since 1956 ; during 1955–57 he was president of the Botanical Society of Edinburgh. Dr. Macdonald's special interests are in fungal cytology, the general biology and life-cycles of rust fungi and pathogenic fungi. He has brought to these studies the very needful qualities of healthy scepticism, great tenacity and patience. His work has stimulated interest in the somewhat neglected field of somatic fungal cytology. To his teaching Dr. Macdonald brings humour and good sense ; to his University, loyalty and a wide acquaintance with university administration ; to his colleagues and students, friendliness and understanding. He will take up his appointment on January 1, 1961.

U.K. Agricultural and Food Attaché in Argentina : Mr. A. G. Mill

Mr. A. G. Mill, a livestock husbandry advisory officer of the National Agricultural Advisory Service, has been appointed agricultural and food attaché on the staff of the British Embassy in Buenos Aires, in succession to Mr. R. H. Smyth, who has retired. Mr. Mill was educated at Warwick School and Harper

Adams Agricultural College. During 1929–38 he worked for Liebig's Extract of Meat Co., in Argentina. He joined the Ministry of Agriculture and Fisheries in 1939 as a livestock officer. During 1945–49 he was loaned to the Colonial Office for service with the Government of Barbados. On his return to the Ministry in 1949, Mr. Mill was appointed agricultural attaché in Buenos Aires where he served until 1952, having led the United Kingdom delegation to the Inter-American and Food and Agriculture Organization Conference in Monte Video, Uruguay, in 1950. Since 1952 he has been a livestock husbandry advisory officer of the National Agricultural Advisory Service, stationed in the West Midland Region.

Future of Broadcasting in Great Britain

THE Committee on Broadcasting under the chairmanship of Sir Harry Pilkington is ready to receive representations. The terms of reference of the Committee are: "To consider the future of the broadcasting services in the United Kingdom, the dissemination by wire of broadcasting and other programmes, and the possibility of television for public showing, to advise on the services which should in future be provided in the United Kingdom by the B.B.C. and the I.T.A.; to recommend whether additional services should be provided by any other organization, and to propose what financial and other conditions should apply to the conduct of all these services". Any person or organization desiring to submit evidence or to make representations to the Committee should address them in writing to the Secretary, Committee on Broadcasting, G.P.O. Headquarters' Building, St. Martin's-le-Grand, London, E.C.1, as soon as possible, but not later than November 30.

Electronic Equipment in the French Nuclear Energy Industry

No. 3 in the Review Series published by the International Atomic Energy Agency, Vienna, is entitled "Electronic Equipment used in the Nuclear Energy Industry in France" and is in French with English, Russian and Spanish translations of the introduction and table of contents. The authors, P. Desneiges, M. Doireau, L. Koch and J. Weill, are members of the staff of the Centre d'Etudes Nucléaires, Saclay, and the subject-matter refers particularly to French practice, though much is common to other countries and equipment similar to that described is available in many places. The four sections of the review deal respectively with basic electronics equipment for laboratories, such as rate meters, pulse-height analysers and personnel monitoring instruments, and their standardization; specialized equipment, including particle detectors of various kinds and complex electronic equipment for carbon-14 and tritium measuring techniques; reactor control equipment, including neutron detectors, amplifiers, servo-mechanisms and electronic computers; and special applications of nuclear electronics involved in prospecting for uranium minerals, the control of the chemical processing of plutonium and fission products and the detection of leakage of fuel containers. Details of circuitry are not given; but a comprehensive list of references at the end of the Review includes reviews covering specific aspects and a catalogue published by the French atomic energy authority which contains data on commercially available nuclear electronic instruments.

Report of the Government Chemist

THE report of the Government Chemist for 1958–59 (London: H.M.S.O., 1960. 3*s*. 6*d*. net) contains accounts of a wide range of subjects studied during the period stated. The responsibility for this Laboratory, previously known as the Government Chemist's Department, passed from H.M. Treasury to the Council for Scientific and Industrial Research on July 1, 1959, and the report covers the period from April 1958 to December 1959. An interesting discovery is that of the poisonous alkaloid solanine in dangerous amounts in early new potatoes imported from the sub-tropics. The formation of persistent foams in sewage treatment and in rivers, resulting from the use of synthetic detergents, has been fully investigated and the report contains much information on this subject. The use of alternative material is likely to mitigate the trouble.

Accidents in Mines and Quarries

THE annual reports of H.M. Divisional Inspectors of Mines and Quarries for 1959 (London: H.M. Stationery Office) for each of the eight divisions (Scottish, 3*s*. 6*d*. net; Northumberland and Cumberland, 2*s*. 6*d*. net; Durham, 3*s*. 6*d*. net; North Eastern, 3*s*. 6*d*. net; North Western, 3*s*. net; East Midland, 3*s*. 6*d*. net; West Midland and Southern, 3*s*. 6*d*. net; and South Western, 2*s*. 6*d*. net) have been published at intervals during the past few months. The reports deal with accidents and their prevention, dangerous occurrences, ventilation, safety organization, training, education, health and welfare in connexion with all mines and quarries in Britain. Most of each report concerns coal mines, with emphasis on accidents, dangerous occurrences and safety. Accident-rates, fatal and non-fatal, from all causes show improvements in some divisions, compared with averages for the past three years, but not in others. During 1959 the number of men killed in coal mines varied, among the divisions, from 0·47 to 5·03 per million tons mined, while the number killed per thousand workers varied from 0·18 to 1·13; the corresponding figures for serious non-fatal accidents were 4·62 to 15·01 and 1·97 to 3·17. Except in one division, where 47 men were killed in an underground fire, more accidents at coal mines were due, as usual, to falls of ground than to any other single cause and, over Britain as a whole, accounted for 142 deaths out of a total of 348 and for 710 serious non-fatal accidents out of a total of 1,676. Mining is hazardous; but it is clear from these reports that the accident-rates could be much reduced by adherence to rules and application of good sense.

Introducing Atomic Energy

A SERIES of articles entitled "A Plain Man's Guide to Atomic Energy" is being contributed by P. J. Dunston, the director and general manager of (Heston) Fairey Engineering Ltd., to the quarterly magazine *Fairey Review*. In the first article an outline was given of the general structure of matter and the relationship between matter and energy, and in the second article which appears in the current issue (3, 36; June 1960) radioactivity and the release of nuclear energy are discussed. Reference is made to the classic investigations of the Curies, Rutherford, and Cockcroft and Walton, but the opportunity is taken to mention and to give illustrations of modern methods and equipment for handling and machining radioactive materials. A coloured chart of the elements including all known isotopes, with stable and unstable isotopes and nuclear isomers shown separately, and with two typical radioactive-decay chains, accompanies the article. (Uncreased copies of the chart may be obtained from Fairey Engineering Ltd., 24 Bruton Street, London, W.1.) The third article in the series will deal with the interaction of neutrons with matter and the general economy of neutron production in a fission reaction.

Strontium released from the Windscale Accident

It is perhaps surprising to find another publication on the Windscale reactor accident in October 1957. However, a recent joint report by the United Kingdom Atomic Energy Authority and the Agricultural Research Council, entitled "The Deposition of Strontium-89 and Strontium-90 on Agricultural Land and Their Entry into Milk after the Reactor Accident at Windscale in October 1957", provides a useful reassurance that radiostrontium from the reactor was probably not deposited on the ground in biologically significant quantities (Report AHSB (RP) R2. Pp. ii+26+5 plates. London: H.M. Stationery Office, 1960. 5s. net). The concentrations of strontium-89 and strontium-90 in herbage, root-mat, soil and milk are given in detail for no less than thirteen farms. Only for farms within a 2-mile radius of the factory was it possible to conclude that strontium-90 had come from the Windscale reactor. The highest value recorded, in a field adjacent to the pile, was some sixty times the national average, although a large proportion of the material on this field apparently resulted from emissions prior to October 1957. For farms at distances of 8–20 miles, it could not be established with certainty that the levels were measurably higher than for other parts of Great Britain, where all the strontium-90 is presumed to be the result of nuclear weapon testing. The highest concentration in any of the milk samples from the 'near-in' farms was 11 per cent of the maximum permissible level allowed by the Medical Research Council for reactor accidents. There is a further reassurance in evidence which suggests that the incorporation into food chains of radiostrontium released from the pile is only about one-third of that reported for bomb-produced strontium.

Helium-4 Scale of Temperature

At the meeting of the International Committee of Weights and Measures held in Sevres, during September 29–October 3, 1958, the recommendation was adopted that the '1958 Helium-4 Vapour Pressure Scale of Temperatures', based on a vapour pressure table arrived at by international agreement and co-operation, should be used as the international standard scale of temperature between 1° and 5·2° K. A recent publication by F. G. Brickwedde, H. van Dijk, M. Durieux, J. R. Clement and J. K. Logan, issued by the U.S. National Bureau of Standards, describes the new scale in detail (Monograph No. 10. Pp. ii+17. (Washington, D.C.: Government Printing Office, 1960.) 20 cents). In Part 1 of the monograph, F. G. Brickwedde discusses the three practical methods for the determination of the helium-4 vapour pressure–temperature relation, and the various measurements made, and scales adopted, prior to 1958. Following discussions at Leyden between members of the Kamerlingh Onnes Laboratory and the National Bureau of Standards in June 1958, the Scale and the table of helium-4 vapour pressures later adopted by the International Committee of Weights and Measures were agreed on. The table was distributed at the Kamerlingh Onnes conference on "Low Temperature Physics" held at Leyden during June 23–28, 1958, and was published in the conference proceedings. The vapour pressures were listed at 1/100 degree intervals. The table has since been expanded by Clement and Logan, and the expanded table forms one of the seven tables presented in Part 2 of the monograph. In addition to the vapour pressure of helium-4 (1958 Scale) in microns (10^{-3} mm.) mercury at 0° C. and standard gravity (980·665 cm. sec.$^{-2}$) there are listed the 1958 helium-4 vapour pressure-temperature scale, T in deg. K. as a function of pressure P in mm. mercury, and, for $P > 80$ cm., in cm. mercury, at 0° C. and standard gravity; dP/dT in mm. mercury per deg. K.; an auxiliary table for use in making hydrostatic head corrections; deviations of earlier scales from the 1958 Scale; and an auxiliary table for use in making corrections for the density of mercury at temperatures other than 0° C. Fixed points on the '1958 Helium-4 Scale' are the boiling point at 4·2150° K. and the λ-point at 2·1720° K., for $P = 760{\cdot}00$ mm. mercury at 0° C. and standard gravity, and the critical point at 5·1994° K. if the critical pressure is taken to be 1,718 mm. mercury at 0° C. and standard gravity.

High-Temperature Furnaces

A new range of electric furnaces for use in the laboratory, workshop or tool-room is described in Messrs. A. Gallenkamp and Co. Ltd.'s catalogue No. 620 which has recently been issued. Operating temperatures have been increased and box and tube furnaces are now available for use up to 1500° C. The smallest muffle furnace, the 'Super Hotspot', is a moderately priced, versatile furnace for general laboratory work at temperatures up to 1100° C. The refractory muffle which is wound externally with a high-grade resistance-wire heater is fitted in a non-corroding 'Asbestolite' case of smooth surface by refractory insulating bricks. There are built-in controls and pyrometric equipment, together with a safety fuse to protect the heating element against accidental overheating. The larger muffle furnaces are available in three sizes, and together with the 'Super Hotspot', have internal sizes ranging from 4 × 5 × 6 in. to 8 × 9 × 18 in. The box furnaces are similar to the muffle furnaces, but with 'Crusilite' elements for temperatures up to 1400° C. and with 'super' elements (chiefly molybdenum disilicide) for temperatures up to 1500° C. Tube furnaces with 'Crusilite' and 'super' elements are also available. Two sizes, 4-in. diameter and 9-in. high, and 6-in. diameter and 15-in. high, of vertical-tube crucible furnaces have been introduced. They have wire elements wound on grooved refractory tubes and have built-in manual controls and temperature indicators. Other types of furnaces described in the catalogue include a high-temperature vacuum furnace, ash furnaces, and Gray-King furnaces for coal and coke analysis.

The Tungusska Meteorite

The problematic Tungusska meteorite, which fell on June 30, 1908, is still a subject of discussion (V. N. Rodionov and M. A. Tsikulin, *Priroda*, 11, 84; 1959). It is marked by an elliptical area of full tree-fall, 25 × 10 km., surrounded by a zone of a partial tree-fall, 50 × 40 km. As suggested previously, this devastation is due to the impact of the shock-wave, as no fragments of meteorite itself were ever found. It is suggested by the present authors that the meteorite may have disintegrated and the fragments fallen in the front of the partial tree-fall. On the other hand, B. I. Vronsky (*Priroda*, 3, 88; 1960) suggests, first, that the meteorite in question may have been a stone, and not an iron meteorite; and secondly, that the numerous water-logged hollows, so abundant in this area, may indeed represent impact craters of the meteorite fragments now deeply buried in the bog. Finally, E. L. Krynov, a foremost authority on meteorites (*Priroda*, 5, 57; 1960), does not agree with either view and is inclined to accept the hypothesis originally advanced many years ago by I. S. Astapovich and F. L. Whipple (*Priroda*, 9, 70; 1935), who have suggested that the Tunguska tree-fall was not due to the impact of a meteorite, but of a small comet containing a core of ice which had embedded in it meteoric matter.

Dispersion of Small Bodies

DR. D. O. WOLFENBARGER has prepared a scholarly review of the dispersion in space of small bodies (*Lloydia*, 22, No. 1, 1; 1959). In this paper he covers work published since the appearance of his earlier account, published in 1946. His aim has been to describe and analyse quantitative and objective results published on this topic. This is done with the help of 194 graphs which accompany the examples discussed. The types of unit dealt with are inorganic salts, viruses, fungi, pollen, molluscs, water-fleas, and insects, including grasshoppers, mosquitoes, flies and bees. The agents of dispersal include air currents, water, other organisms, growth, and automotility. The distances involved extend from less than 1 mm. from the source, reached by basidiospores of *Puccinia malvacearum*, the principal agent being gravity, up to the 140 miles covered by some tsetse flies by means of hitch-hiking on trains. In a discussion of the results, Dr. Wolfenbarger considers the achievements of dispersion in the biology of organisms, the details of sampling and measuring, and the endogenous and exogenous factors associated with varying distances of dispersion. There is much in this review that is relevant to plant, animal and human epidemiology, allergy, population genetics, plant breeding, and plant and animal ecology.

Search for Oil in Britain

IN 1937, G. M. Lees and P. T. Cox described a geological basis of oil prospecting in England as then envisaged. This was followed by a report on exploratory work by G. M. Lees and A. H. Taitt (1946), wherein particulars were given not only of the discovery of four new oilfields, but also of new geological information of high academic and economic significance. The search still goes on. A recent Memoir (1960) of the Geological Society, by N. L. Falcon and P. E. Kent, presents geological results of petroleum exploration in Britain by the British Petroleum Company during the years 1945–57 (Memoir No. 2: Pp. 56+5 plates. (London: Geological Society of London and H. K. Lewis and Co., Ltd., 1960.) 25s. net). Altogether eleven oil-producing areas have been established, with a cumulative production total, to the end of 1959, of more than 1·25 million tons. The latest fields are Plungar (Leicestershire) and Egmanton (Nottinghamshire); prospects are at Bothamsall, an extension of Eakring (discovered in 1939), and at Corringham, near Gainsborough. Other possibilities have been and are being pursued in which the well-tried techniques of reflexion seismic exploration and electric logging have been successfully exploited. It is noteworthy that gamma-ray logging proved to be of considerable help in sub-surface correlation of marine-band markers in the East-Midlands projects. Economically important also is that the pattern of oil prospecting as originally delineated has been extended to include search for natural gas, jointly on behalf of the Gas Council and Imperial Chemical Industries, but with what measure of commercial success has yet to be determined.

Freeze-drying of Plant Viruses

WHEREAS freeze-drying has been widely and successfully used for the preservation of bacteria, animal viruses and bacteriophages, there appear to have been relatively few attempts to conserve viruses by this means. It has been ascertained that some plant viruses retain their infectivity for long periods in frozen tissue or sap, or in plant tissue frozen and slowly dried over calcium chloride. Such procedures, however, are not suitable for preserving some labile and certain other viruses. M. Hollings and R. A. Lelliot (*Plant Path.*, 9, No. 2, 63; 1960) have now described effective methods for the freeze-drying of a considerable number of viruses. The preservation of sap preparations of forty-six isolates of thirty-nine plant viruses by the rapid sublimation of water from frozen suspensions and subsequent storage under vacuum (freeze-drying) was investigated. Infective virus was recovered from preparations of all strains, except one of potato virus *A*, after freeze-drying and after storage during periods varying from four to eleven months. It appeared that the spherically shaped viruses studied lost little or no infectivity during freeze-drying, but that several of the rod-shaped viruses lost much of their infectivity. There was no evidence of further serious loss of infectivity in forty-five of the preparations during the storage period.

Lalor Grants and Awards for 1961

THE Lalor Foundation has announced the programme of awards for 1961 which it is offering for support of research on the fundamental biochemical and physiological mechanisms concerned with fertility and the early stages of reproduction in various forms of life. The objectives are to further the knowledge and understanding of the basic phenomena involved and to extend and develop the possibilities for effective regulation and control. The awards may range up to 8,000 dollars a year, depending on the scope and duration of the project approved. Preference will be given to younger members of university and college faculty and staff, with an upper age limit of 41 years. The work may be carried on at the applicant's own institution or elsewhere. The Foundation will also grant post-doctorate summer or short-term research awards at the Marine Biological Laboratory at Woods Hole, Mass., or elsewhere for appropriate projects in the fields specified. For these awards, the stipends will normally not exceed 1,000 dollars for a single man or a woman, 1,200 dollars for a married man working at his home institution, and 1,350 dollars for a married man with principal programme at another institution. A number of these awards may be granted to nationals other than citizens of the United States, usually under the condition that the award holder's work shall be conducted at an American institution. Applications and inquiries should be sent to the Lalor Foundation, 4400 Lancaster Pike, Wilmington 5, Delaware, and applications must be received by January 16, 1961.

Non-Destructive Testing of Materials

THE British Council is organizing a course on the non-destructive testing of materials in London for two weeks beginning October 16. The course is designed for overseas industrial technologists and scientific research workers. Its aim is to provide them with a broad survey of work in progress in the United Kingdom on the development of non-destructive testing techniques and the uses to which these techniques are being put by industry. The course will consist of lectures, discussions and visits. The main emphasis will be on the scientific background. The inclusive fee for this course, which is residential, will be £47. Further information can be obtained from Miss B. Sinclair, The British Council, 65 Davies Street, London, W.1.

The Leopoldina German Academy of Sciences : Elections

THE Deutsche Akademie der Naturforscher Leopoldina, Halle, recently elected the following new members, among others, in the sections indicated: *Physics*, Prof. Hans Kopfermann (Heidelberg); *Geophysics*, Prof. Alfred Ehmert (Göttingen); *Chemistry*, Prof. Horst Böhme (Marburg), Prof. Harry J. Emeléus (Cambridge), Prof. Gunnar Hägg (Uppsala), Prof. Karl Myrbäck (Stockholm), Prof. Linus Pauling (Pasadena), Prof. Tadeusz Urbański (Warsaw), Prof. K. Venkataraman (Poona); *Botany*, Prof. Rudolf Mansfeld (Gatersleben).

The Night Sky in October

FULL moon occurs on Oct. 4d. 22h. 17m. U.T., and new moon on Oct. 20d. 12h. 03m. The following conjunctions with the Moon take place: Oct. 9d. 09h., Aldebaran 0·3° S.; Oct. 11d. 22h., Mars 5° N.; Oct. 22d. 21h., Venus 6° S.; Oct. 24d. 22h., Jupiter 5° S.; Oct. 25d. 21h., Saturn 4° S. In addition to these conjunctions with the Moon, Venus is in conjunction with Antares on Oct. 28d. 20h., Venus being 3° N. Mercury and Venus are too close to the Sun for observation. Mars rises at 21h. 15m., 20h. 50m. and 20h. 10m. at the beginning, middle and end of the month, respectively. It is in Gemini, and is a very prominent object, of magnitude + 0·1 on October 15, when its distance from the Earth is 88 million miles. Jupiter sets at 20h. 50m., 20h. 05m. and 19h. 15m. on October 1, 15 and 31, respectively. It is in Sagittarius, and may be seen low in the southwest after sunset, but conditions are not favourable for observation. Saturn is in Sagittarius, east of Jupiter, and sets at 22h. 00m., 21h. 10m. and 20h. 15m. at the beginning, middle and end of the month, respectively. Its stellar magnitude is + 0·7 and its distance from the Earth on October 15 is 940 million miles. There is one occultation of a star brighter than magnitude 6 visible at Greenwich: Oct. 9d. 0h. 24.9m., γ Tau. (*D*); Oct. 9d. 1h. 41·7m., γ Tau. (*R*). *D* and *R* refer to disappearance and reappearance, respectively. The Giacobinids are active on October 9, but conditions are unfavourable, and little activity is expected. The Orionids are active during the third week of the month, conditions being favourable; the radiant is near R.A. + 6h. 24m., Dec. +15°.

Announcements

DR. G. JONES, of the Rowett Research Institute, Bucksburn, Aberdeen, has been appointed to hold the Sophie Fricke Royal Society Research Fellowship in the Rockefeller Institute for the academic year 1960–61. Dr. Jones will leave the United Kingdom in October for the Rockefeller Institute, where he will be working on the fractionation and characterization of leaf proteins.

SIR WILLIAM SLATER, until recently secretary of the Agricultural Research Council, has been appointed chairman of the governing body of the Glasshouse Crops Research Institute in succession to Mr. T. Ainslie Robertson.

MR. V. CORY, at present deputy county advisory officer in the National Agricultural Advisory Service, Essex, has been appointed county advisory officer for Yorkshire (West Riding) in succession to Mr. J. Gibbons, who has been appointed county advisory officer for Somerset. Mr. Cory will take up his new post on October 3.

THE Association of British Chemical Manufacturers, 86 Strand, London, W.C.2, has published a booklet entitled "Chemical Plant Instrumentation. Some Notes on the Use of Measuring Instruments" (6*s*. to members; 7*s*. 6*d*. to non-members, post paid). The nine topics covered in some fifty pages include temperature and pressure measurement, gas chromatography, continuous gas analysis by infra-red, glass electrode *p*H-meter and smoke-density meters. The information will be of interest to the managements of industrial firms.

THE Institute of Physics and the Physical Society is arranging a conference on statistical mechanics (with special reference to irreversibility), to be held at Queen Mary College, London, on December 19 and 20. Further information can be obtained from the Secretary, Institute of Physics and the Physical Society, 47 Belgrave Square, London, S.W.1.

THE annual meeting of the Physical Chemistry Society of France will be held at l'Hotel du Col de Voza, Chamonix-Mont Blanc (Haute Savoie), during June 26–30, 1961. The subject of the meeting will be "The Structure, Synthesis and Function of Deoxyribonucleic Acid". Further information can be obtained from the Secretary, Société de Chimie Physique, 10 Rue Vauquelin, Paris V^e.

THE AGARD Avionics Panel has arranged a symposium on "Radio Navigation" in conjunction with the Tenth AGARD General Assembly during October 3–9 in Istanbul. The proceedings will cover general problems concerned with navigation, including papers on wave-propagation, radio-navigation including Doppler and air-traffic control, space and astro-navigation and display methods and automatic approach and landing. Further information can be obtained from the Advisory Group for Aeronautical Research and Development, Organisation du Traité de l'Atlantique Nord, 64 rue de Varenne, Paris 7ème.

ERRATUM. Writing in connexion with the communication entitled "Staining for Iodine in Chromatograms of Human Plasma" in *Nature* of August 20, p. 691, Dr. J. D. H. Slater states that the limit of sensitivity quoted as 0·2 μgm./100 ml. should have been 2·0 μgm./100 ml. (line 19, p. 692). The authors have since developed a considerably more sensitive technique.

THE CHEMISTRY OF NATURAL PRODUCTS

IN the Great Hall of the University of Sydney on August 25 Sir Kenneth Street, Lieutenant-Governor of New South Wales, formally closed the ten-day Symposium, entitled "The Chemistry of Natural Products", which had been opened on August 15 by Sir John Eccles, president of the Australian Academy of Science, in the Wilson Hall of the University of Melbourne. The meeting had made history as the first outside Europe and North America to be sponsored by the International Union of Pure and Applied Chemistry. Some 150 chemists from 33 countries, together with more than 200 Australians, attended as registered members. From overseas, Prof. A. Stoll (Switzerland), past president of the International Union of Pure and Applied Chemistry, represented the present president, Prof. W. A. Noyes, jun. The United Kingdom delegates were led by two Nobel laureates, Sir Alexander Todd and Sir Robert Robinson. Prof. R. Kuhn, also a Nobel laureate, due to arrive from Heidelberg, was unfortunately absent through illness.

The Symposium has differed from those hitherto held in other countries in that it was not located only in one city. It began in Melbourne in the State of Victoria, where it remained during August 15–18, then migrated about 300 miles to Canberra in the Australian Capital Territory, and finally shifted another 200 miles to Sydney; these movements all being made by air.

The Symposium was organized by the Australian Academy of Science, and the choice of subject was logical because the investigation of the constituents of Australian plants has formed the longest continuing organo-botanical-chemical research endeavour of scientists in Australia during the past century. In a sense its origin can be said to lie with Dr. John White, surgeon-general to the 'first settlement', who—soon after 1788—ran out of English peppermint oil, and discovered that an efficient substitute could be obtained by distillation of the leaves of the eucalyptus growing around Sydney Harbour. Prof. John Read (one-time professor of organic chemistry in the University of Sydney) devoted a whole chapter of his "Humour and Humanism in Chemistry" to this and subsequent periods under the title: "Chemistry Reaches the Australian Bush". Half a century ago the pioneering investigations of Smith and Baker (in what is now the Sydney Museum of Applied Arts and Sciences), followed later by those of Read himself, and Penfold (for many years director of the Museum) and others, have given Australia a significant place in essential oil and terpene research.

Alkaloids were first extracted from Australian sources in 1861. Shortage of certain drugs during the Second World War, and the problem of stock poisons occurring in plant foods, have caused a more intensive and systematic examination of Australian flora, and have led to the setting up of a phytochemical survey; this has stimulated much research in university and government laboratories, and brought to light many novel colouring matters, glycosides, alkaloids, toxic or pharmacologically active compounds, etc., which were reported during the Symposium.

The scientific proceedings were divided into four sections, namely: (*A*) Aliphatic and Homocyclic Chemistry; (*H*) Heterocyclic Chemistry; (*B*) Biological Chemistry; and (*P*) Physical Methods. Owing to the large number of papers submitted, the first three sections unfortunately (for the chemists interested) ran as concurrent sessions. Pillars in the construction of the programme were 14 lectures, attended by the whole assembly. At the opening ceremony, Prof. A. Stoll (Switzerland) spoke on "Impact of Studies of Natural Products on Chemical Industry". Three symposium lectures were delivered as follows: Section *A*, Prof. F. Šorm (Czechoslovakia), "Terpenic Compounds with Medium-Sized Rings"; Section *H*, Prof. R. B. Woodward (United States), "The Total Synthesis of Chlorophyll"; and Section *P*, Dr. H. W. Thompson (United Kingdom), "Physico-Chemical Methods of Studying Natural Products". Prof. Kuhn's eagerly awaited "Chemistry of the Gangliosides" had perforce to be omitted. Eight section lectures, also attended by all delegates, were: Section *A*, Prof. D. H. R. Barton (United Kingdom), "Some Aspects of Terpenoid and Steroid Chemistry", and Prof. N. A. Sørensen (Norway), "Structural Patterns of Polyacetylenic Compounds isolated from the Plant Family Compositae"; Section *H*, Prof. H. Brockmann (West Germany), "Chemistry of the Actinomycins", and Prof. T. R. Govindachari (India), "Recent Investigations on Some Alkaloids from Indian Plants"; Section *B*, Dr. J. W. Cornforth (United Kingdom), "The Biosynthesis of Polyisoprenoids", and Prof. E. Lederer (France), "Chemistry and Biochemistry of Biologically Active Bacterial Lipids"; Section *P*, Prof. C. Djerassi (United States), "Application of Optical Rotatory Dispersion Studies to Problems in Natural Products Chemistry", and Dr. A. McL. Mathieson (Australia), "The Direct Determination of the Molecular Structure of Natural Products". Dr. J. R. Price (Australia) gave a special lecture entitled "Australian Natural Product Research".

Sir Alexander Todd, as president of the Symposium, gave as his presidential address in the new Academy headquarters in Canberra a general review, coupled with a plea that biochemistry must bridge biology and organic chemistry, by studies of function and structure, if it is to make its most successful contribution to knowledge. He spoke on "Natural Product Chemistry—Retrospect and Prospect".

Sir Robert Robinson summed up the scientific achievements of the Symposium at its closing ceremony. He said: "It would be presumptuous for me, or anyone else for that matter, to pretend to be able to perform adequately the task which I must now attempt. For one thing, none of us has been able, as we might have wished, to be in three places at the same time. Furthermore, the printed abstracts are largely of the nature of appetizers, an invitation to the lunch, but with a masterly reticence with regard to the menu, to say nothing of the details of the cooking". . . . "For me it has been throughout an entrancing and spectacular display of progress and promises of future advances". Sir Robert specifically referred to Dr. Thompson's lecture, saying that although Thompson himself was a pioneer of infra-red spectroscopy he "gave pride of place to X-ray crystallography, because this method 'gives full structural information—not only that, but also solves the stereochemical problems". Sir Robert proceeded to note the part taken by Djerassi's work on optical rotatory dispersion, by mass spectrometry and by nuclear magnetic resonance, as well as by infra-red and ultra-violet spectra, in the discussions and lectures of the Symposium. He warned, however, that the classical organic chemist is certainly not to be displaced by machines . . . there is no need to discuss whether an absorption band is due to N—H or O—H if the compound does not contain nitrogen. "even if we know the structure we still have to explore the surrounding chemical territory . . . would it be good for organic chemistry as a whole if the structure of indigo had been solved by looking at a few milligrams of it, and if Baeyer had not carried out any of his wonderful work which led to the determination of its formula ? I think not !"

He went on: "We were greatly privileged to hear the lecture by Prof. R. B. Woodward, in which he described, I believe for the first time, the outstanding achievement of the total synthesis of chlorophyll. Prof. Woodward is not only a most brilliant synthetic organic chemist, but also an expositor, able to convey a sense of the drama of development to his audience. His lecture was thoroughly enjoyable, even thrilling as an experience. No doubt in places he admitted to a little good fortune, but he also made it clear it was expected. I was reminded of Benjamin Franklin's 'Luck is the bonus that accrues to industry'. Woodward and his team were surely industrious".

"This achievement of the synthesis of chlorophyll is a very good example of the kind of thing which one is often asked about . . . What good is it ? Of course, the good that it is, is the new knowledge which is obtained . . . the new knowledge of the behaviour of chlorophyll, the nature of the molecule, how it is likely to behave in other circumstances. . . . That new knowledge may lead us we don't know where".

About Prof. Lederer's lecture Sir Robert said: "It was quite outstanding in interest and importance. I had no means for measuring decibels of applause or its duration, but it was clear my assessment was widely shared. Lederer described extensive studies on biologically active bacterial lipids. . . . He explained in full the problems which had been finally solved, and even more useful, he indicated the stages reached in the solution of others, including some which may have great significance for the therapy of tuberculosis in the future. Lederer's mastery and humorous style charmed us. His contribution will certainly be remembered".

He continued: "Another aspect which has been running through the Symposium is that of biogenesis and structural relations, and the use of isotopic tracers to test the various hypotheses advanced in this connexion. . . . I think the lecture by Dr. J. W. Cornforth was an extremely important event in the conference—one of the real highlights. The way in which Cornforth was able to describe the complete story for the synthesis of poly*iso*prenoids was quite remarkable. It was . . . a lecture of great value to all of us".

Sir Robert then referred in terms of praise to all the other lectures mentioned above, to the "infectious enthusiasm" of Erdtman, the "brilliance" of Barton, Šorm and Brockmann, the many valuable and novel facts presented by Sørensen, Govindachari and Mathieson, impossible to summarize in the detail they deserve. Concerning Prof. Stoll's review of the impacts which natural product research has on industry, Sir Robert said: "These reverberations are important . . . Stoll's work is as academic as anyone else's . . . he has made extraordinarily valuable and neat contributions to the chemistry, for example, of the digitalis and ergot series". These have not been without profit in all senses of the word. Sir Robert paid a tribute to the survey of past and present Australian work by Dr. Price in his special lecture, and to the results presented by Price and collaborators in papers to Sections *H* and *P*. These, he said, showed how many opportunities exist in Australia for natural product research, and how beneficial has been the guidance of Dr. Price and his associates in the laboratories of the Commonwealth Scientific and Industrial Research Organization.

Sir Robert concluded: "Possibly the outstanding scientific value of the Symposium has been the opportunity it has afforded for the meeting of colleagues from all over the world for discussions . . . not only in the lecture theatres, but also in other places where we meet and talk together. . . . It has been the most outstandingly successful symposium I personally have ever taken any part in. I have never experienced a symposium in which so many papers of the greatest possible interest have been delivered . . . and I must say that I think it is due to the enthusiastic coming together of organic and physical chemists in the past twenty years, from which union we have gained advantages of powerful procedures . . . of chromatography, ordinary and vapour phase, of micro methods of analysis and of manipulation, of the many physical ways of examining products, of the availability of isotopes, and the techniques for handling them, and from which we can still see further new methods developing on the horizon . . . all this has made the Symposium a most significant occasion. We hope to repeat it in Czechoslovakia in 1962".

Sir Robert then spoke with appreciation of Sir Alexander Todd's services as president of the Symposium—this was received with great applause—and the meeting was closed by Sir Kenneth Street.

Officially the planners received strong support in high places. His Excellency the Governor-General of Australia, Viscount Dunrossil, was patron-in-chief, and Their Excellencies the Governors of New South Wales and of Victoria were patrons.

Official receptions were given by the Premiers of Victoria and New South Wales in Melbourne and Sydney respectively, and by the Prime Minister in Canberra. Immediately prior to the opening, Sir Alexander Todd received the honorary degree of doctor of laws from the University of Melbourne, and on August 24 the University of Sydney conferred on Sir Robert Robinson (first professor of organic chemistry in Sydney) its D.Sc. (*honoris causa*).

A full programme of social events and excursions for members and their ladies was also carried through. Outstanding were the Government receptions, the banquet in Canberra, a 'wine and cheese tasting' in Sydney by courtesy of the Australian Wine Producers' Association of New South Wales, and a fashion parade in Melbourne of Australian woollens, arranged by the Australian Wool Board. The last two, together with the many scenic tours possible from the three centres, proved of great interest to visitors who had not previously seen the Australian way and place of life. Post-Symposium tours to north and south Queensland and to New Guinea are now in progress—the last-named being for men only and at the invitation of the Commonwealth Government and the New Guinea Administration.

The lectures mentioned above will be published through the Publications Committee of the International Union of Pure and Applied Chemistry by Butterworth's Scientific Publications, London.

R. J. W. LE FÈVRE

WARREN SPRING LABORATORY

IN planning the Warren Spring Laboratory at Stevenage, the Council for Scientific and Industrial Research decided that it should be a versatile station free to carry out research which cannot be fitted into the programme of another research body, especially work involving pilot-scale investigations of any subject of national importance.

As a result, the Laboratory's research programme includes a number of important investigations in several different fields[*].

In chemical engineering, for example, the work is concerned mainly with providing the chemical plant designer with basic information. Considerably more knowledge is required to achieve greater precision in design work. The basic programme is confined to the study of mass transfer in gas–liquid systems, and these investigations will provide data for the precise design of large-scale equipment without the need for costly pilot-plant studies. For example, the investigation should enable more accurate prediction of the performance of gas–liquid contacting equipment to be made and thus facilitate the design of equipment such as distillation columns and gas absorption towers.

Much of the work of the Mineral Processing Division is undertaken for mining companies and other organizations, on repayment. Three main subjects of basic research are being studied: (*a*) grinding in the presence of additives such as surface-active agents; (*b*) the composition of surface minerals and the kinetics of bubble attachment to mineral surfaces; (*c*) the behaviour of mineral particles in a high-tension field and the modifications of this behaviour by various surface treatments. There have been indications during the year that automation may become important in mineral processing plants and an experimental programme is being considered.

In the Process Development Department, work has continued on the Fischer–Tropsch synthesis, which provides a method of obtaining liquid and gaseous fuels from carbon monoxide and hydrogen, which are produced by the complete gasification of low-grade high-ash coal. Basic research on catalysis has included work on the catalytic and other physico-chemical aspects of fuel cell operation.

A small human sciences research team is being formed at the Laboratory, and the Human Sciences Research Sub-committee, under the chairmanship of Mr. H. Briggs, labour adviser to Unilever, Ltd., is now considering the programmes of research in this increasingly important field.

Current research into air pollution concerns both methods of abatement and assessment of atmospheric pollution throughout Britain, with relation to the effects of clean air legislation. Estimates made during the year have shown that, in general, smoke from the burning of industrial coal has ceased to be a serious problem although in some instances it creates a local nuisance. The Laboratory has co-operated with the Port of London Authority and owners of tugs in demonstrating methods of reducing smoke emission from ships in coastal waters.

Smoke from Diesel exhausts provides another research problem. While a well-maintained and correctly operated Diesel vehicle need never produce black smoke, the fact remains that large numbers of lorries frequently do. Methods of removing smoke from exhaust gases are being studied. A 10-ton Diesel lorry fitted for road tests with various proprietary devices is being used for this purpose.

The Laboratory has continued to collaborate with local authorities on the measurement of pollution, and this is providing "a wealth of background information against which future improvements can be assessed".

Methods of measuring low concentrations of oxides of nitrogen (known to be emitted by practically all fuel-burning appliances) are being examined. These emissions may be significant factors in air pollution.

---

[*] Report of the Warren Spring Laboratory, 1959. Published for the Department of Scientific and Industrial Research. (London: H.M. Stationery Office, 1960.) 1*s*. net.

U.K. ATOMIC ENERGY AUTHORITY

THE sixth annual report of the Atomic Energy Authority, the first to appear over Sir Roger Makin's signature and also the first to be submitted to the Minister for Science, covers the period April 1, 1959–March 31, 1960[*]. During that year, those major projects undertaken primarily to support the defence programme were completed, and all main plants constructed for that purpose were operating successfully. New capital projects approved during the year were on a relatively small scale. The Authority continued to devote a major effort in support of the civil power programme of the Central Electricity Generating Board and the South of Scotland Electricity Board. The report includes as an appendix the observations of the Minister for Science, in consultation with the Authority, on the fifth report of the Select Committee on Estimates on the Authority's Industrial Group. These comments have now been transmitted to the Committee.

---

[*] United Kingdom Atomic Energy Authority. Sixth Annual Report for the period 1st April, 1959–31st March, 1960. Pp. vi+72+4 plates. (London: H.M. Stationery Office, 1960.) 5*s*. net.

Generally, the Authority welcomes the report and has accepted and will implement most of its recommendations. On the remaining recommendations, it is commented that the Authority has reviewed its budgeting procedure and taken steps to ensure that the original factory and laboratory estimates are prepared on as broad a basis as possible and contain no more detail than is essential to ensure the build-up of a realistic total. The Authority agrees with the Committee's view of the importance of taking account of long-term effects, both in staff and further capital expenditure, of current proposals, and will include in any application for sanction of a capital project connected with the development of a new reactor system a rough forecast of expenditure which may be necessary in the foreseeable future as a consequence of the particular capital project for which sanction is requested. The Authority also accepts that the Treasury should be informed of the contingency margin allowed in project estimates for experimental facilities for which it is impossible to give precise detailed specifications at the outset, and the Treasury will also be informed at the next stage of estimating what margin has been retained as a working margin. The Authority also accepts the general intention of the recommendation that it should be standard practice to allow design officers sufficient time to go out to tender for all major components of large civil reactor and plant projects, and fully endorses the Committee's statement that "the future course of the nuclear power programme will be directly affected by the availability or otherwise of the fast reactor in the early 1970's, which means that its value must be established by about 1966". The fast reactor is regarded as an integral part of the nuclear power programme and the Authority will press on with its development as rapidly as possible: it is already receiving, and will continue to receive, full technical support.

On the financial side it must be observed that the balance sheet appended to the report still gives no indication as to the way in which the £92,433,010 of the 1959–60 estimates were expended. The sixth report, like its predecessors, gives no indication whatever of the magnitude of our effort in research on nuclear energy or of the cost of the nuclear power programme, either as a whole or in the development of reactors. Indeed, even less information is available than was to be found in some earlier reports, though it is stated that early in 1959 the Authority decided to limit the growth of man-power on research and development for the next three years to an annual rate of not more than 8 per cent. Within this rate of expansion, recruitment in general has been satisfactory, although difficulty is still experienced in recruiting engineers and scientists of sufficient experience and calibre for higher management posts, and in obtaining scientific and professional staff in particular disciplines in which there is a national shortage. The total staff employed increased from 35,260 on April 1, 1959, to 38,500 on March 31, 1960, industrial employees increasing from 18,217 to 19,572.

On the production side the report records an increase of 40 per cent in the output of fissile material and of 300 per cent in that of electricity, while most of the teething troubles of the full-scale prototype unit for converting uranium nitrate into tetrafluoride, using fluidization techniques, have been overcome, and the plant is operating as a production unit yielding uranium tetrafluoride of good quality at the design throughput. Satisfactory progress is also recorded in the reactor development programme, and stress is laid on the importance of reductions in capital costs if nuclear power is to be competitive not only at base load but also at the lower load factors at which nuclear power stations will have to operate when substantial nuclear capacity has been built. This largely depends on the development of more advanced reactors, and here a large effort has been devoted to the support of the 'magnox' stations, particularly the development of fuel elements to provide good performance with reliability. Progress in the advanced gas-cooled reactor system has been encouraging: the system should be capable of lower capital costs than 'magnox' stations and its prospects are good. Development of the fast reactor proceeded steadily, and the experimental reactor at Dounreay came into operation at low power. Most of the staff working on the high-temperature gas-cooled reactor system were seconded to the *Dragon* project, under the auspices of the Organization for European Economic Co-operation. Other work on reactors included investigations into the design of a steam-cooled heavy-water reactor and its variant, the steam generating heavy-water reactor.

The wide range of the Authority's research activities is displayed in the chapter on general research and development. In nuclear physics, for example, a major group of work is concerned with the behaviour of nucleons when they collide in free space, uncomplicated by the proximity of other nucleons as in nucleon–nuclear reactions. The cyclotron has also been used to investigate the interaction of a high-energy nucleon with a nucleus and the interactions between nucleons and nuclei have also been studied at fairly low energies, using the 5-MV. Van de Graaff generator and newly completed 12-MV. tandem electrostatic accelerator at Harwell. A new particle detector has been developed in which a p–n junction in a semiconductor, such as silicon or germanium, is used as a solid-state ion chamber to produce an electrical impulse when a nuclear particle traverses the junction, and also a large heavily shielded liquid scintillation counter for work on neutron emission in fission. In solid-state physics a fundamental experiment has been carried out using lithium isotopes, and a change of thermal resistance with isotope concentrations was observed in measurements at Capenhurst of the thermal conductivity of single crystals of lithium fluoride containing lithium-6 and lithium-7 in the temperature range 10°–90° K. In radiation chemistry much work has been undertaken in connexion with the problems of radiation change in reactors and in fuel processing plants. For example, work on the γ-radiolysis of methyl acetate has shown how complicated the degradation of a simple ester can be, and work on the radiolysis of trialkyl phosphates showed that, in addition to hydrogen and light hydrocarbons, dialkyl and smaller amounts of mono-alkyl phosphoric acids are produced. The behaviour of the system carbon dioxide/carbon monoxide/graphite under irradiation has been studied to determine the basic parameters that affect the rates of the reactions, and the influence of geometrical factors on the radiation-induced reaction producing carbon monoxide is being studied in sealed tubes. Another investigation was concerned with the nature and properties of radioactive aerosols, and laboratory experiments have been made on the release of iodine in air and carbon dioxide at very low vapour concentrations. Considerable technical work has been undertaken into criticality to back particular design studies as well as a more generalized study.

Work continued on the application of radioisotopes, especially in industry. The method of fluorescence spectroscopy, using radioactive sources, has been applied to measuring very thin surface coatings, and by tracer methods the rate of flow of liquid in closed channels can now be measured with an error of less than one part in 200. Further work has been done on the use of large sources of γ-radiation for sterilization and other purposes, and a pilot-scale plant for irradiating packages of materials with γ-rays has been built at Wantage. A mass spectrometer has been developed at Capenhurst for the analysis of the active species present in gas/solid chemical reactions, and basic studies have been made of the friction and wear behaviour of materials in reactor coolant environments at high temperatures. Considerable progress has been achieved at Aldermaston in the provision of short-duration radiographs of systems opaque to ordinary light and moving at high speed, and two types of mechanical very-high-speed cameras are manufactured at Aldermaston, one, the streak camera recording along a length of film the size of a light source which is varying with time, the other, the framing camera, producing individual pictures at intervals on a strip of film. A third type takes a single picture with a time of exposure of 1×10^{-7} sec., using a Kerr cell shutter.

In the work on controlled thermonuclear reactions, the stored energy supply and the stabilizing magnetic field supply of *Zeta* were both increased by about six times during the year, and experimental elucidation of the physical phenomena in the *Zeta* and *Sceptre* plasmas continued successfully, while work also continued on some other plasma physics problems, and considerable progress was made in solving the formidable technological problems associated with the production and control of currents in the range of 10^4 amp., and in the development of methods of construction to withstand the severe conditions expected in experiments such as the Intermediate Current Stability Experiment. The Authority has reconsidered its earlier decision to move controlled thermonuclear research from Harwell to Winfrith, and has chosen instead a site at Culham, where the laboratories to be erected will form a large autonomous unit within the Authority's Research Group. The Authority's commitments under its long-term uranium contracts are now greater than its immediate requirements, and for some years, mainly due to the slowing down of the nuclear power programme, it will hold larger uranium stocks than it needs. A new Health and Safety Branch, independent of the Groups, was established as from July 1, 1959, to advise on the formulation of health and safety policy and disseminate this policy for application by heads of groups and establishments, apply this policy to the assessment and inspection of reactors and plant, and provide the focal point for conducting external relations in this field. A wide range of health and safety problems investigated during the year included developments in measuring techniques applied to the monitoring of fall-out from nuclear weapon tests, controlled studies of the uptake from fresh water of strontium-90 by fish and of this and other radioisotopes by common aquatic plants, and work on the diffusion and dispersion of gases and particulates.

Information Services have included, besides the Harwell Reactor School, the Calder Operation School, the Isotope School, now at Wantage, and the training programme for Central Electricity Generating Board operating staff, the issue of an illustrated summary of this sixth annual report, together with some additional material to July 1, 1960*.

---

* Atom 1960: an Illustrated Summary of the Sixth Annual Report from 1st April, 1959, to 31st March, 1960, of the United Kingdom Atomic Energy Authority, with some additional material to 1st July, 1960. Pp. 34. (London: H.M. Stationery Office, 1960.) 2s. 6d. net.

TUBERCULOSIS: RISK TO FAMILY CONTACTS

In developed countries with adequate hospital accommodation, drug treatment of tuberculosis has often freed beds. In less-developed countries with inadequate hospital accommodation, the problem of beds for tuberculous patients remains acute. In India, for example, it is particularly serious, since there are only 23,000 beds for tuberculous patients, against a total number of persons affected that may be put at between 1·5 and 2·5 million. Because of this, a comparative study of domiciliary and sanatorium treatment of tuberculosis was undertaken by the Tuberculosis Chemotherapy Centre, Madras, which was set up in 1956 under the joint auspices of the World Health Organization, the Indian Council of Medical Research, the Madras Government and the Medical Research Council of Great Britain. The purpose of the study was to determine whether drug treatment of tuberculosis in a country like India was as effective in the home as in the sanatorium; or, to put it differently, whether domiciliary treatment did away with the need to send a fair number of tuberculosis patients to hospital (*World Health Org. Chron.*, 14, No. 7; July 1960).

A group of 193 patients were selected, most of them from the poorest classes of Madras City. They had to be more than twelve years old, to have had no previous drug treatment, and to have a positive sputum. Out of these 193 patients, 96 were treated at home, 97 in the sanatorium. The period of comparison lasted a year, and the results of the study indicated that domiciliary treatment seemed to give as good results as sanatorium treatment.

There remains the important point whether the risk of infection to the family is not greater when the patient is treated at home. A fresh study was carried out under World Health Organization auspices on the same group of patients to determine the overall prevalence of cases of tuberculosis among family contacts when the diagnosis of tuberculosis was established in the family member included in the comparative study (the index case), and the number of fresh clinical and primary cases occurring among family contacts during the first year of his treatment. Contacts include all the other members of the family, but the inquiry was limited to 'close' family contacts, that is, those who had been living with the index case for at least three months before diagnosis. In fact, 96·7 per cent of the 693 close family contacts had been living with the index case for at least a year.

Examinations were carried out in 693 contacts of the 193 patients treated at home or in the sanatorium; of these, 347 were men and 346 women. The survey of the prevalence of tuberculosis when the index case started treatment was based on 672 contacts. Active tuberculosis was found in 46; in another 2, activity was doubtful; and in 11, tuberculosis was inactive.

Of still more interest was the inquiry into fresh cases of tuberculosis appearing in close family contacts of patients treated either at home or in the sanatorium during the first year of treatment. There were 257 contacts of the 75 patients treated at home, and 275 contacts of the 73 patients in the sanatorium. The two groups were alike in the proportion of men to women, in the kind of home they lived in and in the results of the initial examination; and they were followed up in the same way during the year of the inquiry. During this year, 26 active cases of tuberculosis were discovered in the two groups of contacts; 9 (3·5 per cent) in the group of contacts of patients treated at home, and 17 (6·2 per cent) in the group of contacts of patients treated in the sanatorium.

Of these 26 cases, 15 were less than five years old and 21 less than two years old. The most serious cases all belonged to the group whose index cases were treated in the sanatorium.

Even if encouraging conclusions can be drawn from this study, domiciliary treatment of the open tuberculous patients should be considered an emergency measure only, to be taken when institutional treatment for 3–6 months is impossible because of shortage of beds. Every effort should be made not to send patients home until their sputum has become negative for tubercle bacilli, at least on microscopical examination.

A final conclusion is that the frequency and seriousness of tuberculosis lesions in young contacts are a sufficient justification for systematic prophylactic treatment of children whenever a sputum-positive patient is newly diagnosed in their household. This treatment should be started immediately and carried out for a minimum period of six months.

NOISE IN FACTORIES AND ITS CONTROL

NOISE is always associated with the application of power, and the trend towards the use of more powerful machines in industry is making the problem of noise in factories increasingly serious. A survey "Noise in Factories", by A. G. Aldersey-Williams, which has recently been published for the Department of Scientific and Industrial Research (Building Research Station) in the series "Factory Building Studies" (No. 6. Pp. iv+26. London: H.M. Stationery Office, 1960. *3s. 6d.* net), emphasizes that the noise factor should be considered at the earliest stages in the planning of a factory. Choice of the manufacturing method, which largely determines the noise-level and its effect on the occupants of the factory and residents in the area, is the responsibility of the management. Noise at source can be reduced by machine manufacturers in the design of their machines, but where this is not possible, factory engineers can minimize the effect by taking precautions in the installation of the machines, and the building designer can reduce annoyance by siting noisy equipment away from other buildings and by the use of enclosures and sound-absorbing roof linings.

The 26-page booklet consists of two parts. Part 1 deals with the properties of sound and explains the terms used, the sources of noise in factories, and the effects of noise. It is pointed out that the most intense noise in factories is generally caused by machine tools and by operations involved in making and handling the product, and it is only when the process is a quiet one that the noise from service equipment, such as fans, pumps and compressors, may be the more intense. Excessive noise will influence the welfare, safety and, indirectly, the efficiency of the occupants of the factory. As the level of noise increases, its effect on people is first annoyance, then interference with communication and, finally, damage to hearing. In addition, since noise is associated with vibration, the performance of delicate equipment in the factory may be upset, and if the noise is transmitted through the factory structure or through the ground to the outside of the factory, it may also cause discomfort.

In Part 2, methods for the reduction of noise and their effectiveness are discussed. The radiation of noise, resonance and damping, and vibration isolation are dealt with first, then noise reduction and lay-out, enclosures to reduce noise, sound-absorbing materials, partial enclosures and screens, and finally ear protection. The most effective way of controlling noise once it has been generated and radiated is to contain it within an enclosure, a reduction of about 50 db. being readily provided by an ordinary building enclosure; but the efficiency of an enclosure depends on its completeness and uniformity, and direct air leaks through a hole or through porous material reduce the efficiency considerably. The build-up of reverberant sound within an enclosure can be controlled by the use of sound-absorbing materials to reduce the amount of sound reflected. The booklet gives a list of absorption coefficients of common sound-absorbing materials and contains illustrations of various sound-absorbing arrangements in factories. For individual ear protection, where operators of noisy machines are exposed to high levels of noise, two forms of commercially available 'ear defenders' are ear plugs and ear muffs. Ear plugs are inexpensive, small and inconspicuous, but may be uncomfortable when first worn. Dry cotton wool is not an effective ear plug. Ear muffs fit over the ears, and though heavier and more expensive than ear plugs, they give greater reduction of noise. In the latest types the seal around the ear is made by a plastic cushion partly filled with liquid, and the muff is very comfortable to wear even for long periods of time.

S. Weintroub

PENETRATION OF CHARGED PARTICLES IN MATTER

DURING September 15–18, 1958, an informal conference was held at Gatlinburg, Tennessee, to discuss the penetration of charged particles in matter. Penetration of Charged Particles in Matter: Proceedings of an Informal Conference, Gatlinburg, Tennessee, September 15–18, 1958. Edited by A. Vehling. (Nuclear Science Series, Report No. 29. Publication No. 752.) Pp. x+174. (Washington, D.C.: National Academy of Sciences—National Research Council, 1960.) 2 dollars.) The conference, which was attended by about fifty scientists from Canada, Europe, Asia and the United States of America, was organized by the Sub-committee on Penetration of Charged Particles in Matter of the National Academy of Sciences—National Research Council and sponsored by the United States Atomic Energy Commission, National Science Foundation, and the Air Force Office of Scientific Research.

About twenty-five talks were given and the proceedings of the conference, edited by E. A. Vehling of the University of Washington, have now been published. Topics ranging from the reliability of experimental data to new approaches in the theoretical description of energy-loss mechanisms were discussed. The papers are presented under five headings: stopping power and range, recent developments in the theory of stopping power, charge-changing collisions, atomic and molecular scattering, ionization in gases by high-energy particles, and microscopic and macroscopic energy-loss distributions.

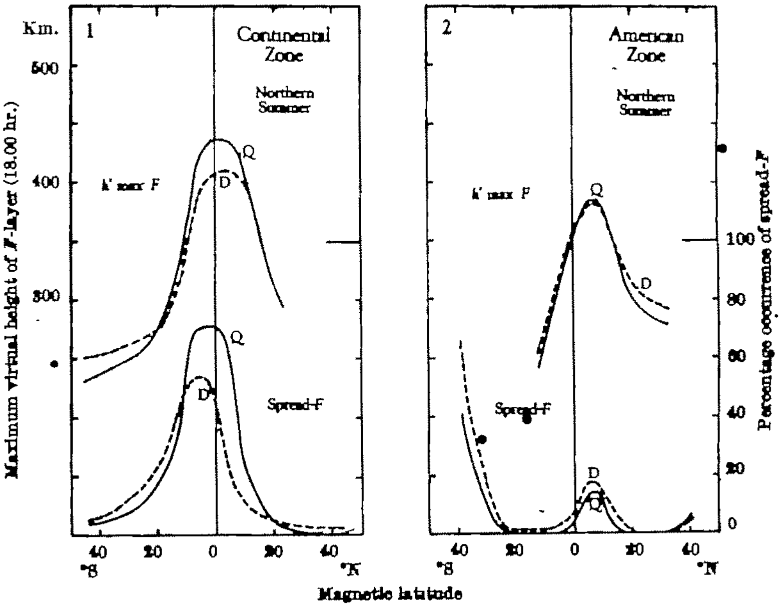
Prof. S. K. Allison, who introduced the papers on charge-changing collisions, discusses measurements on the formation of negative lithium ions, and C. Y. Fan explains briefly the spectroscopic study of electron-capture processes. U. Fano summarizes the various theoretical reviews given in the final section of the proceedings dealing with energy-loss distributions and adds an appendix in which he comments on 'collective' effects in atoms and in extended media. J. B. Hasted, of University College, London, the only representative from the United Kingdom, reports on coincidence methods of studying inelastic ionic collisions.

The articles have been prepared either by the speakers or by the chairmen of the various sessions in collaboration with the speakers. In some instances the reports include the results of the subsequent discussions. In a few cases the original reports have been shortened or reduced to abstract form because of publication of the full report elsewhere. References are given.

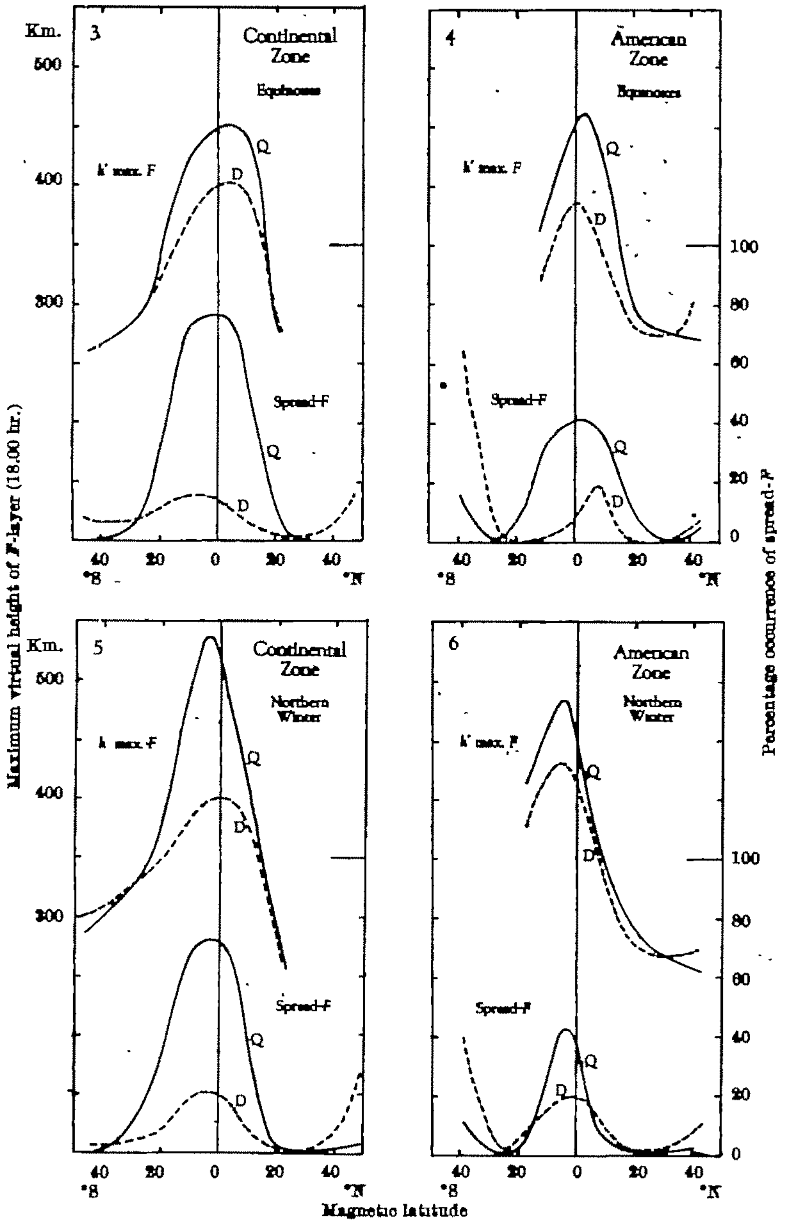
EQUATORIAL SPREAD-*F* AND *F*-LAYER HEIGHTS

By DR. A. J. LYON and DR. N. J. SKINNER
University College, Ibadan, Nigeria
AND
PROF. R. W. WRIGHT
University College of Ghana, Legon, Ghana

WE recently reported[1] on the surprising inverse correlation observed near the magnetic equator between the occurrence of spread-*F* echoes and magnetic disturbance, in contrast to the direct correlation observed at temperate latitudes. The evidence then presented related to the exceptionally disturbed month of September 1957, and was derived from observations at only a few ionospheric stations. We have now extended our analysis to cover a twelve-month period of the International Geophysical Year (November 1957–October 1958), and have used observations from about sixty stations distributed over a wide range of magnetic latitude. In addition we have made a parallel study of the rapid rise in the height of the equatorial *F*-layer which occurs just after local sunset (from about 300 km. to more than 400 km. in 1–2 hr.). It



Figs. 1 and 2



Figs. 3–6. Variations of $h'_{\max.}$ F, the maximum value of $h'F$ in the six hours after local sunset, and of the percentage occurrence of spread-F, both plotted against magnetic latitude, for magnetically quiet (Q) and magnetically disturbed (D) conditions

was noted many years ago[2,3] that this rise occurs just prior to the development of the spread-F condition.

The twelve months under review were divided into three 'seasons', and the stations were divided into two zones, the American zone and the 'Continental zone' comprising Europe, Africa, and Asia. The mean percentage frequency of the occurrence of spread-F at night, and the mean maximum virtual height ($h'_{\max.}$ F) reached by the F-layer in the early part of the night, were computed both for magnetically quiet and for magnetically disturbed conditions for all the stations. The spread-F index was derived mainly from published tables of f_0F_2, but was checked whenever possible by reference to the ionograms. The results of this analysis are summarized in Figs. 1–6. The upper curves refer to heights and the lower ones to the spread-F index in each case, and both parameters are plotted against magnetic latitude.

A number of conclusions may be drawn from these graphs.

(1) The equatorial belt, within which spread-F is a common occurrence under magnetically quiet conditions, extends from roughly 20° north to 20° south of the magnetic equator. The smaller incidence in the American zone is at least partly due to different conventions in scaling the data. There is probably little if any difference in the general incidence of spread-F between the hemispheres. Only in one case (northern summer, American zone, Fig. 2) is the belt substantially narrower.

(2) Within this belt there is in general a sharp diminution of spread-F during magnetic disturbance. (Again only American summer is exceptional.)

(3) The change-over to a direct correlation between spread-F and magnetic activity generally occurs at about 30° N. or 30° S. magnetic latitude.

(4) In the American zone there is a small seasonal movement (about ± 5°) of the maximum of the spread-F belt, but no corresponding movement has been detected in the other region.

(5) Comparison of the upper and lower curves in Figs. 1–6 shows that there is a remarkably close coincidence between the spread-F belt and the belt of steep post-sunset rise in $h'F$. The widths of the belts and the positions of the maxima agree very well; in particular, in the American zone the belt of rising $h'F$ follows exactly the seasonal movement of the spread-F belt. Moreover, the reduced spread-F incidence during magnetic disturbance corresponds to reduced rise of $h'F$ in every case. Perhaps most convincing of all, in the one exceptional case where there is no reduction in spread-F during magnetic disturbance (Fig. 2), there is also no reduction in the rise of $h'F$; and indeed in this case both the rise in $h'F$ and the spread-F incidence are the smallest.

The remarkable correlation between the occurrence of spread-F and the prior rise of height of the layer might be accounted for in terms of Martyn's theory[4], which ascribes the irregularities producing spread-F to upward vertical drift of ionization. Alternatively, it might be considered to support the theory of Dessler[5] that spread-F arises from hydromagnetic waves of extra-terrestrial origin propagated downwards and "channelled by refraction into the 400 km. level". The evidence of Figs. 1–6 might well suggest that a height of about 400 km. is critical for the formation of spread-F. However, neither theory appears to account satisfactorily for the fact that equatorial spread-F usually continues throughout the night, even although after about 20 hr. the height of the layer decreases and for much of the night is below 300 km.

The results summarized above will shortly be published in greater detail elsewhere.

---

[1] Lyon, A. J., Skinner, N. J., and Wright, R. W., *Nature*, 181, 1724 (1958).

[2] Booker, H. G., and Wells, H. W., *Terr. Mag.*, 43, 249 (1938).

[3] Osborne, B. W., *J. Atmos. Terr. Phys.*, 2, 66 (1951).

[4] Martyn, D. F., *Proc. Inst. Rad. Eng.*, 47, 147 (1959).

[5] Dessler, A. J., *J. Geophys. Res.*, 63, 507 (1958).

A NEW LIMIT TO THE GALACTIC MAGNETIC FIELD SET BY MEASUREMENTS OF THE ZEEMAN SPLITTING OF THE HYDROGEN LINE

By DR. R. D. DAVIES, C. H. SLATER, W. L. H. SHUTER and P. A. T. WILD

Nuffield Radio Astronomy Laboratories, Jodrell Bank, University of Manchester

THE existence of a magnetic field in the Milky Way system has been inferred from the regularity in direction of polarization of the light from distant stars, from the isotropy of high-energy cosmic rays and the presence of galactic radio-frequency emission attributed to the synchrotron mechanism. However, none of these observations gives a direct measure of the magnitude of the galactic magnetic field; various estimates of the magnetic field in the galactic disk based on these data give values in the range $0{\cdot}5 \times 10^{-5}$ oersted to 3×10^{-5} oersted.

The Zeeman splitting of the line radiation from interstellar neutral hydrogen can be used as a technique for detecting weak interstellar fields. The line-of-sight component of the magnetic field gives rise to a splitting of the radiation into left- and right-hand circularly polarized components separated by 2·8 mc./s. per oersted. The effect is most readily measurable in the narrow deep absorption features in the spectra of the intense radio sources. A previous attempt to detect the field in this way gave an upper limit of 5×10^{-5} oersted[1]. The present article describes further experiments which set a new limit to this interstellar magnetic field.

The three deep lines in the Cassiopeia-*A* absorption spectrum were studied. One is caused by a cloud in the Orion arm and two by clouds in the Perseus arm. The narrow feature investigated in the Taurus-*A* spectrum is in the Orion arm and that in the Sagittarius-*A* spectrum is in the 3 kiloparsecs expanding arm. The positions of all the five clouds studied are indicated schematically in Fig. 1. The experiment was conducted in two parts; the Orion arm cloud and the 'near' Perseus arm cloud of the Cassiopeia-*A* spectrum were measured in the period March 6–22, 1960, while the three other clouds were investigated during May 26–June 7, 1960.

The experimental technique consisted of controlling the 250-ft. radio telescope to follow the required radio source and switching the receiver to accept left-hand and then right-hand circular polarization once every 24 sec. This polarization switching was effected by rotating a quarter-wave dielectric plate from one plane to the other of the square wave-guide section which illuminated the paraboloid. The receiver incorporated a phase-sensitive detector and would respond to any Zeeman splitting since this would produce a phase-sensitive component with a 24-sec. period. The half-power band-width used was 7 kc./s. in all measurements except those on the narrow feature in the Taurus-*A* spectrum, where it was 4 kc./s. A given absorption feature was then scanned in frequency using a variable second local oscillator. 60–100 such scans were taken on each of the five absorption lines.

Each of the absorption profiles was analysed for the presence of a magnetic field in the following way. About 40 of the best scans were added together to obtain a mean curve. If polarization were present this curve would have the shape of the differential of the absorption profile and for any given profile the amplitude of this expected curve would be directly proportional to the strength of the magnetic field. As an example, the mean curve and the absorption profile observed in the Orion arm cloud in the Cassiopeia-*A* spectrum are shown in Fig. 2. Each mean curve was then fitted by an expected curve the amplitude of which gave the least-squares deviation, and the magnetic field corresponding to this curve is given in column five of Table 1 together with the

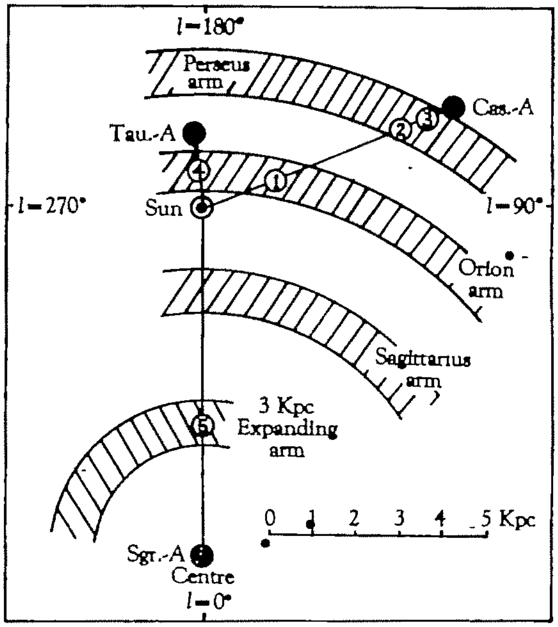


Fig. 1. Schematic diagram of the neutral hydrogen arms of the Galaxy showing the positions of the radio sources Cassiopeia-*A*, Taurus-*A* and Sagittarius-*A* (filled circles), and the absorbing clouds (open circles) studied in this investigation

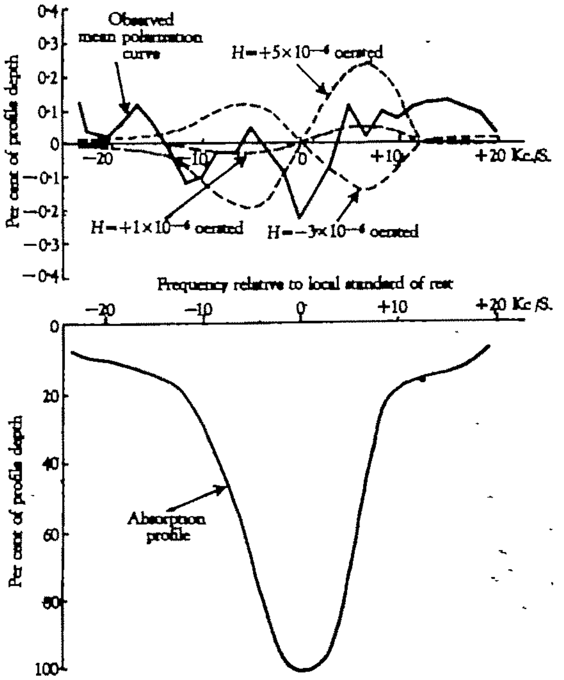


Fig. 2. Limits of the magnetic field in the Orion arm cloud in the direction of Cassiopeia-*A*. The full-line plot is the mean of the observed scans and the dotted curves are those for the best fitting magnetic field and the fields a standard deviation different. The plot underneath shows the shape of the Orion arm absorption profile

estimated standard deviation. The magnetic field is tabulated as positive when directed away from the observer.

These results give no positive evidence for a magnetic field in any of the clouds studied. The line-of-sight component of the magnetic field in each of the three clouds in the direction of Cassiopeia-*A* is less than 1 × 10⁻⁵ oersted, and indeed for the case of the Orion arm cloud it is less than 0·5 × 10⁻⁵ oersted.

Table 1. Limits of the Magnetic Field determined from Absorption Features in Three Intense Radio Sources

	Source	Velocity displacement of absorption feature (km./sec.)	Galactic longitude (new co-ordinates)	Magnetic field (units of 10⁻⁶ oersted)
1.	Cassiopeia-*A* (23*N*5*A*)	− 1 (Orion arm)	112°	+ 1 ± 4
2.	Cassiopeia-*A* (23*N*5*A*)	− 38 (Perseus arm)	112°	+ 1 ± 7
3.	Cassiopeia-*A* (23*N*5*A*)	− 48 (Perseus arm)	112°	− 3 ± 7
4.	Taurus-*A* (5*N*2*A*)	+ 10 (Orion arm ?)	185°	+ 10 ± 10
5.	Sagittarius-*A* (17*S*2*A*)	− 53 (Expanding arm)	0°	+ 14 ± 40

If the magnetic field configuration follows the spiral pattern of the Galaxy the line-of-sight to Cassiopeia-*A* would make an angle of about 30° to the direction of the field. Accordingly the magnitude of the actual field has limits only 15 per cent greater than those given for the Cassiopeia-*A* features shown in Table 1.

The measurements on the Taurus-*A* cloud gave a higher limit to the magnetic field because it is a weaker absorption feature. Nevertheless they show that the radial field of the Galaxy near the Sun is less than 2 × 10⁻⁵ oersted. The cloud studied in the Sagittarius-*A* spectrum shows a radial component of magnetic field less than 5 × 10⁻⁵ oersted. It lies in the 3 kiloparsecs expanding arm where anomalous conditions occur[2] and the magnetic field may be substantially higher than farther out in the galactic disk near the Sun. Here the neutral hydrogen gas is expanding outwards at 50 km./sec. having left regions nearer the centre where the expansion velocity is 200 km./sec.

The upper limit of the magnetic field in the disk of the Galaxy set by this experiment is smaller by a significant factor than that demanded by some theories. The theory of Biermann[3], which explains the synchrotron radio emission from the Galaxy in terms of electrons derived from cosmic rays, requires fields of 2–3 × 10⁻⁵ oersted in the galactic disk. The model of the Galaxy proposed by Elvius and Herlofson[4] postulates a magnetic field of 2 × 10⁻⁵ oersted. Attempts to understand the polarization of starlight[5] have often required fields of greater than 1 × 10⁻⁵ oersted. Such theories may have to be reconsidered in view of the present results.

We wish to thank Prof. A. C. B. Lovell, director of the Laboratories, for making available the facilities for this research. The help gained from discussion with Prof. R. Hanbury Brown is also gratefully acknowledged. The programme of research was supported by a grant from the Department of Scientific and Industrial Research.

[1] Galt, J. A., Slater, C. H., and Shuter, W. L. H., *Mon. Not. Roy. Astro. Soc.*, 120, 187 (1960).
[2] Rougoor, G. W., and Oort, J. H., *Proc. U.S. Nat. Acad. Sci.*, 46, 1 (1960).
[3] Biermann, L., "Present Problems Concerning the Structure and Evolution of the Galactic System", N.U.F.F.I.C. Summer Course (1960).
[4] Elvius, A., and Herlofson, N., *Astrophys. J.*, 131, 304 (1960).
[5] Davis, L., and Greenstein, J. L., *Astrophys. J.*, 114, 206 (1951).

COMPARISON OF THE CHEMICAL COMPOSITION AND MAGNETIC PROPERTIES OF TEKTITES AND GLASSES FORMED BY FUSION OF TERRESTRIAL ROCKS

By Dr. IRVING FRIEDMAN, Dr. ARTHUR THORPE and Dr. FRANK E. SENFTLE
U.S. Geological Survey, Washington, D.C.

It has been suggested by some investigators[1] that tektites are of terrestrial origin and hence were formed in an atmosphere of composition similar to that surrounding the Earth to-day. In particular, Hawkins[2] has pursued the hypothesis that tektites may be a special form of fulgurite. In order to shed more light on this problem an attempt has been made to determine the changes in chemical composition that silicate rocks would undergo when heated to 2,000–3,000° C., in air in a solar furnace. The fused materials were analysed chemically and magnetically before and after fusion.

Table 1. CHEMICAL COMPOSITION OF ROCK MELTS BEFORE AND AFTER HEATING*

	Sand, Big Stone Gap, Va. 3104–2, 3		Bentonite, Phoenix, Ariz. 3104–6, 7		Basalt glass, Hawaii 67–3, 4617–4		Obsidian, Iceland 3024–1 4617–1		Rhyolite, Thomas Mts., Utah, 4617–3A, 3B		Rhyolite, New Mexico, 2–2 3104–4, 5	
SiO_2	89·3	87·0	68·7	68·2	51·8	51·8	73·8	74·7	77·3	76·6	76·7	76·7
Al_2O_3	4·5	6·8	18·6	19·0	15·0	15·0	13·7	14·0	12·6	13·2	13·0	13·1
Fe_2O_3	2·5	1·0	1·2	0·5	0·9	2·4	0·7	0·4	0·9	0·3	0·3	0·3
FeO	1·4	2·5	0·00	0·72	10·3	8·8	1·7	1·9	0·05	0·68	0·79	0·68
MgO	0·39	0·59	6·9	7·1	7·4	7·4	0·12	0·13	0·08	1·0	0·04	0·05
CaO	0·77	1·0	1·2	1·1	11·8	11·7	1·0	1·0	0·75	1·5	0·58	0·51
Na_2O	0·21	0·20	2·9	2·8	2·4	2·4	4·8	4·3	3·4	2·9	4·0	4·0
K_2O	1·1	0·92	0·49	0·53	0·56	0·55	4·0	3·5	5·1	4·7	4·6	4·6
$Na_2O + K_2O$	1·31	1·12	3·39	3·33	2·96	2·95	8·8	7·8	8·5	7·6	8·6	8·6
Fe^{3+}/Fe^{2+}	1·63	0·36	0·91	0·62	0·08	0·24	0·37	0·19	16·2	0·40	0·34	0·40
Magnetic susceptibility χ (10^{-6} e.m.u./gm. units)	41	32	1·38	1·23	17·1	16·0	4·75	3·31	0·2	1·1	11·6	1·41
Magnetization, σ (10^{-4} e.m.u./gm. units)	2,640	660	1·20	0	0	0	50·6	0	19·6	0	107	0
Heating time	45 min.		8 min.		5 min.		15–20 min.		15–20 min.		5 min.	

* Analyses performed by Rapid Rock Analysis Group, U.S. Geological Survey.

The rock samples were heated by placing them at the focal spot of the solar furnace at the U.S. National Bureau of Standards. This unit consists of an 8-ft. square mirror controlled photoelectrically by a heliostat and adjusted to reflect the Sun's light into a 60-in. diameter parabolic mirror of 24-in. focal length. A relatively large specimen is fastened in a holder that can be moved independently around three mutually perpendicular azimuths by means of individual electric motor drives. The operator can view the sample through a small hole in the centre of the parabolic mirror. The hot focus can thus be moved to different parts of the specimen by the motor drives on the sample holder in order to melt an area larger than the focal area. The construction of the furnace makes it necessary to have the sample mounted vertically, and any molten material produced tends to drop off after a relatively short time. This limits the time of heating for those rocks the melts of which are very fluid, such as basalt. In the case of the bentonite and basalt glass, the material dropped off after a few minutes of heating at temperatures estimated to be more than 2,500° C. The more siliceous melts, on the other hand, were far more viscous, and the molten area could be kept hot for periods of 1/2 hr. or more before they dropped off.

The temperature measurements were crude estimates, at best. The melts were far from black bodies, and tended to reflect the Sun into the optical pyrometer, which tended to make the temperature readings high. The value of 2,500 ± 300° C. is thus a rough estimate corrected for reflexion.

Total chemical analyses by the method of Shapiro and Brannock[3] were made on all the unheated and fused specimens. As magnetic measurements have been used to show the state and quantity of iron in glasses (see Senftle and Thorpe[4]), the magnetic susceptibility and saturation magnetization were also measured on all samples before and after heating. The results listed in Table 1 have been reduced to a water-free basis.

In tektites the monovalent alkali oxides (K_2O, Na_2O) are generally lower than the divalent oxides (FeO, MgO, and CaO). It was expected, therefore, that due to loss of volatiles, the chemical composition of the fused rocks might approach the average composition of some of the tektites as shown in Table 2. The loss of silica and alkalis and the concentration of alumina are apparent in most of the samples. However, the changes are small, and one can conclude that much higher temperatures and/or longer periods of heating would be necessary to change the composition of even an obsidian to that of an indochinite, two materials the silica and alumina composition of which are fairly close even before heating.

Another interesting observation is that the ferric–ferrous iron ratio in the fused samples tends to approach the average value of 0·4. The iron in the basalt and rhyolite glasses oxidized whereas that in the obsidian and other more oxidized materials was reduced. The reduction of ferric to ferrous iron in air begins at some temperature between 1,300° C. and 1,400° C. primarily due to the decomposition of Fe_2O_3. Abou-el-azm[5] has examined the change in composition of many silicate glasses with temperature, and has shown that the ferrous iron increases rapidly above 1,400° C. By extrapolation of his results it can be shown that in the region of 1,700° C. the conversion of Fe^{3+} to Fe^{2+} reaches a limiting value. He has also found that if the ferric–ferrous ratio is low (high ferrous iron) initially, part of the ferrous iron tends to be oxidized due to contact of the glass with the air at the surface of the melt, or by oxygen contributed by the other constituents. His work indicates that the melt approaches an equilibrium between Fe^{3+} and Fe^{2+} depending on the available oxygen and the temperature of the melt. Thus, it can be expected that as the temperature is raised above 1,700° C., the ferric–ferrous ratio of fused rock will approach a limiting value for a given oxidizing atmosphere.

In the experimental work reported here the fused rock glass was in contact with 1/5 atmosphere of oxygen at approximately 2,500° C. At this oxygen pressure and high temperature the ferric–ferrous iron ratio appears to approach an equilibrium value of about 0·4. In comparison, the same ratio for tektites is somewhat smaller as shown in Table 2. This difference in the ferric–ferrous ratio between fused rocks and tektites suggests that the tektites were probably heated in a gas phase the partial pressure of oxygen of which was less than 1/5 atmosphere.

If the last heating of the tektites occurred as they passed through the atmosphere, it is possible that the major portion of the heating occurred in the upper atmosphere at oxygen pressures many orders of

Table 2. Average Composition of Tektites (Computed from Data given by Barnes, ref. 6)

	Philippine tektites	Texas tektites	Moldavites	Indochinites	Billitonite and assoc. tektites (not Java)	Australites	Java tektites
SiO_2	71·21	75·64	79·60	73·14	70·50	73·33	73·73
Al_2O_3	12·57	14·59	11·02	12·48	12·53	12·75	11·33
Fe_2O_3	1·47	0·41	0·15	0·19	0·74	0·50	0·53
FeO	4·19	4·00	2·24	4·98	5·27	4·25	4·46
MgO	2·90	1·28	1·30	2·00	3·07	1·98	2·39
CaO	3·19	0·05	1·92	2·51	3·14	3·01	2·49
Na_2O	1·52	1·86	0·51	1·45	1·75	1·25	1·15
K_2O	1·93	1·85	3·00	2·40	2·28	2·05	2·32
H_2O^+	0·37	0·05	0·07	0·28	0·45	0·19	0·25
H_2O^-	—		0·04	0·10	0·09	0·09	0·06
TiO_2	0·89	0·81	0·80	0·94	0·85	0·67	0·87
MnO	0·11	0·01	0·11	0·13	0·16	0·16	0·11
	100·35	100·05	101·39	100·60	100·83	100·23	99·99
Fe^{3+}/Fe^{2+}	0·31	0·09	0·06	0·03	0·13	0·11	0·17
Average magnetic susceptibility χ (10^{-6} e.m.u./gm. units)*	$7{\cdot}0_4$	$5{\cdot}2_6$	$2{\cdot}6_5$	$6{\cdot}3_6$	$7{\cdot}5_4$	$6{\cdot}1_6$	$7{\cdot}3_6$

* See Senftle, F., and Thorpe, A. (ref. 4).

magnitude less than at the surface—perhaps as low as 10^{-4} to 10^{-6} atmosphere. As the air density increased, the objects were slowed down and the heat produced was lost more efficiently. This is in accordance with the observation that stony meteorites that are heated sufficiently in their passage through the upper atmosphere to form a fusion crust are cool enough to handle by the time they strike the Earth.

The saturation magnetization, σ, of the molten rocks is similar to that reported for tektites. The data in Table 1 show that, after melting, the magnetization dropped to zero (with the exception of the sand specimen from Big Stone Gap, Virginia) in accordance with similar measurements on tektites reported by Senftle and Thorpe[4]. Zero magnetization indicates complete solution of the iron, and one therefore concludes that complete solution of the iron has taken place in these melts within the heating time. The above authors have previously shown evidence that the minimum heating time necessary to dissolve particulate iron oxide is probably of the order of 1 min. for temperatures of the order of 2,000° C. and maybe slightly less for higher temperatures. For the experimental temperatures and chemical composition, the heating time shown here can be considered ample to produce tektite-like glass. The heating period of tektites is probably greater than one minute, but not necessarily larger than fifteen minutes, except perhaps for specimens containing a very high silica content, for example, Libyan Desert glass (this glass is not considered to be a true tektite by some investigators).

The change in the value of the magnetic susceptibility is not considered too important from the point of view of the formation of tektites. Its magnitude simply reflects the total iron content, and the observed changes can be explained by the solution of the iron in the glass. Thus, the high susceptibility for the sandstone is due to incomplete solution of the iron in the glass, whereas the high value for basalt glass is due to the high iron content. The rest of the rocks contain less iron than most tektites, and hence their corresponding magnetic susceptibilities are lower than those of tektites.

Table 3 shows the results of the magnetic measurements on the unheated and fused rock in which tektites have been found. The values of the magnetic susceptibility and saturation magnetization are not too unlike that for tektites in general, but the results show that the magnitude of the susceptibility is quite different from that of the tektites found in the area. It indicates that the moldavite contains less iron than the enclosing sand, whereas bediasites contain more iron than the local rock. One cannot help but conclude that tektites are not formed from the local rock in which they are found, for example, by local surface heating or effects of lightning.

In summary, the chemical and magnetic measurements of several types of rocks have been made before and after fusing at 2,500° C. in air at atmospheric pressure. The changes in composition indicate that tektites were either (*a*) melted at temperatures in excess of 2,500° C., or (*b*) heated at this temperature for periods in excess of 20 min. Thus, the small change noted in the composition suggests that the observed composition of tektites probably reflects the composition of the material from which they came. The larger ferric–ferrous ratio of the fused rocks compared to that of tektites suggests that the tektites were melted in an oxygen atmosphere the pressure of which was less than that on the surface of the Earth. The changes observed in the magnetic properties indicate that a heating period of 15–20 min. at 2,500° C. is sufficient to produce magnetic properties similar to those of tektites, but does not preclude the possibility of longer periods of heating. Comparison of the magnetic susceptibility of tektites and the melted rock from the same location show that tektites could not be formed from the rocks in which

Table 3. Comparison of the Magnetic Properties of Tektites and the Glass made from the Enclosing Rock Formation

Sample	Magnetic susceptibility χ (e.m.u./gm.)	Saturation magnetization (e.m.u./gm.)
Sand from Nechov, Bohemia*	$3{\cdot}35 \times 10^{-6}$	$31{\cdot}5 \times 10^{-4}$
Glass made from sand	$6{\cdot}45 \times 10^{-6}$	0
Moldavite from the same site*	$2{\cdot}04 \times 10^{-6}$	0
Sandstone from Wellborn sandstone of the Jackson group, Texas†	$2{\cdot}46 \times 10^{-6}$	$1{\cdot}2 \times 10^{-4}$
Glass made from sand	$2{\cdot}41 \times 10^{-6}$	0
Bediasites from Texas	$4{\cdot}2–5{\cdot}4 \times 10^{-6}$	0

* Specimens collected and contributed by A. J. Cohen, Mellon Institute, Pittsburgh, Pa.

† Specimen collected and contributed by G. S. Hawkins, Boston University Observatory, Boston, Mass.

they are found. The above data suggest that tektites were not formed by heating of surface material *in situ* or by lightning.

We are indebted to Dr. Van Valkenburg of the U.S. National Bureau of Standards for use of the solar furnace. We also thank our colleagues who contributed specimens or helped us by their critical discussions.

Publication of this article is authorized by the Director of the U.S. Geological Survey.

[1] Symposium on Tektites, *Geochim. Cosmochim. Acta*, 14 (1958).
[2] Hawkins, G. S., *Nature*, 185, 300 (1960).
[3] Shapiro, L., and Brannock, W., U.S. Geol. Survey Bull., 1036-*C* (1956).
[4] Senftle, F. E., and Thorpe, A., *Geochim. Cosmochim. Acta*, 17, 234 (1959).
[5] Abou-el-azm, A., *Trans. Soc. Glass Tech.*, 38, 101 (1954).
[6] Barnes, V. E., Univ. of Texas Pub., 3945, 477 (1940).

ZONE ELECTROPHORESIS OF ANTHOCYANINS

By Prof. P. MARKAKIS

Food Science Laboratory, Michigan State University, East Lansing, Michigan

THE molecule of anthocyanins has been considered ionic since the classical studies of Willstätter[1]. Migration of these pigments in an electric field should, therefore, be expected. Recently, Schmidt and Schönleben[2] and Wyler and Dreiding[3] observed that the red beet pigment, the anthocyanic nature of which is still in doubt, does show electrophoretic migration.

In this article it is reported that the typical anthocyanins of sour cherries, strawberries, plums and roses, when placed within an electric field applied across filter paper (or cellulose powder), move to the anode or the cathode, depending on the pH of the electrolyte solution. The isoelectric points of the two anthocyanins of the tart cherry, *Prunus cerasus* L., var. Montmorency, are also given, along with the observation that the isoelectric points of these anthocyanins seem to coincide with the pH at which the pigments display minimum colour.

The Montmorency cherry pigments were in a 70 per cent ethanol extract saved from a parallel experiment on the pectins of this fruit. This extract was stored at 0° C. and aliquots were concentrated at 40° C. in a vacuum, rotating evaporator. The strawberry anthocyanins were extracted with n-butanol, and those of the dried rose petals or plum skins with methanol. The extracts were shaken with enough petroleum ether, or ether and petroleum ether, to precipitate the pigments in a small quantity of 1 per cent aqueous hydrochloric acid, and this concentrated aqueous solution of pigment was subjected to paper electrophoresis.

The concentrates of the anthocyanins of various origins were streaked on strips of a Spinco model *R* paper electrophoresis apparatus. A variety of electrolytes such as phosphoric acid, acetic acid, formic acid, or their sodium salts, in concentrations of 0·1 or 0·01 M, were found suitable for the electrophoretic separation of the pigments. After the application of a voltage gradient of 7–8 V.cm.$^{-1}$ for 5–10 hr., the pigments generally moved toward the cathode, if the pH of the electrolyte was below 6, and toward the anode if the pH was above 7. To render the pigmented zones more visible after runs close to the isoelectric point or the alkaline side of it, the strips were exposed to hydrochloric acid fumes. Fig. 1 is a photograph of the strips after electrophoresis of the cherry anthocyanins at various pH.

In order to obtain larger quantities of purified cherry anthocyanins for further study, the pigments were separated by means of a Reco model *E*-800-2 flat electrophoresis apparatus. A 5-mm. thick layer of Whatman standard cellulose powder, suspended in 1 M acetic acid, was applied on the plate of the apparatus and the pigment concentrate was streaked at three or four different places across the field. With a voltage gradient of 10–15 V.cm.$^{-1}$, satisfactory separation of the two cherry anthocyanins was achieved after 8 hr. The coloured zones were removed, eluted with methanol, and the eluate was concentrated in the vacuum evaporator at room temperature. The electrophoretically isolated pigments showed the same mobilities on the strip electrophoresis apparatus as those displayed when

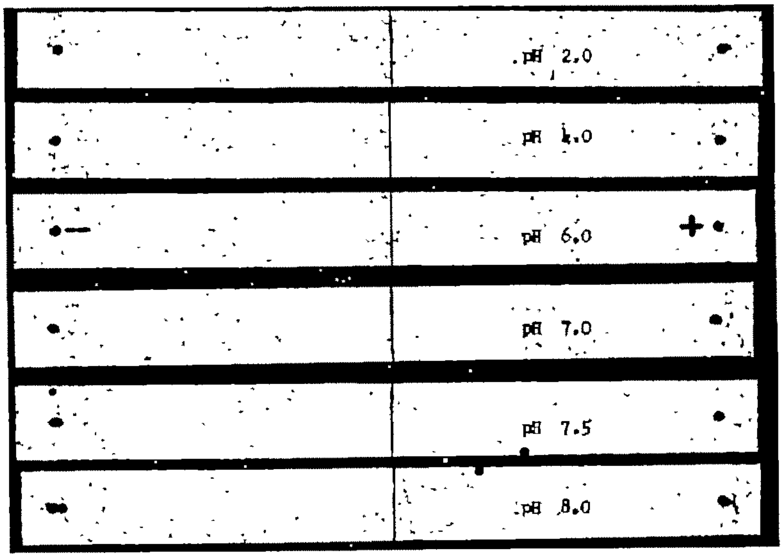


Fig. 1. The anthocyanins of *Prunus cerasus* L. var. Montmorency after paper electrophoresis in a Spinco apparatus. Electrolyte: 0·03 M ortho-phosphoric acid adjusted to various pH's with sodium hydroxide. Voltage gradient. 7 V.cm.$^{-1}$. Duration 5 hr. Room temperature

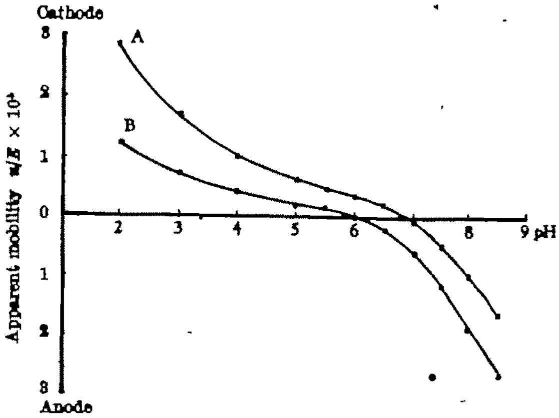


Fig. 2. Apparent electrophoretic mobilities (in cm. per sec. per voltage gradient of 1 V.cm.$^{-1}$) of the Montmorency cherry anthocyanins as functions of pH. Conditions same as in legend of Fig. 1

the original mixture was streaked. Also no difference in mobility was observed when the pigments were first isolated by means of column chromatography (performed with cellulose powder and *n*-butanol : acetic acid : water, 40 : 10 : 12·5 v/v) and then subjected to electrophoresis. The pigment which travelled the fastest in chromatography moved the slowest in acidic electrophoresis.

Consequently, the original mixture was deemed adequate for ascertaining the electrophoretic mobilities at various *p*H's and the isoelectric points of the individual cherry pigments. The mixture was further dried *in vacuo* to a syrupy mass, which was then diluted with 0·03 *M* phosphate buffer of various *p*H's and streaked on the strip apparatus. After electrophoresis under the conditions described in the legend of Fig. 1, the apparent electrophoretic mobility (not the real mobility of the molecules in the tortuous path of the paper capillaries) was calculated. The electro-osmotic correction was estimated for each *p*H by means of the dextran indicator as described by Kunkel and Tiselius[4]. The corrected values are graphically presented in Fig. 2. It appears that the isoelectric point of pigment *A* is 6·9 and that of *B*, 6·0.

To test the hypothesis that the isoelectric point and the *p*H of minimum colour display coincide, the electrophoretically isolated cherry anthocyanins were dissolved in 1 *M* citric acid–sodium hydroxide buffer of various *p*H's, and the absorption spectrum of the solutions was measured by means of a Beckman *DK*-2 recording spectrophotometer. In the red region (500–530 mμ) in which these pigments show a maximum of absorption, the least optical density was found to be very close to the isoelectric point, as is indicated in Table 1.

Since the Montmorency cherry anthocyanins have been characterized[5], it was easy to identify the electrophoretic fractions *A* and *B*. Both paper chromatography and the sodium carbonate test[6] indicated that pigment *A* is the mecocyanin and pigment *B* the antirrhinin of Li and Wagenknecht[5].

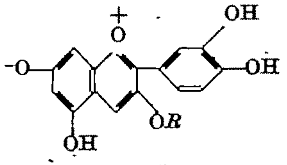
Table 1. OPTICAL DENSITIES AT 520 mμ OF THE MONTMORENCY CHERRY ANTHOCYANINS IN SODIUM CITRATE BUFFER AT VARIOUS *p*H'S

*p*H	Anth. *A*	Anth. *B*
3·0	0·678	0·688
4·0	0·160	0·155
5·0	0·124	0·108
5·5	0·106	0·105
6·0	0·088	0·098
6·5	0·085	0·110
7·0	0·084	0·119
7·5	0·086	0·120
8·0	0·087	0·122

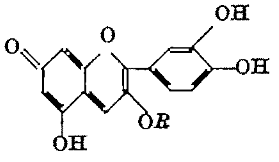
Experiments in progress on the separation of anthocyanins by paper curtain continuous electrophoresis are encouraging.

In view of the findings described, paper electrophoresis appears as a promising method of separation, purification, characterization and preparation of anthocyanins. It is still unknown, however, whether it will be as widely applicable as the chromatography of these pigments.

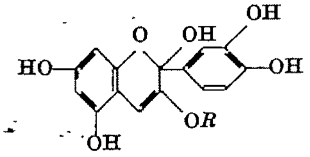
From the structural point of view, the formulæ proposed by Ingold[7] and Sondheimer[8] may account for the electrophoretic and chromatic behaviour of the anthocyanins studied. At the isoelectrical point of antirrhinin, for example, all eight of Ingold's forms—four tautomers differing in the distribution of the phenolic protons, each tautomer being mesomeric between a betanoid and a quinonoid form, such as the pair I and II—and Sondheimer's pseudobase III can explain the electrophoretic immobility; the pseudobase, however, may be the dominant form, since its interrupted conjugated bond system is more compatible with the lack of colour at this *p*H. On the acidic side of the isoelectric point, form IV should prevail, although the rather unstable oxonium forms involving the phenolic oxygens may be present. At *p*H higher than the isoelectric point, the oxonium configuration probably disappears and the negatively charged tautomers of type V constitute the dominant forms.



(I)

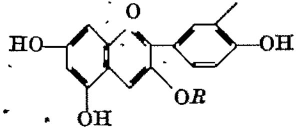


(II)

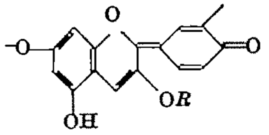


(III)

R = rhamnoglucoside



(IV)



(V)

Acknowledgment is made of the technical assistance of Miss S. Krishna.

---

[1] Willstätter, R., and Everest, A. E., *Liebigs Ann.*, 401, 189 (1913).

[2] Schmidt, O. L., and Schönleben, W., *Naturwiss.*, 43, 159 (1956).

[3] Wyler, H., and Dreiding, A. S., *Helv. Chim. Acta*, 40, 191 (1957).

[4] Kunkel, H. O., and Tiselius, A., *J. Gen. Phys.*, 35, 89 (1951).

[5] Li, K. C., and Wagenknecht, A. C., *J. Amer. Chem. Soc.*, 78, 979 (1956).

[6] Willstätter, R., and Zollinger, H. H., *Liebigs Ann.*, 412, 164 (1916).

[7] Ingold, C. K., "Structure and Mechanism in Org. Chem." (Cornell Univ. Press, 1953).

[8] Sondheimer, E., *J. Amer. Chem. Soc.*, 75, 1507 (1953).

USE OF FERRITIN-CONJUGATED ANTIBODY TO LOCALIZE ANTIGEN BY ELECTRON MICROSCOPY

By RICHARD A. RIFKIND*, KONRAD C. HSU, COUNCILMAN MORGAN,
BEATRICE C. SEEGAL, ALICE W. KNOX and HARRY M. ROSE
Department of Microbiology, College of Physicians and Surgeons, Columbia University, New York

THE conjugation of ferritin with globulin, as described by Singer[1], provides a reagent which allows adaptation of the basic principle of immunofluorescent staining[2] to electron microscopy. The ferritin molecule, a protein of molecular weight about 700,000, contains a central core, 55–60 Å. in diameter, of four ferric hydroxide particles which are sufficiently dense to be readily identified in electron micrographs[3–5].

Horse spleen ferritin[6,7] (supplied by courtesy of Dr. A. Mazur, Cornell University Medical College, and the Sylvana Chemical Co., Orange, New Jersey) and antibody globulin[8] were conjugated according to Singer's method[1] with minor modifications, as follows: 4 ml. of a 1·8 per cent solution of purified amorphous ferritin were mixed with 2 ml. of 0·3 M borate buffer (pH 9·5) to achieve a final 0·1 M buffer solution. 0·12 ml. of *m*-xylylene di*iso*cyanate (supplied by courtesy of the Carwin Co., North Haven, Conn.) was added, the mixture was stirred for 45 min. at 0° C., left to stand 1 hr. and centrifuged for 30 min. in the cold. The supernatant was removed from the unreacted xylylene di*iso*cyanate, which was discarded. The ferritin–xylylene *iso*cyanate complex and the immune globulin were mixed on a weight-for-weight basis and buffered with 0·1 M borate buffer. Sodium chloride was added to 1 M concentration. The mixture was stirred at 4° C. for 48 hr., dialysed against 0·1 M ammonium carbonate overnight and dialysed an additional two days with 0·1 M phosphate buffer (pH 7·5). It was then centrifuged, the supernatant passed through a 'Millipore' filter and stored for use.

In order to ascertain the effect of conjugation on the reactivity of antibody with its homologous antigen, a hæmagglutination system with conjugated antibody to purified bovine serum albumin was used. By means of Boyden's technique[9], as modified by Heller *et al.*[10], tanned sheep erythrocytes were coated with bovine serum albumin and exposed to serial dilutions of ferritin-anti-bovine serum albumin. It was found that conjugation with ferritin did not reduce the hæmagglutinin titre of the anti-bovine serum albumin globulin. The agglutinated red cells were washed, lysed with saponin, washed again repeatedly and dried from suspension on 'Formvar'-coated grids. Electron microscopic examination revealed numerous ferritin particles on the red cell stromata. Controls included unconjugated anti-bovine serum albumin globulin mixed with ferritin, a non-specific ferritin-conjugated antibody (rabbit anti-pneumococcus type 15 globulin) and purified ferritin alone.

The technique was applied to the identification of viral antigens in tissue using influenza virus, *PR*8 strain, which was inoculated by the allantoic route into 11-day-old chicken embryos. After incubation at 35° C. for 44–48 hr., portions of infected chorio-allantoic membranes, still attached to the egg shell, were placed for 1–60 min. at room temperature in ferritin-conjugated chicken anti-*PR*8 globulin which had been absorbed overnight with acetone-extracted chicken embryo powder. (This anti-*PR*8 globulin had not lost any appreciable hæmagglutinin-inhibition titre in the course of conjugation with ferritin.) After washing in Tyrode's solution the membranes were detached from the shell, fixed for 20 min. in buffered osmium tetroxide, dehydrated in graded dilutions of ethanol, trimmed, embedded in N-butyl methacrylate, sectioned on a Porter–Blum microtome and examined in an R.C.A. *EMU-2E* electron microscope.

In work using the fluorescent antibody technique, it has been repeatedly demonstrated that in the course of influenza and fowl plague infection viral antigen eventually concentrates at the cell surface[11–13]. Previous work in this laboratory has elucidated the morphology of the virus and shown that it differentiates at the cell surface of the infected chorio-allantoic membrane[14]. Fig. 1 illustrates a thin section through the superficial portion of a chicken chorio-allantoic cell infected with *PR*8 influenza virus and afterwards exposed to ferritin-conjugated anti-*PR*8 globulin for 1 hr. (Subsequent experiments have shown that optimal specific tagging of the virus is achieved in 2 min.) The limiting membrane, which traverses the lower border, has been cut obliquely and is therefore poorly defined. Extending upward into the chorioallantoic space is a cellular protrusion. On the cellular surface are scattered oval viral particles which exhibit a poorly defined core, a dense limiting membrane and a diffuse outer coat. Serial sections[14] have shown that structural appearance of the particles depends on the level at which they are cut: they are relatively dense and sharply

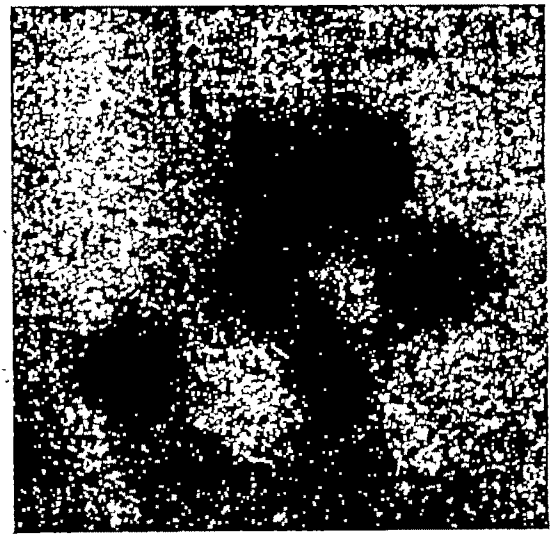


Fig. 1. Influenza virus at the cell surface. Ferritin granules associated with the viral particles are clearly visible. (×170,000)

defined when sectioned centrally, but appear less dense and more diffuse when the plane of section is eccentric. The opaque, sharply defined ferritin granules are attached to the diffuse outer coat of the virus. As may be seen in several instances, ferritin overlies the viral particle when it is eccentric to the plane of section. It is likely that with our present methods all the antibody is not conjugated with ferritin and hence determination of the precise arrangement and number of antigenic units on the viral surface must await further study. As a control to the foregoing experiments, chorioallantoic membranes were infected with the Lee strain of influenza virus and treated in an identical manner with ferritin-conjugated anti-*PR*8 globulin. Although a few scattered ferritin granules were present on these cells, there was no predilection for the viral particles. Likewise, *PR*8-infected membranes exposed to other non-specific ferritin-conjugated antibodies (rabbit anti-pneumococcus type 15 globulin and duck anti-rabbit-globulin globulin) showed only sparse and randomly distributed ferritin particles. Further to document the specificity of the reaction, *PR*8-infected membranes were exposed to unconjugated anti-*PR*8 globulin for 1 hr., then washed and placed in ferritin-conjugated anti-*PR*8 globulin for 2 min. This resulted in no localization of ferritin on the virus, whereas an infected membrane exposed for 1 hr. to normal serum before immersion in ferritin-anti-*PR*8 globulin showed characteristic tagging of the virus.

---

* Fellow of the National Foundation.

It appears that ferritin-conjugated antibody globulin maintains its serological specificity and thus renders visible in the electron microscope the sites of antigen–antibody interaction. Within the limits of these experiments it has been shown that tagging of virus with ferritin-conjugated antibody is specifically blocked by prior treatment with unconjugated antibody globulin. Work is in progress to modify the technique so that identification and localization of intracellular antigens may become possible.

These investigations were conducted under the auspices of the Commission on Influenza, Armed Forces Epidemiological Board, and were supported in part by the Office of the Surgeon General, Department of the Army, Washington, D.C., by a grant from the National Foundation, and USNIH grant *H*-3929*C*.

[1] Singer, S. J., *Nature*, 183, 1523 (1959).
[2] Coons, A. H., and Kaplan, M. H., *J. Exp. Med.*, 91, 1 (1950).
[3] Farrant, J. L., *Biochim. Biophys. Acta*, 13, 569 (1954).
[4] Harrison, P. M., *J. Molec. Biol.*, 1, 69 (1959).
[5] Kuff, E. L., and Dalton, A. J., *J. Ultrastruct. Res.*, 1, 62 (1957).
[6] Granick, S., *Chem. Rev.*, 38, 379 (1946).
[7] Mazur, A., and Shorr, E., *J. Biol. Chem.*, 176, 771 (1948).
[8] Kekwick, R. A., *Biochem. J.*, 34, 1248 (1940).
[9] Boyden, S. V., *J. Exp. Med.*, 93, 107 (1951).
[10] Heller, G., Jacobson, A. S., Kolodny, M. H., and Kammerer, W. H., *J. Immunol.*, 72, 66 (1954).
[11] Watson, B. D., and Coons, A. H., *J. Exp. Med.*, 99, 419 (1954).
[12] Liu, C., *J. Exp. Med.*, 101, 677 (1955).
[13] Breitenfeld, P. M., and Schäfer, W., *Virology*, 4, 328 (1957).
[14] Morgan, C., Rose, H. M., and Moore, D. H., *J. Exp. Med.*, 104, 171 (1956).

IMMUNOLOGICAL RELATIONSHIPS BETWEEN THE RAT GLOMERULUS AND NEPHRITOGENIC STREPTOCOCCI

By A. S. MARKOWITZ, S. HOWARD ARMSTRONG, Jun., and DANIEL S. KUSHNER

Hektoen Institute for Medical Research, Cook County Hospital, Chicago, Illinois

FOR many years efforts have been made to establish an experimental counterpart for human glomerulonephritis utilizing the streptococcus or its products without notable success. The most recent, by Kelly and Winn[1], employed an intraperitoneal diffusion chamber containing Group *A*, type 12 streptococci. These workers reported that such a procedure led to the establishment of glomerular lesions.

Utilizing such chambers, approximately 10^8 cells of an 18-hr. culture grown in Todd–Hewitt broth were introduced and the side arm sealed off by heat-fusing a polyethylene tube. Strains *NAC*, *NV* and *NVC*, Group *A*, type 12 streptococci were obtained through the generosity of Dr. Elizabeth Potter, Dept. of Medicine, Northwestern Medical School. All strains were originally isolated from the throats of acute glomerulonephritic patients. The chambers were inserted into the peritoneal cavity of female, Holtzman strain rats weighing 150 gm.; removed after 72 hr. and the animals killed one, two, and four weeks from the date of insertion of the chamber. In all instances the kidneys appeared both grossly and histologically normal, that is, within the limits of histological variation in normal rats which show focally increased cellularity of glomeruli and rare casts within tubules. Especially within this context, histopathological interpretations have been made initially by several observers without prior knowledge of the experimental procedure employed and afterwards reviewed in the light of such knowledge. (We are indebted to Dr. Paul B. Szanto, director of pathology of Cook County Hospital, for his critically cautious counsel in histological interpretation as well as for the support of his department's facilities.)

Studies of the virulence of the strains employed revealed no useful LD_{50}, since 10^8 cells failed to affect a single mouse. Virulence enhancement by means of mouse passage was then instituted with one of the strains, *NAC*. The first passage required intraperitoneal introduction of the organisms with an equal volume of a 5 per cent suspension of hog gastric mucin in order to obtain sufficient numbers of bacteria for subsequent splenic homogenate transfers. After 27 passages the *NAC* strain presented an LD_{50} of 10^2 and was then sub-labelled NAC_v.

Introduction of the NAC_v strain into the chambers, implantation for 72 hr. and killing of a group of 12 rats at four weeks consistently produced lesions the maximum degree of which is illustrated in Fig. 1. (A representative glomerulus from a control animal is illustrated in Fig. 2.) The glomerular lesions never approached, either in intensity or in diffuseness, those we have seen in initial biopsies of streptococcal related acute glomerulonephritis in the human. The spotty glomerular changes were uniformly accompanied by eosinophilic casts both in proximal and distal convoluted tubules in numbers far in excess of those seen in control animals.

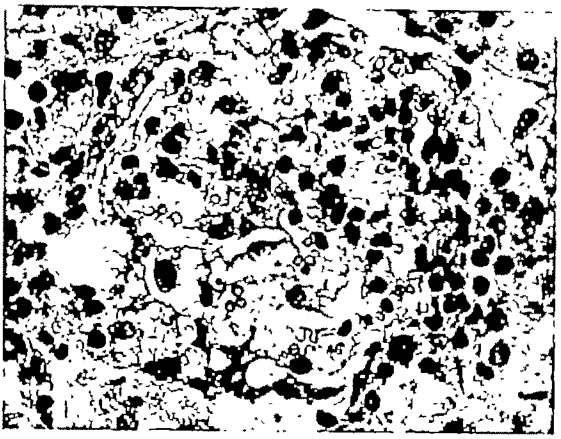


Fig. 1. Cellular, swollen glomerulus Filling out of Bowman's space with free red cells in space; sparse polymorphonuclear leukocytes in glomerular tuft. (×c. 360)

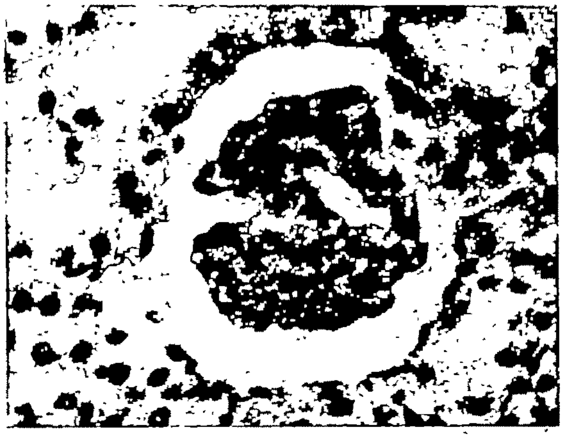


Fig. 2 Normal glomerulus. (×c. 360)

Subsequent to these experiments an additional strain, A_{12}-41, was obtained which after five passages in mice had an LD_{50} of $2\cdot5 \times 10^1$ and within peritoneal chambers induced similar histological changes in a group of 12 animals. (We are indebted to Dr. J. Hayashi, Department of Biochemistry, University of Illinois Medical School, who obtained this Red Lake strain for us through the courtesy of Dr. W. Schmitt of the Cuyahoga County Hospital, Cleveland, Ohio.)

The virulent state of these two strains was maintained by quick freezing (acetone-'dry ice') a 1-ml. broth suspension in ampoules and storing in the cold at −15° C. For diffusion chamber experiments the content of the ampoule was permitted to thaw at room temperature and transferred to a tube of Todd–Hewitt broth. The resultant 18-hr. culture was then introduced into the chambers.

Based upon the results presented above, no satisfactory conclusion could be reached as to the genesis of the renal lesions, that is, toxic or immunological. It has been suggested by one of us (A. S. M.) that the nephritogenic streptococcus and the glomerulus may share an antigenic component in common. Accordingly, an extraction procedure was elaborated in an effort to isolate a soluble, antigenic component from the streptococcus capable of inducing the formation of nephrotoxic antibody.

Whole, heat-killed, washed, 18 hr. old A_{12}-41 cells geny of quick-frozen cells) were suspended in phosphate buffer, *p*H 8, and trypsinized for 4 hr. at 37° C. The supernatant, after removal of particulate matter by centrifugation and Seitz filtration, was treated with an equal volume of 'Genetron' (trifluorotrichloroethane) in the manner of Markowitz and Henderson[2]. The aqueous phase of this treatment was dialysed against water in the cold for 24 hr. and then lyophilized. Rabbits were immunized with 75 mgm. of the extract combined with Freund's adjuvant and the serum obtained was assayed for nephrotoxic activity in the rat. Serum dosages of 0·01 ml. per gm. of body-weight were introduced into the tail veins of a group of 12 rats. Equivalent amounts of control rabbit serum (obtained from animals immunized with Freund's adjuvant plus 0·89 per cent sodium chloride solution) were likewise introduced into a similar group of animals. Fig. 3 represents the most pronounced of glomerular lesions observed in the experimental group killed two weeks after introduction of serum. The sparse focal distribution of such glomeruli, in contrast to the clearly abnormal numbers of tubular casts (also illustrated in Fig. 3), cannot be overemphasized. The group receiving control rabbit serum presented normal renal histology within the range indicated earlier.

Using isolated whole rat glomeruli prepared according to Greenspon[3] as the starting material and the same extraction procedure indicated above, a material was

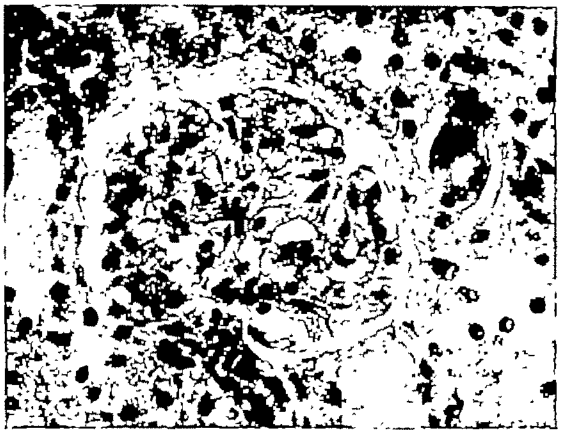


Fig. 3. Glomerulus showing granular precipitate in Bowman's space and a cast in adjacent proximal tubule. (×c 305)

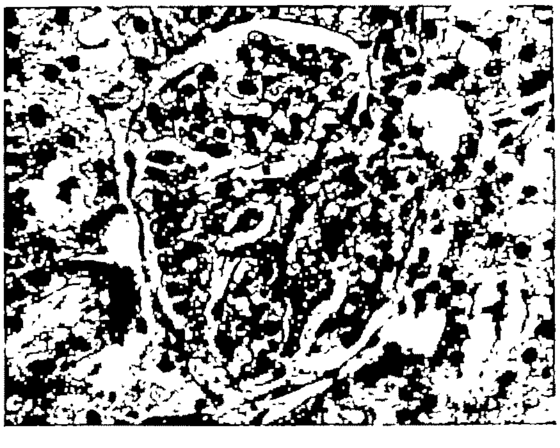


Fig. 4 Moderately hypercellular glomerulus, bridging of Bowman's space; swollen perithelial cells. (×c 315)

NORTH-HOLLAND BOOKS

just *out*

FOUNDATIONS OF GEOMETRY*

by KAROL BORSUK and WANDA SZMIELEW (Warsaw)

CONTENTS: **part one:** Euclidean and Bolyai-Lobachevskian Geometry: 1. Axioms of Incidence; 2. Axioms of Congruence 3. Axiom of Continuity; 4. Models of Absolute Geometry; 5. Euclidean Geometry; 6. Bolyai-Lobachevskian Geometry.

part two: Projective Geometry: 7. Axioms of Incidence and Order; 8. Axiom of Continuity; 9. Models of Projective Geometry.

6x9" IX + 444 pp. 327 ill. Gld. 45.- (90s.)

★

LINCOS

DESIGN OF A LANGUAGE FOR COSMIC INTERCOURSE, PART I

by HANS FREUDENTHAL (Utrecht)

CONTENTS: 1. Mathematics; 2. Time; 3. Behaviour; 4. Space, motion, mass.

With the means now available in LINCOS not only the fundamentals of mathematics and mechanics can be described, but also many features of human behaviour.

6x9" V + 224 pp. Gld. 22.50 (45s.; $ 6.00)

★

SPACE RESEARCH*

PROCEEDINGS OF THE FIRST INTERNATIONAL SPACE SCIENCE SYMPOSIUM. NICE 1960.

Edited by H. K. KALLMANN BIJL (Los Angeles)

Abstracts in English, Russian and French

6¼x9½" XVI + 1200 pp. 650 ill. + 61 plates, Gld. 90.- (170s.)

**SOLE AGENCY FOR U.S.A.: INTERSCIENCE PUBLISHERS INC. - NEW YORK*

NORTH-HOLLAND PUBLISHING COMPANY - AMSTERDAM

RECENT SCIENTIFIC and TECHNICAL BOOKS

Volumes marked with an asterisk (*) have been received at "Nature" Office

Mathematics

HALMOS, Paul R. Lectures on Ergodic Theory 8¼ in × 5½ in. (21 cm. × 14 cm.). Pp. vii+100. (New York: Chelsea Publishing Company.) 2.95 dollars.*

KUROSH, A. G. The Theory of Groups. Translated from the Russian and edited by K. A. Hirsch. Second English edition. Vol. 1: Pp. 272. Vol. 2: Pp. 308. (New York: Chelsea Publishing Company, 1960.) 4.95 dollars each volume.*

LANDAU, Edmund. Grundlagen der Analysis (Das Rechnen mit Ganzen, Rationalen, Irrationalen, Komplexen Zahlen): Ergänzung zu den Lehrbuchern der Differential- und Intergralrechung. Third edition. 8 in. × 5¼ in. (20 cm. × 13 cm.). Pp. 173. (New York: Chelsea Publishing Company, 1960.) 1.95 dollars, paper bound.*

LANGER, Rudolf E. (edited by). Frontiers of Numerical Mathematics: a Symposium conducted by the Mathematics Research Center, United States Army, and the National Bureau of Standards, at the University of Wisconsin, Madison, Wisconsin, October 30–31, 1959. 9½ in. × 6¼ in. (24 cm. × 16 cm.). Pp. xi+132. (Madison, Wisconsin: University of Wisconsin Press, 1960.) 3.50 dollars.*

WHITTAKER, E. T. A Treatise on the Analytical Dynamics of Particles and Rigid Bodies, with an Introduction to the Problem of Three Bodies. Fourth edition. 9 in. × 6 in. (23 cm. × 15.5 cm.). Pp. xiv+456. (London: Cambridge University Press, 1960.) 30s. net; 4.95 dollars, paper bound.*

Physics

AJZENBERG-SELOVE, Fay (edited by). Nuclear Spectroscopy. Part A. Pp. xxi+1–622. Part B: Pp. xvi+623–1147. (Pure and Applied Physics: a Series of Monographs and Textbooks, Vol. 9.) 9¼ in. × 6¼ in. (23.5 cm. × 16 cm.). (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 16 dollars per part.*

ALLIS, William P. (edited by). Nuclear Fusion. (Second Geneva Series on the Peaceful Uses of Atomic Energy.) 9¼ in. × 6¼ in. (23.5 cm. × 16 cm.) Pp. viii+488. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1960.) 94s.; 12.50 dollars.*

CHERNOV, L. A. Wave Propagation in a Random Medium. Translated from the Russian by R. A. Silverman. 10 in. × 7½ in. (25.5 cm. × 19 cm.). Pp. viii+168. (London: McGraw-Hill Publishing Co., Ltd., 1960.) 58s.*

CLAUSER, Francis H. (edited by). Symposium of Plasma Dynamics. (Sponsored by the Air Force Office of Scientific Research. Prepared under the auspices of the National Academy of Sciences.) 9 in. × 6 in. (23 cm. × 15.5 cm.). Pp. ix+369. (London: Pergamon Press; Reading, Mass.: Addison-Wesley Publishing Company, 1960.) 84s. net.*

MENDELSSOHN, K. (edited by). Progress in Cryogenics, Vol. 2. 10 in. × 6¼ in. (25.5 cm. × 16 cm.). Pp. viii+280. (London: Heywood and Co., Ltd., 1960.) 63s. net.*

NILSSON, N. R. (edited by). Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17–21 August, 1959. (Series in Physics.) 11½ in. × 8¼ in. (29 cm. × 21 cm.) Vol. 1: Pp. xii+552. Vol. 2: Pp. viii+553–1210. (Amsterdam: North-Holland Publishing Company, 1960.) £12 6s. the two volumes.*

RIBAUD, G. Conduction de la Chaleur en Régime Variable. (Mémorial des Sciences Physiques, Fasc. 65.) 9½ in. × 6 in. (24 cm. × 15.5 cm.). Pp. iv+90. (Paris: Gauthier-Villars, 1960.) 18 NF.*

ROBERTS, J. K. Heat and Thermodynamics. Fifth edition, revised by Dr. A. R. Miller. 8¾ in. × 6 in. (22 cm. × 15.5 cm.). Pp. xx+619. (London and Glasgow: Blackie and Son, Ltd., 1960.) 45s. net.*

ROCARD, Y. Principles of Electricity and Magnetism. Translated by G. P. Herrenden Harker. 8¾ in. × 5¾ in. (22 cm. × 15 cm.). Pp. x+779. (London: Sir Isaac Pitman and Sons, Ltd., 1959.) 70s. net.*

SEITZ, Frederick, and TURNBULL, David (edited by). Solid State Physics: Advances in Research and Applications, Vol. 10. 9 in. × 6 in. (23 cm. × 15.5 cm.). Pp. xv+516. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 14.50 dollars.*

SLATER, Noel B. Theory of Unimolecular Reactions. 9½ in. × 6¼ in. (24 cm. × 16 cm.). Pp. xi+230. (London: Methuen and Co., Ltd., 1959.) 36s. net.*

STALLO, J. B. The Concepts and Theories of Modern Physics. Edited by Percy W. Bridgman. (The John Harvard Library.) 8½ in. × 5¾ in. (21.5 cm. × 15 cm.). Pp. xxix+325. (Cambridge, Mass.: The Belknap Press of Harvard University Press; London: Oxford University Press, 1960.) 38s. net.*

VIERTER INTERNATIONALER KONGRESS FÜR ELEKTRONENMIKROSKOPIE, Berlin, 10–17 September, 1958. Verhandlungen Band 1: Physikalisch-Technischer Teil. Herausgegeben von G. Mollenstedt, H. Niehrs und E. Ruska. 10¾ in. × 8¼ in. (27 cm. × 21 cm.). Pp. xix+851. (Berlin: Springer Verlag, 1960.) 228 D.M.*

Engineering

ALLEN, E. Using Centrifugal Pumps. 8¾ in. × 5¾ in. (22 cm. × 15 cm.). Pp. xv+246. (London: Oxford University Press, 1960.) 30s. net.*

DRYDEN, H. L., von KARMAN, Th., and KUERTI, G. (edited by). Advances in Applied Mechanics, Vol. 6. 9 in. × 6 in. (23 cm. × 15.5 cm.). Pp. x+294. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 9 dollars.*

HAWTHORNE, W. R., and OLSON, W. T. (edited by). Design and Performance of Gas Turbine Power Plants. (High Speed Aerodynamics and Jet Propulsion, Vol. 11.) 9¼ in. × 6¼ in. (23.5 cm. × 16 cm.). Pp. xiii+563. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1960.) 105s. net.*

ISAAC, Peter C. G. (edited by). Waste Treatment: Proceedings of the Second Symposium on the Treatment of Waste Waters, 14–19 September, 1959. (Organized by the Public Health Engineering Section, Department of Civil Engineering, University of Durham, King's College, Newcastle-upon-Tyne.) 10 in. × 6¼ in. (25.5 cm. × 16 cm.). Pp. xii+477. (London and New York: Pergamon Press, 1960.) 84s. net.*

LANCE, G. N. Numerical Methods for High Speed Computers. 8¾ in. × 5½ in. (22 cm. × 14 cm.). Pp. x+166. (London: Iliffe and Sons, Ltd., 1960.) 42s. net.*

Chemistry : Chemical Industry

3e COLLOQUE DE MÉTALLURGIE CORROSION (Sèche et Aqueuse). (Organisé à Saclay les 29–30 juin et 1er juillet 1959 par M. Salesse, Chef du Département de Métallurgie, sous la Présidence de M. le Professeur Chaudron.) Commissariat à l'Énergie Atomique: Institut National des Sciences et Techniques Nucléaires. 11 in. × 8½ in. (28 cm. × 21.5 cm.). Pp. v+239. (Gif-sur-Yvette: Centre d'Études Nucléaires de Saclay; Amsterdam: North-Holland Publishing Company, 1960.) 72s.*

MANSKE, R. H. F. (edited by). The Alkaloids: Chemistry and Physiology. Vol. 7: Supplement to Volumes 2, 3, 4 and 5. 9¼ in. × 6¼ in. (23.5 cm. × 16 cm.). Pp. xiii+558. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 17 dollars.*

MINKOFF, G. J. Frozen Free Radicals. 9 in. × 6 in. (23 cm. × 15.5 cm.). Pp. ix+148. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.) 5 dollars; 36s.*

PUTILOVA, I. N., BALEZIN, S. A., and BARANNIK, V. P. Metallic Corrosion Inhibitors. Translated from the Russian by G. Ryback. Edited by E. Bishop. 8¾ in. × 5½ in. (22 cm. × 14 cm.). Pp. viii+196. (London and New York: Pergamon Press, 1960.) 63s. net.*

RENFREW, A., and MORGAN, Philip. Polythene: The Technology and uses of Ethylene Polymers. Second edition. 9¾ in. × 6 in. (25 cm. × 15.5 cm.). Pp. xxi+781+93 plates. (London: Iliffe and Sons, Ltd.; New York: Interscience Publishers, Inc., 1960.) 165s. net.*

UBBELOHDE, A. R., and LEWIS, F. A. Graphite and its Crystal Compounds. 9¼ in. × 6¼ in. (23.5 cm. × 16 cm.). Pp. xii+217. (Oxford: Clarendon Press; London: Oxford University Press, 1960.) 35s. net.*

WESTBROOK, J. H. (edited by). Mechanical Properties of Intermetallic Compounds. (A Symposium held during the 115th Meeting of the Electrochemical Society, Philadelphia, Pennsylvania, May 3–7, 1959, and sponsored by the Electrothermics and Metallurgy Division of the Society.) 9 in. × 6 in. (23 cm. × 15.5 cm.). Pp. ix+435. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1960.) 76s. net.*

YATSIMIRSKII, K. B., and VASIL'EV, V. P. Instability Constants of Complex Compounds. Translated from the Russian by D. A. Patterson. Edited by Dr. R. H. Prince. 8¾ in. × 5¾ in. (22 cm. × 15 cm.). Pp. viii+218. (London and New York: Pergamon Press, 1960.) 42s. net.*

Technology

FAIRES, R. A., and PARKS, B. H. Radioisotope Laboratory Techniques. Second edition. (Newnes Practical Science Books.) 8¾ in. × 5¾ in. (22 cm. × 15 cm.). Pp. xii+244+4 plates. (London: George Newnes, Ltd., 1960.) 25s. net.*

HIGH SPEED TESTING, Vol. 1: Proceedings of a Symposium held at Boston, Massachusetts, December 8, 1959. Sponsored by Plas-Tech Equipment Corporation, Natick, Massachusetts. 9 in. × 6 in. (23 cm. × 15.5 cm.). Pp. vii+112. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.) 5 dollars.*

PANOV, D. Yu. Automatic Translation. Translated from the Russian by R. Kisch. Edited by A. J. Mitchell. 8¾ in. × 5¾ in. (22 cm. × 15 cm.). Pp. vii+73. (London and New York: Pergamon Press, 1960.) 21s. net.*

PROCEEDINGS OF THE SYMPOSIUM ON THE NATURE OF COAL, held at the Central Fuel Research Institute, Jealgora, India, 7th–9th February, 1959. 10 in. × 7 in. (25.5 cm. × 18 cm.). Pp. viii+321. (Jealgora: The Central Fuel Research Institute, undated.) n.p.*

Astronomy

LETSCH, Heinz. Captured Stars. English translation by Dr. Harry Spitzbardt. Edited by Roland Haupt. 9½ in. × 7 in. (24 cm. × 18 cm.). Pp. 183 (125 illustrations). (Jena: Gustav Fischer Verlag, 1959.) 16 D.M.*

SADLER, D. H. Transactions of the International Astronomical Union, Vol. 10: Tenth General Assembly, held at Moscow, 12–20 August 1958. (International Council of Scientific Unions: International Astronomical Union.) 10 in. × 7½ in. (25.5 cm. × 19 cm.). Pp. ix+774. (Cambridge: At the University Press, 1960.) 90s. net.*

THE INDIAN EPHEMERIS AND NAUTICAL ALMANAC FOR THE YEAR 1961. 10 in. × 7 in. (25.5 cm. × 18 cm.). Pp. xxvi+448. (Delhi: Manager of Publications, 1960.) Rs 12.5 nP.; 19s. 6d.*

THE SPACE ENCYCLOPAEDIA: a Guide to Astronomy and Space Research. Second, revised edition. 9¾ in. × 6¾ in. (25 cm. × 17 cm.). Pp. 28. (Horsham: The Artemis Press, 1960.) 35s.*

Meteorology : Geophysics

PFEFFER, Richard L. (edited by). Dynamics of Climate: Proceedings of a Conference on the Application of Numerical Integration Techniques to the Problem of the General Circulation, held October 26–28, 1955. (Sponsored jointly by Institute for Advanced Study, Princeton, N.J., and Geophysics Research Directorate, Air Force Cambridge Research Center, Air Research and Development Command.) 9¼ in. × 6¼ in. (23.5 cm. × 16 cm.). Pp. xv+137. (London and New York: Pergamon Press, 1960.) 35s. net.*

SESHADRI, T. N., RAO, K. R., SHARMA, M. R., SARMA, G. N., and ALI, Sharafat. Climatological and Solar Data for India (to Design Buildings for Thermal Comfort). 11¼ in. × 9 in. (28.5 cm. × 23 cm.). Pp. 164. (Roorkee: Central Building Research Institute.) Rs 10.*

SMITH, L. P. Weathercraft. 8¾ in.×6 in. (22 cm.×15·5 cm.). Pp. 86. (London: Blandford Press, Ltd., 1960.) 9s. 6d. net.*

SUTTON, Sir Graham. Understanding Weather. (Pelican Book No. A469.) 7 in.×4¼ in. (18 cm.×11 cm.). Pp. 215+4 plates. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1960.) 3s. 6d.*

Geography : Travel

GASKELL, T. F. Under the Deep Oceans: Twentieth Century Voyage of Discovery. 8¾ in.×5¾ in. (22 cm.×15 cm.). Pp. 240. (London: Eyre and Spottiswoode (Publishers), Ltd., 1960.) 25s. net.*

LEWIS, W. V. (edited by). Investigations on Norwegian Cirque Glaciers. (Royal Geographical Society Research Series, No. 4.) 10 in.×7¼ in. (25·5 cm.×18 5 cm.). Pp. iv+104+19 plates. (London: Royal Geographical Society, and John Murray (Publishers), Ltd., 1960.) 22s. 6d.*

STEERS, J. A. The Coast of England and Wales in Pictures. 11 in.×7¾ in. (28 cm.×19·5 cm.). Pp. ix+146 (167 plates). (Cambridge: At the University Press, 1960.) 30s. net.*

THE AUSTRALIAN ENVIRONMENT. Third edition, revised. 9¾ in.×7 in. (25 cm.×18 cm.). Pp. 151. (Melbourne: Commonwealth Scientific and Industrial Research Organization, in association with Melbourne University Press; London: Cambridge University Press, 1960.) 30s. net.*

WILLIAMS, W. W. Coastal Changes. 8¾ in.×5¾ in. (22 cm.×15 cm.). Pp. xviii+220+8 plates. (London: Routledge and Kegan Paul, Ltd., 1960.) 28s. net.*

General Biology : Natural History
Zoology : Botany

BALINSKY, B. I. An Introduction to Embryology. 9½ in.×6¼ in. (24 cm.×16 cm.). Pp. xiv+562. (Philadelphia and London: W. B. Saunders Company, 1960.) 54s.*

BRAUNGART, Dale C., and BUDDEKE, Rita. An Introduction to Animal Biology. Fifth edition. 9¾ in.×7 in. (25 cm.×18 cm.). Pp. iv+416. (St. Louis: The C. V. Mosby Company; London: Henry Kimpton, 1960.) 47s.*

HAYES, W., and CLOWES, R. C. (edited by). Microbial Genetics: Tenth Symposium of the Society for General Microbiology held at the Royal Institution, London, April, 1960. 10 in.×6¼ in. (25·5 cm.×16 cm.). Pp. x+300. (London: Cambridge University Press, 1960. Published for the Society for General Microbiology.) 42s. net.*

HENES, Erich. Fossile Wandstrukturen untersucht am Beispiel der Tracheidenwände Paläozoischer Gefässpflanzen. (Handbuch der Pflanzenanatomie, Band III, Teil 5. Zweite, völlig neubearbeitete Auflage herausgegeben von Prof. Dr. Zimmerman und Prof. Dr. P. G. Ozenda.) 9¾ in.×7 in. (25 cm.×18 cm.). Pp. viii+108+9 tafeln. (Berlin-Nikolassee: Gebrüder Borntraeger, 1959.) 50 D.M.*

HOCKENHULL, D. J. D. (edited by). Progress in Industrial Microbiology, Vol. 2. 10 in.×6¼ in. (25·5 cm.×16 cm.). Pp. viii+194. (London: Heywood and Co., Ltd., 1960.) 45s. net.*

HOLLOM, P. A. D. The Popular Handbook of Rarer British Birds. 8½ in.×5½ in. (21·5 cm.×14 cm.). Pp. xiv+133+40 plates. (London: H. F. and G. Witherby, Ltd., 1960.) 37s. 6d. net.*

MAYR, Ernst, and GREENWAY, Jr., James C. (edited by). Check-List of Birds of the World, Vol. 9. (A continuation of the work of James L. Peters.) 9 in.×6 in. (23 cm.×15 5 cm.). Pp. xii+506. (Cambridge, Mass.: Museum of Comparative Zoology; Copenhagen: Zoological Museum, 1960.) 7.50 dollars.*

PRIME, Cecil T. Lords and Ladies. (A New Naturalist Special Volume.) 8 in.×5½ in. (20 cm.×14 cm.). Pp. xiv+241+5 plates. (London: William Collins, Sons and Co., Ltd., 1960.) 21s. net.*

RAMON Y CAJAL, Santiago. Studies on Vertebrate Neurogenesis. Translated by Lloyd Guth. 9¼ in.×6¼ in. (23·5 cm×16 cm.). Pp. xiv+432. (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, Ltd., 1960.) 108s.*

TITSCHAK, Erich, und KOEPCKE, Hans-Wilhelm (herausgegeben von). Beiträge zur Neotropischen Fauna, Band 2, Heft 1: Pp. 1–64. Band 2, Heft 2: Pp. 65–141. 10 in.×7 in. (25 5 cm.×18 cm.). (Jena: Gustav Fischer Verlag, 1960.) Band 2, Heft 1, 11.45 D.M. Band 2, Heft 2, 7.55 D.M.*

VON GUTTENBERG, Hermann. Grundzüge der Histogenese Höherer Pflanzen. I: Die Angiospermen. (Handbuch der Pflanzenanatomie, Band VIII, Teil 3. Zweite, völlig neubearbeitete Auflage herausgegeben von Prof. Dr. W Zimmerman und Prof. Dr. P. G. Ozenda.) 9¾ in.×7 in. (25 cm.×18 cm.). Pp. viii+315. (Berlin-Nikolassee: Gebrüder Borntraeger, 1960.) 110 D.M.*

Agriculture : Horticulture : Forestry

CHUPP, Charles, and SHERF, Arden F. Vegetable Diseases and Their Control. 9¼ in.×6¼ in. (23·5 cm.×16 cm). Pp. v+693. (New York: The Ronald Press Company, 1960.) 12 dollars.*

METCALF, R. L. (edited by). Advances in Pest Control Research, Vol. 3. 9 in.×6 in. (23 cm.×15·5 cm.) Pp. vii+448. (New York: Interscience Publishers, Inc; London: Interscience Publishers, Ltd., 1960.) 109s.*

SETHI, B. L., SIKKA, S. M., DASTUR, R. H., GADKARI, P. D., BALASUBRAHMANYAN, R., MAHESHWARI, P., SWAMY, N. S. R., and JOSHI, A. B. Cotton in India: a Monograph. 10 in.×7½ in. (25·5 cm.×19 cm.). Pp. xiv+474+30 plates. (Bombay: Indian Central Cotton Committee, 1960.) Rs. 30; 45s.*

WILSON, G. Fox. Horticultural Pests: Detection and Control. New edition revised by Dr P. Becker. (Agricultural and Horticultural Series.) 8¾ in.×5¾ in. (22 cm.×15 cm.). Pp. xii+240+4 plates. (London: Crosby Lockwood and Son, Ltd., 1960.) 25s. net.*

Biochemistry : Physiology

CLARK, F., and GRANT, J. K. (edited by). The Biosynthesis and Secretion of Adrenocortical Steroids. (Biochemical Society Symposium No. 18, held at Senate House, University of London, 14 February 1959.) 9¾ in.×6 in. (25 cm.×15·5 cm.). Pp. vii+112. (Cambridge: At the University Press, 1960.) Paper 15s. net; Cloth 25s. net.*

DAVENPORT, Harold A. Histological and Histochemical Technics 9½ in.×6½ in. (24 cm.×16 5 cm.). Pp. xxii+401. (Philadelphia and London: W. B. Saunders Company, 1960.) 49s.*

GRAN, Fredrik G. Studies on Calcium and Strontium-90 Metabolism in Rats. (Norwegian Monographs on Medical Science.) 9 in.×6 in. (23 cm.×15·5 cm.). Pp. 109. (Oslo: Oslo University Press, 1960.) n.p.*

HALL, Victor E. (edited by). In association with FUHRMAN, Frederick A., and GIESE, Arthur C Annual Review of Physiology, Vol. 22. 9 in.×6 in. (23 cm.×15·5 cm.). Pp. vii+725. (Palo Alto: Annual Reviews, Inc., 1960.) 7 dollars.*

HARRIS, Robert S., MARRIAN, G. F., and THIMANN, Kenneth V. Vitamins and Hormones: Advances in Research and Applications, Vol. 17. 9 in.×6 in. (23 cm.×15·5 cm.). Pp. xi+359. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd, 1959.) 14 dollars.*

JAMES, W. Warwick. The Jaws and Teeth of Primates. Photographs and Commentaries. 10 in.×7½ in. (25·5 cm.×19 cm.). Pp. xii+328. (London: Pitman Medical Publishing Co., Ltd., 1960.) 105s. net.*

LAPAGE, Geoffrey. Achievement: Some Contributions of Animal Experiment to the Conquest of Disease. 8¾ in.×5¾ in. (22 cm.×15 cm.). Pp. viii+255. (Cambridge: W. Heffer and Sons, Ltd., 1960.) 18s. net.*

LARDY, Henry A. (edited by). Biochemical Preparations, Vol. 7. 9 in.×6 in. (23 cm.×15·5 cm.). Pp. ix+102. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1960.) 42s. net.*

LARKS, Saul David. Electrohysterography: The Electrical Activity of the Human Uterus in Pregnancy and Labor. (American Lecture Series. A Monograph in American Lectures in Gynecology and Obstetrics.) 9¼ in.×6¼ in. (23·5 cm.×16 cm.). Pp. xiii+123. (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, 1960.) 46s.*

REYNIERS, James A., ERVIN, Robert F., GORDON, Helmit A., and WAGNER, Morris. Germfree Life Studies. (Lobund Reports, No. 3.) 9 in.×6 in. (23 cm.×15·5 cm.). Pp. vi+182. (Notre Dame, Indiana: University of Notre Dame Press, 1960.) n.p.*

SCHACHTER, M. (edited by). Polypeptides which Affect Smooth Muscles and Blood Vessels: Proceedings of a Symposium held in London on 23rd and 24th March, 1959. (Biological Council's Coordinating Committee for Symposia on Drug Action Series, Vol. 4.) 8¾ in.×5¾ in. (22 cm.×15 cm.). Pp xv+336. (London and New York: Pergamon Press, 1960.) 50s. net.*

Philosophy : Psychology

ISAACS, Nathan. New Light on Children's Ideas of Number: The Work of Professor Piaget. 8½ in.×5½ in. (21 5 cm.×14 cm.). Pp. vi+40. (London: Educational Supply Association, 1960.) 3s. 6d. net.*

GREENWOOD, David. The Nature of Science and Other Essays. 7½ in.×4¾ in. (19 cm.×12 cm.). Pp. xiii+95. (New York: Philosophical Library, 1959.) 3.75 dollars.*

LAING, R. D. The Divided Self: a Study of Sanity and Madness. 8¾ in.×5¾ in. (22 cm.×15 cm.). Pp. 240. (London: Tavistock Publications, 1960.) 25s. net.*

MADDEN, Edward H. The Structure of Scientific Thought an Introduction to Philosophy of Science. 9½ in.×7¼ in. (24 cm.×18 5 cm.). Pp. ix+381. (London: Routledge and Kegan Paul, Ltd., 1960.) 35s. net.*

NIDDITCH, P. H. Elementary Logic of Science and Mathematics. 7¼ in.×5 in. (18 5 cm.×12 5 cm.). Pp. vii+371. (London: University Tutorial Press, Ltd, 1960) 18s.*

Miscellany

ACTA IMEKO 1958: Proceedings of the International Measurements Conference, Budapest, 24–30 November 1958. Vol. 1: Pp. 443. Vol. 2: Pp. 444. Vol. 3: Pp. 372. Vol. 4: Pp. 460. Vol 5: Pp. 419. 9½ in.×6½ in. (24 cm.×16·5 cm.). (Budapest: Hungarian Scientific Society for Measurement and Automation, 1959.) n.p.*

FURNEAUX, Rupert. Günther Podola (Crime Documentary, No. 1.) 8¼ in.×5½ in. (21 cm.×14 cm.) Pp. xi+319+11 plates. (London. Stevens and Sons, Ltd., 1960.) 18s. 6d.*

GLASS, Bentley. Science and Liberal Education. (Davis Washington Mitchell Lectures—Tulane University.) 8¼ in×5½ in. (21 cm.×14 cm.). Pp. x+115. (Baton Rouge: Louisiana State University Press, 1959.) 3 dollars.*

HABER, Francis C. The Age of the World: Moses to Darwin. 8¾ in.×5¾ in. (22 cm.×15 cm.). Pp xi+303. (Baltimore, Md.: The Johns Hopkins Press; London: Oxford University Press, 1959.) 40s. net.*

HOGBEN, Lancelot, and CROSS, K. W. Design of Documents: a Study of Mechanical Aids to Field Enquiries. 10 in.×7½ in. (25·5 cm×19 cm.). Pp. vii+79. (London: Macdonald and Evans, Ltd., 1960.) 35s. net.

HOLLITSCHER, Walter. Die Natur in Weltbild der Wissenschaft. 9½ in.×6¾ in. (24 cm.×17 cm.). Pp. 500+16 plates. (Wein. Globus Verlag, 1960.) 160 schillings.*

JACQUEMONT, Victor. Letters to Achille Chaper: Intimate Sketches of Life Among Stendhal's Coterie. With an Introduction and Notes by Prof J. F. Marshall. (Memoirs of the American Philosophical Society, Vol. 50.) 9½ in.×6¼ in. (24 cm.×16 cm.). Pp vii+264. (Philadelphia: American Philosophical Society, 1960.) 3.50 dollars.*

McGIVERING, I. C, MATTHEWS, D. G. J., and SCOTT, W. H. Management in Britain: a General Characterization. 8¾ in.×5½ in. (22 cm.×14 cm.). Pp. viii+157. (Liverpool Liverpool University Press, 1960.) 25s. net.*

MIGDALSKI, Edward C. How to Make Fish Mounts and other Fish Trophies. 9 in.×6 in. (23 cm.×15·5 cm). Pp. x+218. (New York: The Ronald Press Company, 1960.) 5.50 dollars.*

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON SCIENTIFIC INFORMATION, Washington, D.C., November 16–21, 1958. Vol. 1: Pp. xxiv+1–812. Vol. 2: Pp. xi+813–1635. 10 in.×6¾ in. (25·5 cm.×17 cm.). (Washington, D.C.: National Academy of Sciences—National Research Council, 1959.) 20 dollars the two volumes.*

REYNER, J. H. The Universe of Relationships. 8¾ in.×5¾ in. (22 cm.×15 cm.). Pp. vii+130. (London: Vincent Stuart, Ltd, 1960.) 25s. net.*

THE SCIENCE OF MEAT AND MEAT PRODUCTS. By Members of the Research Staff of the American Meat Institute Foundation. (Series of Books in Agricultural Science.) 9¼ in.×6¼ in. (23 5 cm.×16 cm.). Pp. x+438. (San Francisco and London: W. H. Freeman and Company, 1960.) 68s.*

A new technique for separation of substances of different molecular sizes

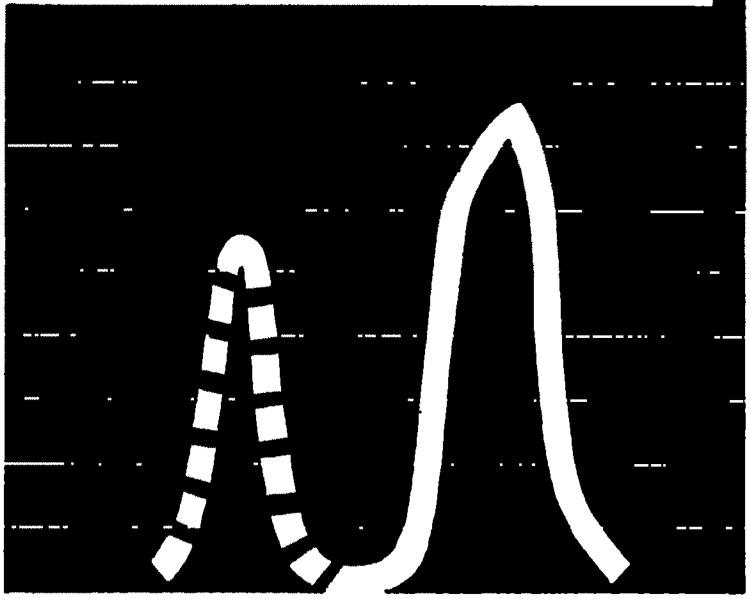
Sephadex

IN GEL FILTRATION

SEPHADEX is now available in three types, for a multiplicity of applications, such as:

Desalting of protein solutions
Fractionation of polymers
Group separation of biological extracts

GEL FILTRATION with SEPHADEX is simpler and far more rapid than previous procedures



Lower limit for complete exclusion:

Sephadex G - 25 Mw 3,500 - 4,500
Sephadex G - 50 Mw 8,000 - 10,000
Sephadex G - 75 Mw 40,000 - 50,000

PHARMACIA
UPPSALA · SWEDEN

In Great Britain:
Savory & Moore Ltd.,
60/61 Welbeck Street, London, W.1.

In the U.S.A.:
Pharmacia Laboratories Inc.
Sales Office, Box 1010, Rochester, Minn.

For complete information, please write for our brochure.

obtained which also stimulated production of a nephrotoxic antiserum. The assay, which was conducted in a group of 12 rats, again revealed that the maximal glomerular changes (illustrated in Fig. 4) were of modest degree and focal in distribution; many glomeruli in the experimental animals could not with reliability be distinguished from glomeruli in certain control animals, while a clear distinction between experimental and control groups could be made by reason of numbers of casts and other tubular differences in the former. All three groups of experimental animals displayed proteinuria greatly in excess of control animals.

Based upon electrophoretic analysis of the extracts which indicated heterogeneity and the focal and modest character of the glomerular lesions in the experimental animals, the necessity for more potent antisera directed against further purified, monospecific entities is recognized.

It would appear from the observations presented in this preliminary communication that the diffusion-chamber-streptococcus induction of experimental glomerulonephritis has probably an immunological basis and that common antigen(s) may be shared between the nephritogenic streptococcus and the rat glomerulus. Additionally, there is a clear-cut relationship between the virulence and the nephritogenic capacity of our strains.

This work was supported by the Elizabeth McCormick Research Foundation. The senior author wishes to express his appreciation to the Board of Commissioners of Cook County and to Warden Fred A. Hertwig, Cook County Hospital, for their interest and development of facilities for basic medical research.

[1] Kelly, D. K., and Winn, J. F., *Science*, 127, 1337 (1958).
[2] Markowitz, A. S., and Henderson, J. R., *Nature*, 181, 771 (1958).
[3] Greenspon, S. A., and Krakower, C. A., *Arch. Path.*, 49, 291 (1950)

BEHAVIOUR OF PAPER DURING TENSILE STRAINING

By A. E. RANGER and L. F. HOPKINS

Bowater Research and Development Co., Ltd., Research Division,
Northfleet, Kent

FOR many years the view has been widely held that the final fracture in the tensile testing of paper is governed by failure of inter-fibre bonds, and that very few of the fibres themselves are actually broken. Recent work by Van den Akker[1], however, in which individual fibres in the failure region could be observed, has cast doubt on this belief. Of those fibres involved in the fracture a high proportion was found to be ruptured—as many as 77 per cent in one instance. Although Van den Akker is careful to point out that many of the fibres failed after the paper had started to fracture and that such fracture could still be initiated by bond failure, he nevertheless concludes that: "the strength of the fibres of a papermaking pulp is of much greater importance than had hitherto been generally recognized".

A critical analysis of the evidence in favour of inter-fibre bond failure as opposed to fibre failure had led us, independently, to the same conclusion and to attempt to describe the tensile behaviour of paper on a basis of predominance of fibre failure.

A difficulty arose at the outset when considering the increase in optical opacity which occurs during the plastic stage of straining. Although generally accepted as indicating fracture of inter-fibre bonds, this change could also be due to the rupture of fibres. Experiments designed to detect such pre-fracture damage were carried out, but with negative results.

A way was therefore sought of reconciling the two apparently contradictory ideas—that of inter-fibre bonds being broken during the straining process, and that of the final fracture being predominantly governed by fibre failure.

During the course of previous experiments it had been established that a paper strip undergoing longitudinal extension contracts significantly in width. One effect of this is that fibres oriented approximately at right angles to the direction of tension are subjected to longitudinal compressive forces. It is suggested that, because of their slenderness, these fibres will tend to buckle at comparatively low strains, and in so doing will tend to peel apart from those fibres which are, because of their orientation, held in tension. Such a process can occur at a much lower stress-level than rupture by simple shear, which is the predominant mode of failure of those bonds which are ruptured at final fracture of the paper. The complete picture, then, is of the tensile strength of the fibres being intermediate between two effective bond 'strengths' which differ by virtue of the two distinct modes of rupture.

This proposed mechanism of bond failure during plastic straining has been invoked to explain the phenomenon of strain lines. When a strip of tracing paper is strained, the increase in opacity can be followed visually, and it is seen that the opaque regions form a reticulate pattern orientated at a characteristic angle to the direction of tension. Rance[2], who first directed attention to these strain lines, also demonstrated their existence in other types of paper by a method analogous to the brittle lacquer technique in stress analysis, which incidentally showed that they are regions of high local deformation.

The failure of a small group of bonds by peeling will raise the stress-level in the immediate vicinity and give rise to a band of local deformation; but if the relative movement of the two parts of the paper is parallel to the direction of tension the deformation will be limited, since there will be no tendency for further fibre buckling to occur. In addition, a simple analysis shows that the deformation band in this case would be perpendicular to the direction of tension, which contradicts experience.

However, if the two parts of the strip tend to separate by a shear or slip movement along the band of deformation itself, these difficulties do not arise. Such movement would automatically subject more fibres to compressive forces and lead to further bond failure by peeling.

An analysis of the situation was made, based on this assumption of shear movement, which led to a prediction of the angle at which such a band of local deformation should occur. An 'orientation factor' was included in the analysis to facilitate comparison with machine-made paper, which is anisotropic with respect to fibre orientation. Fig. 2 shows the predicted variation of strain-line angle with strip direction, the angles being defined in Fig. 1.

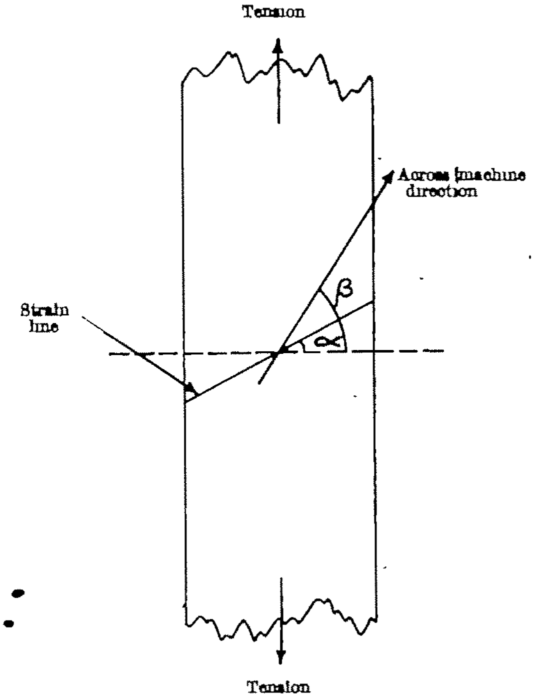


Fig. 1. Orientation of strain line and machine direction with respect to test strip

In view of the assumptions made in the mathematical treatment and the uncertainty involved in the degree of fibre orientation in machine-made paper, the agreement in the case of tracing paper is perhaps not unsatisfactory, especially since in this instance it is not possible to verify the complete variation of strain-line angle because the pattern becomes indistinct as the machine direction is approached and the angles can no longer be measured. However, the proposed mechanism of formation of strain lines, despite its genesis, does not apply only to strong papers, and it was found that very weak papers (for example, from an unbeaten pulp) tended to fracture along a diagonal line which was tentatively identified as a strain line. A technique evolved from this observation whereby strips of strong machine-made paper were wetted locally and thus weakened excessively and the angle of the fracture was measured. By this means the complete variation of 'strain-line' angle could be investigated, and this result also is shown in Fig. 2.

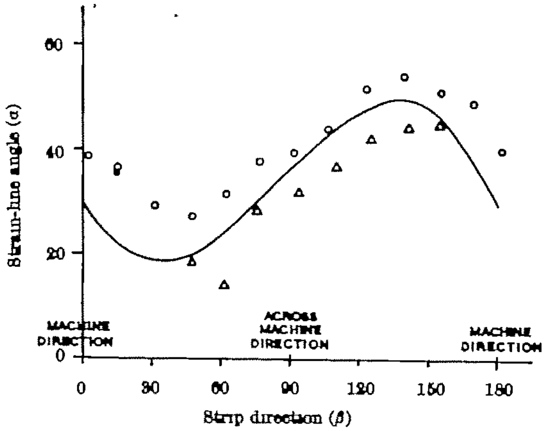


Fig. 2. Variation of strain-line angle with strip orientation. Δ, tracing paper; O, wetted Kraft paper (fracture angle); —, theoretical curve

Wetted strips also show quite clearly the shear movement at fracture and the local increase in paper thickness caused by the buckling of fibres (Fig. 3).

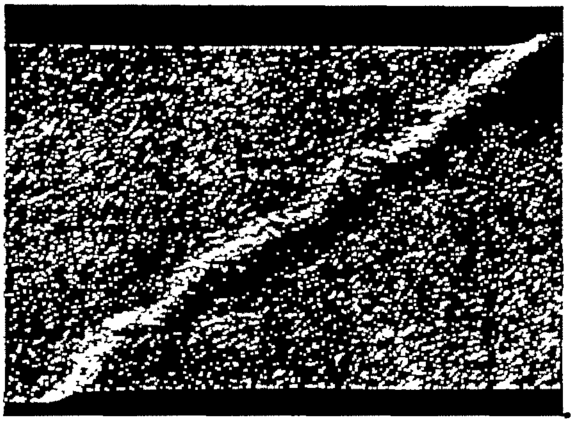


Fig. 3 Shear movement and local increase in thickness with wetted paper

This theory of paper behaviour during tensile straining leads to several interesting predictions which are being investigated, and it is hoped to present a full account of this work in September 1961 at the Fundamental Research Symposium which is being organized by the Technical Section of the British Paper and Board Makers' Association.

[1] Akker, J. A. Van den, Lathrop, A. L., Voelker, M. H., and Dearth, L. R., *Tappi*, 41, 416 (1958).

[2] Rance, H. F., "Some Recent Developments in Rheology", ed. by Harrison, V. G. W., 90 (United Trade Press, Ltd., London, 1950).

LETTERS TO THE EDITORS

PHYSICS

Pulse-shortening in Electron Linear Accelerators

During the past few years several electron linear accelerators have been designed in Great Britain, France and the United States to support pulse currents in excess of 250 m.amp. for durations of 1–10 μsec. Many of these machines have failed to reach design performance due to a phenomenon which has come to be known as 'pulse-shortening'. This effect appears as a premature termination of the output electron pulse and occurs at pulse currents in the range 300–600 m.amp. and pulse-lengths of 1 or 2 μsec. depending on the particular machine. Further increase of pulse current is possible only at the expense of pulse-length. The current pulse and the radio-frequency loading are normal until the point in time at which 'shortening' occurs. Beyond this point, where there is typically a 0·1/0·2 μsec. jitter of the trailing edge of the current pulse, there is little or no electron current and usually the radio-frequency pulse shows an increase somewhat above the normal loaded level but does not reach that corresponding to zero beam.

The values of current quoted above refer to the onset of pulse-shortening at the S-band (3,000 Mc./s.). At least one machine constructed in the United States operates on the L-band (1,250 Mc./s.) and is reported as exhibiting pulse shortening but at much higher pulse currents (1–2 amp.). Conversely X-band (9,250 Mc./s.) accelerators designed in this laboratory have shown this effect at about 40 m.amp. It would appear that for accelerators operating at different frequencies but of similar energy gain and length the current obtained at the onset of pulse-shortening is proportional to $1/f^3$.

Our experiments on a single accelerator section have shown that pulse-shortening occurs first at the high-energy (low radio-frequency power) end of the accelerator wave-guide, and that the buncher and first half of the accelerator are capable of supporting rather more than the design current and at least three times the current required to produce shortening in the last half. It has been shown also that the current at which pulse shortening occurs is proportional to the radio-frequency power-level in the accelerator tube. If the mechanism of pulse-shortening is a 'field effect', we might expect to increase significantly the current obtainable by designing the guide to use feedback or more conveniently by the use of a constant-field design.

A 'constant-field' accelerator has been constructed to operate at the X-band and has yielded currents in excess of 100 m.amp. without showing pulse-shortening as compared to 40 m.amp. for the equivalent constant-impedance design. This increased current is normal and is limited by the radio-frequency power available.

If both 'constant-field' and 'feedback' accelerators yield this increased current it would seem that the pulse-shortening mechanism is a 'field' effect associated with low values of field in the normal mode. If, however, the 'constant-field' solution is the only successful one, then it appears that higher order spurious radio-frequency modes may be responsible, as has been suggested by other workers in this field. Investigations of the free space wave-length and type of such modes with a phase velocity equal to that of light have been made by K. W. Robinson, Cambridge Electron Accelerator Project (private communication), and W. Gallagher, Stanford University, California (private communication).

Further work on this problem is being carried out and will be reported shortly.

We wish to thank Dr. C. F. Bareford, managing director of Vickers Research, Ltd., for permission to publish these preliminary results of our investigations.

M. G. Kelliher
R. Beadle

Group Research Establishment,
Vickers Research, Ltd.,
Sunninghill, Ascot,
Berks.

Dependence on Latitude of the Amplitude of the Diurnal Variation of Cosmic Rays

The solar diurnal variation of cosmic-ray intensity is usually assumed to be due to the rotation of the Earth in a cloud of particles. The velocity of the latter should be randomly distributed with a small additional component in one direction, thus constituting a kind of particle wind. For various reasons it can be assumed that this wind is following the Earth, approximately parallel to its orbital plane[1]. The yearly mean amplitude of the diurnal variation should then have a maximum for primary particles having asymptotic directions approximately parallel to the equatorial plane. It should have a minimum for primaries with asymptotic directions parallel to the Earth's axis of rotation. For an experimental study of the relative magnitude of the amplitudes in these directions, it is necessary to record the variations of cosmic-ray intensity with inclined counter telescopes. However, it is difficult to gain access to both directions at one and the same point on the Earth's surface.

From the terrella experiments by Brunberg[2], it was found that one of the desired directions could be recorded with an inclined counter telescope at Uppsala, while the other direction could be recorded in the same way from a station in the Arctic. What seemed most promising, however, was the fact that not only could the two stations be linked together by a second directional telescope in each place, but also the station at Kiruna could serve as an extra link[3]. In August 1957 an Arctic station was erected at Murchison Bay, Spitsbergen.

Telescopes with a zenith angle of 30° could be used in all the three places. The telescopes at Uppsala (lat. 59·9° N., long. 17·9° E.) and Murchison Bay (lat. 80·1° N., long. 18·3° E.) should point in the east

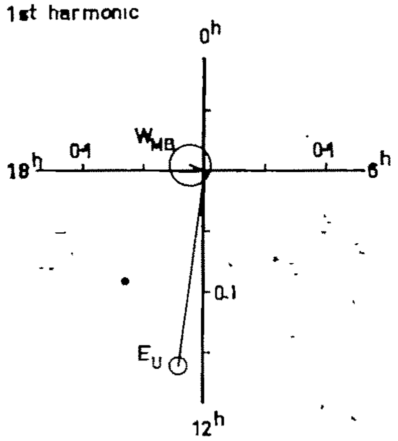


Fig. 1. Harmonic dial for the diurnal variation recorded by the east-pointing counter telescope at Uppsala (E_U) and by the west-pointing telescope at Murchison Bay (W_{MB})

and west directions, those in Kiruna (lat. 67·8° N., long. 20·4° E.) north and south. The axis of the east-pointing telescope at Uppsala corresponds to primaries entering the geomagnetic field in an asymptotic direction making an angle of 14° with the equatorial plane of the Earth. The axis of a west-pointing telescope at Murchison Bay corresponds to primaries making an angle of 82° with the equatorial plane. The values are approximate. They were derived from the assumption that the effective rigidity of the primaries[4] is 25 GeV./c. If instead the effective rigidity is assumed to be 35 GeV./c. the values will be 20° and 80°. Actually, the relation between the asymptotic directions, the axis of the counter telescope, and the rigidity spectrum cannot be calculated in a simple way[5]. However, in the present experiment, the angles of the two asymptotic directions differ in any event by such a considerable amount as to make the experiment decisive.

To secure the most reliable results, the harmonic analysis has been carried out for the mean daily variation during exactly the same days for the directions to be compared. Nevertheless, 312 days were available for the calendar year 1958. The harmonic dial in Fig. 1 suffices to show that the west-pointing telescope at Murchison Bay (W_{MB}) does not have an amplitude exceeding the standard error, whereas the east-pointing telescope at Uppsala (E_U) has an amplitude which is large compared to the standard error.

As regards the north- and south-pointing telescopes in Kiruna and the east-pointing telescope in Murchison Bay, the mean asymptotic directions make angles of 40–55° with the equatorial plane. The amplitudes of these intermediate directions are all slightly smaller than that of the asymptotic direction approximately parallel to the equatorial plane of the Earth (E_U). The primaries observed by means of the west-pointing telescope in Uppsala have asymptotic directions covering angles between 50° and 90°. The yearly mean amplitude is one-third of that of the direction parallel to the equatorial plane.

The results reported here clearly show that the amplitude of the diurnal variation decreases with increasing angle between the asymptotic direction of the primaries and the equatorial plane of the Earth. The fact that observations in two directions at the same point have given contradictory results[6] or failed to show any dependence on latitude[7] is certainly due to the difficulty in such cases in resolving the radiation cones of the primaries[8].

A full account of the present experiment will be published as soon as possible.

ARNE ELD SANDSTRÖM
ERIC DYRING
STIG LINDGREN

Institute of Physics,
University of Uppsala. June 8.

---

[1] Sandstrom, A. E., *Tellus*, 8, 18 (1956).
[2] Brunberg, E. Å., *Tellus*, 5, 135 (1953); 8, 215 (1956).
[3] Sandström, A. E., *Kosmos*, 33, 56 (1955) (in Swedish).
[4] Brunberg, E. Å., and Dattner, A., *Tellus*, 6, 73 (1954).
[5] Brunberg, E. Å., *Ark. Fys.*, 14, 195 (1958).
[6] Elliot, H., and Rothwell, P., *Phil. Mag.*, 1, 669 (1959).
[7] Stensland, B., *Ark. Fys.*, 11, 253 (1957).
[8] Discussion on pp. 402–403, "Electromagnetic Phenomena in Cosmical Physics", edit. by Lehnert, B. (Cambridge, 1958).

Fractionation of Nuclear Weapon Debris

EDVARSON *et al.*[1] report evidence for a fractionation effect noted in the radioactive analysis of samples of nuclear weapons debris collected in filters carried by a jet plane flying over central Sweden. Certain individual particles selected from the filters appeared to be rich in (zinc-90 + niobium-90) radiations and impoverished in ruthenium-103 radiations.

The purpose of this communication is to present a somewhat similar finding from an earlier study. At the time of one of the nuclear detonations at the Pacific Proving Grounds, gummed paper fall-out collectors were placed on platforms at various locations in the vicinity of the Eniwetok atoll. A few of these gummed papers were available for nuclear radiation analysis. There was a wide range of individual particle-sizes, but among the particles were some that were large enough (between about 0·3 mm. and 1 mm. diameter) to be picked off the gummed paper with tweezers. Eleven such particles were removed from two gummed paper collectors, five from a paper that had been twelve miles down-wind from the point of detonation and six from another paper that had been thirteen miles cross-wind.

Gamma-radiations from the individual particles fall into two groupings, one rich in (zinc-90 + niobium-90)

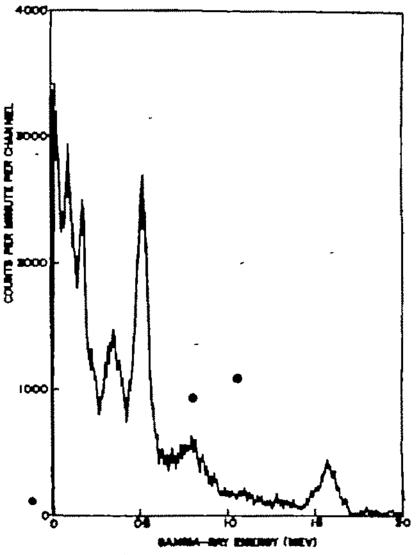


Fig. 1

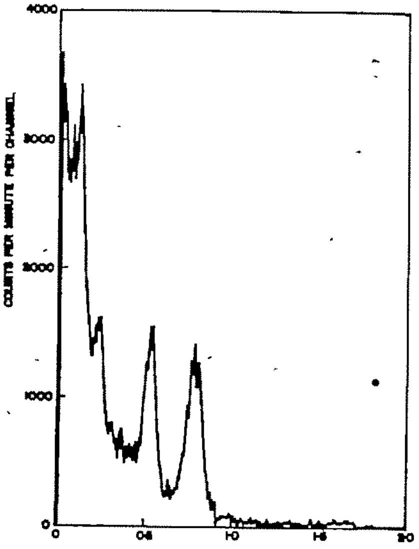


Fig. 2

radiations and the other essentially depleted of these radiations. Both types of samples were found at both stations. Pulse-height analyses, using a 4-in. diameter by 4-in. high sodium iodide (thallium) crystal, are shown in Figs. 1 and 2. Both sets of results were recorded 30 days after the detonation. It will be noted that in the spectrum of the particle from which the (zinc-90 + niobium-90) radiations at 750 keV. have been depleted, the 1·6 MeV. gamma-ray of lanthanum-140 can be observed; but this gamma-ray is not clearly distinguishable in the spectrum of the particle enriched with zinc-90 + niobium-90. A gamma-ray at about 500 keV., presumably ruthenium-103, appears in both spectra, but in much larger relative amounts in the sample depleted of zinc-90 + niobium-90.

The assistance of Mr. E. Schuert in supplying the gummed paper fall-out collectors is gratefully acknowledged.

C. Sharp Cook
R. L. Mather
R. F. Johnson
F. M. Tomnovec
U.S. Naval Radiological Defense Laboratory,
San Francisco 24, California.

---

[1] Edvarson, K., Low, K., and Sisefsky, J., *Nature*, 184, 1774 (1959).

Stepwise Ablation and Heat Transfer in Cold-Cathode Arcs

A 'cold-cathode' arc is an electric discharge in a gas or *in vacuo* with a cathode fall of about 10 V.[1] and a current density at the cathode of 10^4–10^6 amp./sq. cm.[1,2]; the intense light observed comes from the cathode vapour but not from the ambient gas, if present. The cathode temperature is much too low to give the high current density of electrons if emitted thermionically[2] from the spot, but was thought to be high enough to produce copious evaporation; pyrometric and spectroscopic temperature measurements showed 2,000–2,500° K. for many metals[3–5].

If the loss of energy by thermal conduction from the spot into a copper cathode is calculated, it is found to be equivalent to 30–100 volts for currents <10 amp.—a range free of spot-splitting; thus such arcs could only be maintained by more than 30 V. Yet measured minimum arc voltages[6] suggest a loss of heat conduction from the active spot equivalent to a few volts. Against this view can be held that such low current arcs often last for a few seconds only[7]. Moreover, with 'selected' data the calculated conduction loss from a stationary spot with $i > 20$ amp. may be only $\simeq 4$ V.; but a moving spot would certainly consume many times that value[8].

To resolve this discrepancy a thin layer of low thermal conductivity (oxides) at the spot has been postulated[9]. With oxide-free electrodes, however, the arc voltage differs little, and so one is led to doubt that the measured temperature is that of the cathode spot. In fact the real spot temperature may be much lower[8] than 2,000° K. or so, as found with mercury; there is the dense cloud of luminous metal vapour covering it[1]. If this were so, the existence of this narrow region of dense vapour above the spot—a requirement of the new arc theory[8]—cannot be explained in terms of classical evaporation; hence a new concept of evaporation must be invoked.

A similar argument applies to carbon cathodes in molecular gases[10], such arcs being stable for currents down to about 1 amp. at atmospheric pressure. As the gas pressure is gradually reduced, cathode temperature and cathode fall decrease steadily until at pressures <100 mm. mercury the thermionic spot suddenly changes into a vapour spot, with its characteristic mobility, high current density, emission of spectral lines of carbon, intense ablation and deposition of carbon on the walls of the vessel (our unpublished measurements). Again from this and other observations[10,11], one is forced to conclude that the conventional evaporation picture is untenable.

A pointer to a new solution seems to be the large energy flux from the gas into the spot maintained by unexcited and excited neutral particles, and by ions and quanta. Some of these species may ablate the cathode by a step-wise process: a lattice atom absorbs (and can re-emit) several small amounts of potential energy from incident species, and moves from its original site through intermediate positions into a final position which corresponds to an energy close to that of the boundary. From this it ultimately escapes into the gas phase[12]. A special case would be the presence of a single intermediate energy-state, analogous to a strongly adsorbed layer[13]. The concept of stepwise ablation thus involves the transfer of potential energy, and is therefore very different from that of sputtering by fast ions, for example, through momentum transfer, or classical evaporation through lattice vibrations.

The use of the new model has several consequences. First, a number of species, each of energy less than the evaporation energy λ, can between them release an atom from the lattice. Secondly, by introducing these intermediate energy-states, the flow of heat into the metal matrix can be greatly decreased.

Thus, if n species each of energy ϵ_i fall on the spot per cm.^{2} and sec., classical theory of coupled oscillators shows that evaporation (into 2π) occurs at a rate:

$$(2\lambda/kT)\,(\nu/A)\,\exp(-\lambda/kT)$$

T being the absolute temperature of the lattice determined by heat input, conduction and evaporation, ν the frequency of lattice vibrations, and A the area[12]. Hence only a small fraction of $n\epsilon_i$ contributes to evaporation, and the larger part to conduction, etc. However, with a two-stage ablation process (e_1, e_2 being the energy difference: intermediate state—vacuum and matrix—intermediate state respectively, and $\varkappa_1$, $\varkappa_2$ the corresponding transition probabilities) the energy balance in the steady state with $(e_1+e_2) > e_0 > e_1, e_2$ is:

$$n e_0 = n\varkappa_1 e_1 + n(1-\varkappa_1)\varkappa_2 e_2 + H$$

where H is the conduction loss, and $(e_1 + e_2) = \lambda$. Terms relating to electron emission, etc.[8], have been omitted for clarity.

Since $\varkappa_1$, $\varkappa_2$ have a value between 0 and 1, H is clearly smaller than in the absence of an intermediate state, when $\varkappa_1$ or $\varkappa_2 = 0$. A similar argument applies when $e_0 > \lambda$, as direct evaporation is thought to be unlikely[12]; when $e_0 < e_1, e_2$, classical theory holds.

We conclude that step-wise ablation may explain a high rate of vapour production with low loss of heat by conduction when fairly slow-moving excited particles or low-energy quanta supply energy to a cathode. Moreover, this approach may be of interest to current work on accommodation coefficients and bear on the origin of fast-particle streams emanating from arc electrodes[14,15].

We wish to thank the Director of the Electrical Research Association for the support given to our work and for permission to publish this communication.

A. VON ENGEL
K. W. ARNOLD

The Clarendon Laboratory,
Oxford.
May 7.

---

[1] von Engel, A., "Ionized Gases" (Clarendon Press, Oxford, 1955).

[2] Froome, K. D., *Proc. Phys. Soc.*, 60, 424 (1948); B, 62, 805 (1949). Cobine, J. D., and Gallagher, C. J., *Phys. Rev.*, 74, 1524 (1948).

[3] von Engel, A., and Steenbeck, M., "Elektrische Gasentladungen", 1 and 2 (Springer, Berlin, 1932–34).

[4] Cobine, J. D., and Burger, E. E., *Phys. Rev.*, 93, 653 (1954).

[5] Somerville, J. M., *et al.*, *Proc. Phys. Soc.*, B, 65, 963 (1952).

[6] Somerville, J. M., "The Electric Arc" (Methuen, 1959).

[7] Robson, A. E., *Direct Current*, 4, 36 (1958).

[8] von Engel, A., and Robson, A. E., *Proc. Roy. Soc.*, A, 242, 217 (1957).

[9] von Engel, A., *Naturwiss.*, 23, 305 (1935).

[10] Seeliger, R., and Schmick, H., *Phys. Z.*, 28, 605 (1927).

[11] Luce, J. S., Proc. U.N. Geneva Conference (1958).

[12] Knacke, O., and Stranski, I. N., "Prog. in Metal Physics", 6, 181 (1956).

[13] Discussion by Thomson, G. P., on paper by Charlesbury, A., Finch, G. L., and Wilman, H., *Proc. Phys. Soc.*, 51, 479 (1939).

[14] Meek, J. M., and Craggs, J. D., "Electrical Breakdown of Gases" (Clarendon Press, Oxford, 1953).

[15] Lochte-Holtgreven, W., Proc. Conf. Ionization Phenomena, Uppsala (North-Holland Publishing Co., 1959).

ASTRONOMY

Origin of the Solar System

IN a recent communication[1], Dr. M. M. Woolfson has outlined a model to account for the origin of the solar system. In common with many earlier hypotheses[2], he postulates an interaction between the primitive Sun and a second star. By gravitational interactions he proposes that the Sun lost a large amount of surface matter by the breaking away of tidal bulges. This matter is envisaged to have been lost in a series of isolated events and the resulting separate sections gave rise to a planet.

While there can be no doubt that this model accounts for many of the observed regularities of the solar system, there seem to be other features that are not explained. The latter appear incompatible with any catastrophic account of planetary origins.

First, there are the known properties of meteorites[3], which indicate that the early history of the solar system was most complex and that the present planets are second—or possibly third—generation structures that were preceded by objects of approximately planetary dimensions that have broken up.

Secondly, the densities of the planets (Table 1) indicate considerable fractionation of the chemical materials from which the former arose. On catastrophic hypotheses, it is difficult to see how such fractionation could have occurred as each planet is postulated to have arisen from the same material—the solar surface.

Table 1

Planet	Semi-major axis (km.)	Mean density (c.g.s. units)
Mercury	0·387	5·05
Venus	0·723	4·87
Earth	1·000	5·52
Mars	1·523	4·24
Jupiter	5·202	1·33
Saturn	9·538	0·71
Uranus	19·190	1·26
Neptune	30·070	1·61
Pluto	39·518	2 (?)

Thirdly, the comets are part of the solar system and are not derived from interstellar material. Consequently a satisfactory account of the origins of planets must also be able to account for the origins of comets—unless it be assumed that comets are secondary features of the solar system that arose late in its history. Hypotheses postulating an evolution of the solar system from a solar nebula appear to be able to account for the origins of comets with the minimum of *ad hoc* axioms.

Other arguments that can be levelled at catastrophic hypotheses such as that outlined by Woolfson concern the improbability of forcibly ejected solar material condensing into solid planets, and the probable frequency of occurrence of solar systems in the Galaxy.

Material drawn from the Sun must be for long periods well within the Roche limit, and rapid dissipation by the action of gravitational forces would be predicted. Moreover, as Spitzer[4] has pointed out, the material would be initially at very high temperatures and pressures, and would expand under its own internal pressure and become dissipated. Consequently the prime requirement of any new catastrophic hypothesis must be a satisfactory explanation of how the ejected solar material could form into planets.

If the solar system had a catastrophic origin by a close interaction of two stars, then planetary systems must be very rare in the universe. In fact, the chances are that only the Sun and the star with which it interacted possess planets. Yet there is a growing body of evidence for the existence of extra-solar planetary systems, and there can be no doubt that many nearby stars are accompanied by dark bodies of approximately planetary size[5]. Thus, unless it be suggested that the solar system arose by one improbable mechanism while other planetary systems arose by other means, the catastrophic hypothesis is rendered very unlikely.

It would seem that the most that an interstellar interaction could have achieved is the production of a solar nebula from which the planets could have evolved; but the bulk of available evidence is against this view, as other more likely mechanisms have been suggested to account for the origin of a nebula from which planets could have been formed[6].

M. H. Briggs

Department of Chemistry,
Victoria University of Wellington,
New Zealand.

---

[1] Woolfson, M. M., *Nature*, 187, 47 (1960).

[2] Chamberlin, T. C., *Astrophys. J.*, 14, 17 (1901). Jeans, J. H., *Mem. Roy. Astro. Soc.*, 62, 1 (1917). Jeffreys, H., *Mon. Not. Roy. Astro. Soc.*, 78, 424 (1918); *ibid.*, 89, 636 (1929). Lyttleton, R. A., *ibid.*, 96, 559 (1936). Moulton, F. R., *Astrophys. J.*, 22, 165 (1905). Russell, H. N., "The Solar System and its Origin" (Macmillan, New York, 1935).

[3] Urey, H. C., *Proc. Chem. Soc.*, 67 (1958); "Year Book of the Physical Society", 14 (1957).

[4] Spitzer, L., *Astrophys. J.*, 90, 675 (1939).

[5] Briggs, M. H., *J. Brit. Interplanet. Soc.*, 17, 59 (1959). Deich, A. N., *Priroda*, 5–6, 99 (1944). Kuiper, G. P., in "Astrophysics", 357, edit. by Hynek, J. A. (McGraw-Hill, New York, 1951). Parlinkii, N. N., *Usp. Astron. Nauk*, 2, 137 (1941). Rein, N., and Parinkii, N. N., *Astron. J.* (Moscow), 16, 77 (1939). Strand, K. A., *Proc. Amer. Phil. Soc.*, 86, 364 (1943).

[6] Kuiper, G. P., *loc. cit.*

METEOROLOGY

Change of the Chlorine : Sodium Ratio in the Atmosphere with Altitude and Distance from the Source of Sodium Chloride, and the Distribution of Atmospheric Nitrate over the United States

The change of the chlorine : sodium ratio in rain-water with inland distance from seas is a well-known phenomenon. The experimental evidence available has lately been discussed by Eriksson[1], while further data on an almost continental scale have been supplied by Junge and Werby[2]. The latter measurements were recently used by Papée and Smith for an evaluation of trends between components of rain-water and physical variables[3]. From those computations, an indication of a decrease in the ratio between chlorine and sodium with the altitude of the sampling stations became available, and it was pointed out recently to one of us that a semi-empirical evaluation of the phenomenon might be of interest to workers in mountainous countries. In view of the importance of the process in atmospheric chemistry in general, and especially because of the possible role of activated sodium chloride as nuclei of atmospheric precipitation[4,5], a further study of Junge's data with particular emphasis on this problem was made. Prior to a broader evaluation of the problem and to a laboratory study of the phenomena involved, some results obtained are reported in this communication.

(1) *The Chlorine : Sodium Ratio.* It is well known from observations by Rossby and Egnér[6] that northern air masses carry aerosols of a low chlorine : sodium ratio. Examination of Junge's data shows, however, that this phenomenon which might result in a chlorine : sodium – latitude correlation is smaller in the United States than a strong altitude effect, although it shows in the concentration of nitrate in rain-water (see later). The effect of altitude can be tentatively explained by observing that the intensity of such radiochemical phenomena as may alter sodium chloride aerosols varies nearly exponentially with height[7]. If one assumes that the average yearly horizontal speed of the particle carried by winds does not change considerably from station to station (and therefore that the time which the particle needs to be carried from the shore or an inland salt source to the particular station, is proportional to the distance) the change of chlorine in the air may be expressed as:

$$d\,\mathrm{Cl} = -k\,\mathrm{Cl}\,(\exp \beta h)\,d\,s \tag{1}$$

where s is the distance from the source of particles to the station and h stands for the altitude of the route. s is calculated here from a map and along lines of path straight and orthogonal to Junge's sodium isolines, while both the effective altitude of station (h) and the average altitude of ground-level travel over path s ($\bar{h}$) are used for the height parameter. Values of ($\bar{h}$) are obtained from the map by planimetry of the path. Annual concentrations in gram equivalents × 10^6 × l.$^{-1}$, miles and feet, are used for the chemical species, s and h, respectively.

At the shore or salt-flat point of origin of the particles, $s = 0$; and $\mathrm{Cl} = a\,\mathrm{Na}$, with a obtained directly from ref. 2. Integration of (1) leads to:

$$\log_e\left\{-\frac{1}{s}\log_e\left(\frac{1}{a}\frac{\mathrm{Cl}}{\mathrm{Na}}\right)\right\} = \log_e k + \beta h \tag{1'}$$

It can be seen that (1′) depends on the ratio of components alone and not on their individual concentrations; constants β and k can be obtained by least squares and we find:

$$\beta = (1\cdot_{[illegible]} \pm 0\cdot 9)\,10^{-4};\quad k = (1\cdot_{18} \pm 0\cdot 2)\,10^{-3}$$

It is evident that the true distance an air mass follows may differ substantially from our calculated values of s and that 'individual average speeds' will probably differ. While therefore a relatively large standard deviation of the chlorine : sodium function discussed above ($S.D. = 0\cdot 22$ unit) may well be understood, it appears to be of interest that better consistency is found when parameter s is completely eliminated from the scheme. If altitude alone is assumed to govern the process, then:

$$d\,\mathrm{Cl} = -k\,\mathrm{Cl}\,(\exp k'h)\,d\,h \tag{2}$$

which, following a procedure similar to the one previously described, integrates to:

$$\log_e\left(\frac{1}{a}\frac{\mathrm{Cl}}{\mathrm{Na}}\right) = \frac{k}{k'}\left(1 - (\exp k'h)\right) \tag{2'}$$

When the exponential term in this equation is expanded in series (stopping at the 3rd term) and substituted, (2′) becomes linear in:

$$\frac{\log_e\left(\frac{1}{a}\frac{\mathrm{Cl}}{\mathrm{Na}}\right)}{h} \text{ and } h$$

Constants k and k' can thus be obtained by linear regression; Table 1 gives the results obtained together with standard deviations of the functions computed.

Table 1. Coefficients, Equation of Change of Chloride/Sodium in Rain-water with Altitude (Equation (2′))

Elevation	k	k'	*S.D.* of chlorine : sodium = $f(h)$
h	$(7\cdot_{143} \pm 0\cdot 8)\,10^{-4}$	$(-3\cdot_{[illegible]} \pm 1)\,10^{-4}$	0·156
$\bar{h}$	$(5\cdot_{[illegible]} \pm 0\cdot 7)\,10^{-4}$	$(-2\cdot_{413} \pm 1)\,10^{-4}$	0·144

The expression $\frac{1}{a}\frac{\mathrm{Cl}}{\mathrm{Na}}$ is plotted against $\bar{h}$ in Fig. 1. Since suitable corrections for other factors (such as potassium, latitude, etc.) which might have had an influence on the phenomenon investigated failed to

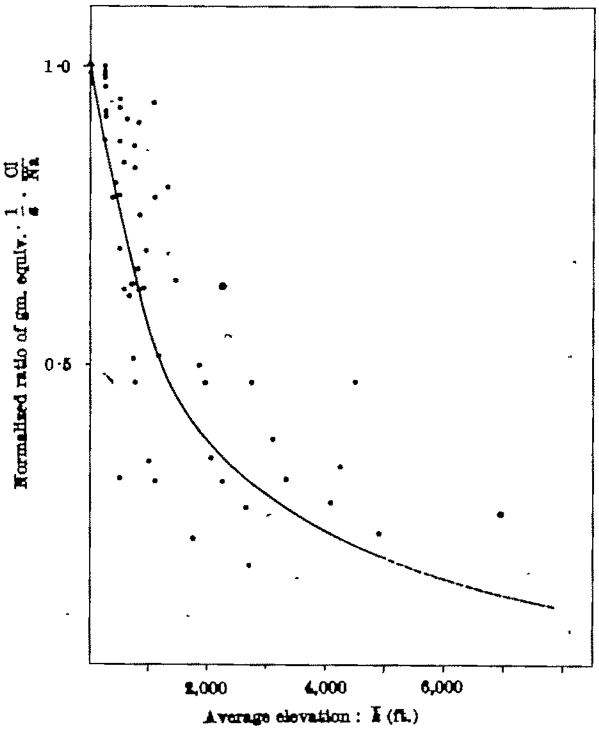


Fig. 1

improve the correlation, and since furthermore equations of type (2) appear to represent the process better than those of type (1) or other patterns considered, it may be thought that in the circumstances prevailing and in view of the large overland distances involved, the transformation of the sodium chloride aerosol must not only be relatively fast but also that it may proceed with a 'pseudo-reversibility'. This could be explained in terms of oxidation of chlorine[8] by factors increasing exponentially with altitude, which would cause a failure of detection of the new species by the chloride test to occur. The oxidized species, after having travelled down-slope, would afterwards be reduced by such atmospheric agents as may prevail at lower heights. An indication of the possibility of such a process may be obtained from the analysis of correlation coefficients between chemical species and altitude over the United States[3]. While in fact an increasing trend of calcium with h is indicated, and sulphate correlates with calcium, an increasing trend between sulphate and chlorine is suggested although both species have negative correlation coefficients with altitude. Second correlation coefficients of sulphate over calcium and chlorine (r_2 = 0·770) and of chlorine over sulphate and h (r_2 = 0·483) are both larger than absolute values of the individual components. We believe that this may be due in part to the oxidation of atmospheric hydrogen sulphide to free sulphuric acid aerosol, by products of oxidation of chlorine.

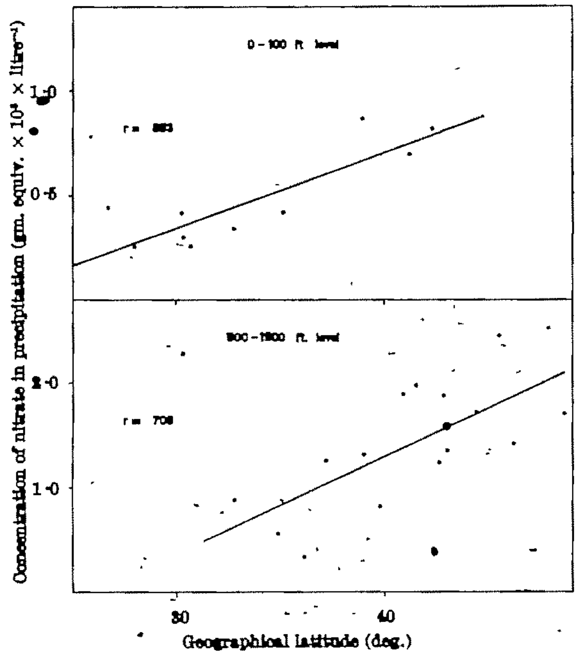


Fig. 2

(2) *Nitrate.* While at higher altitudes nitrate appears almost to be the complement of 'escaped' chlorine, a slight excess of the species over sodium and even over sodium + potassium can be detected at low levels. Plots of nitrate versus latitude for eastern United States are given in Fig. 2; significantly a positive correlation is obtained. The correlation coefficients decrease with altitude and eastward until quite low values for iso-altitudes in the Rocky Mountains are reached. It is possible that the cause of this is to be sought in patterns of atmospheric circulation and in such chemical processes as may be associated with phenomena dependent on geographical or perhaps, rather, geomagnetic co-ordinates.

We are indebted to Prof. V. Caglioti for his encouragement and help and to Prof. G. Fea for his interest in the problems described. Stimulating discussions with Dr. O. Vittori and Prof. D. Fedele are gratefully acknowledged.

HENRY M. PAPÉE
ALBERTO MONTEFINALE

National Research Council of Italy,
C/o the Meteorological Research Division
of the Italian Air Force,
Piazzale Grande Archivio,
Rome.

[1] Eriksson, E., *Tellus*, 11, 1 (1959).
[2] Junge, C. E., and Werby, R. T., *J. Meteor.*, 15, 417 (1958).
[3] Papée, H. M., and Smith, A. C., *Geofisica Pura e Applicata*, 44, 204 (1959).
[4] Papée, H. M., *J. Meteor.*, 16, 217 (1959).
[5] Kline, D. B., Monograph 5, Amer. Geophys. Union, 240 (1960).
[6] Rossby, C. G., and Egnér, H., *Tellus*, 7, 118 (1955).
[7] Mayer, E., *Helv. Phys. Acta*, 14, 625 (1941).
[8] Cauer, H., "Compendium of Meteorology", edit. by Malone, T. F., 1126 (Boston, 1951).

METALLURGY

A Symmetrical Fourfold Helical Fracture in Titanium Oxide

DURING the course of experiments on hot pressing powders of various hard, refractory materials, an interesting and apparently inexplicable fracture occurred in a specimen of titanium oxide. The general form of the fracture is shown in Fig. 1. It consists of four helices projecting as shallow cones. The specimen had also broken into four practically equal segments.

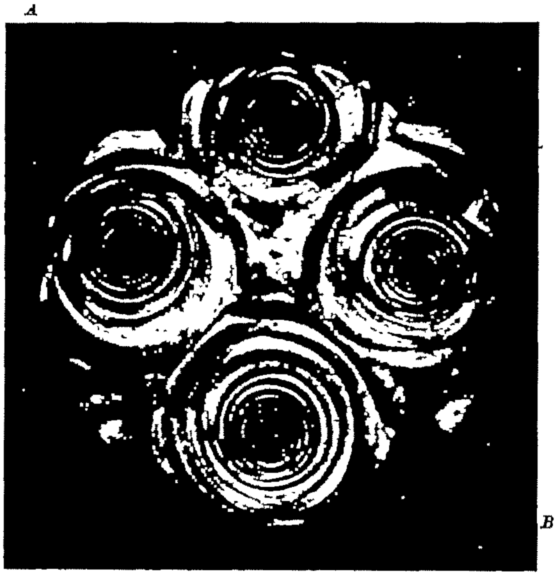


Fig. 1. Fractured surface of titanium oxide. (× 5)

The fracture arose during an attempt to separate the specimen from the cemented tungsten carbide plunger with which it had been pressed and to which it was adhering. Fracture took place almost entirely through the oxide, a layer of which, 0·5–1 mm. thick, remained adhering to the plunger. The second series of fractures, which is perpendicular to the plane of the paper, were normal in appearance. They can be seen in the form of an X with the arms at right angles.

On closer examination of the four helices it can be seen that the tip consists of a very small circle of carbide from the plunger. The helices are of almost identical form and size. Starting at a peak it can be seen that three of the helices are in a clockwise direction; the direction of the fourth is indeterminable. In Fig. 2 one of the helices is shown at a higher magnification.

The specimen was pressed from 98·5 per cent purity titanium dioxide of average particle size 0·2μ in a cemented tungsten carbide die ('Ardoloy *S3*') with a plunger of similar material. A pressure of 10 tons/sq. in. applied for 15 min. at 900° C. was used to produce a specimen ½ in. in diameter approximately ⅛ in. thick. To avoid difficulty in extraction from a cold die, the specimen was ejected while at the pressing temperature into a vessel containing fine aluminium oxide powder heated to 600° C. This could then be slowly cooled to prevent cracking the specimen through thermal shock.

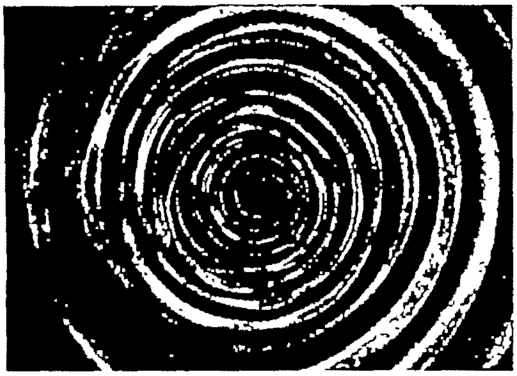


Fig. 2. Spiral fracture. (× 15)

Explanations could possibly be offered to account for the form of fracture shown by the individual segments. The mystifying feature in this case is that such a peculiar form of fracture should occur in a fourfold manner with such a high degree of exactness and symmetry.

The plunger and specimen had been separated by a bending action, the point of pivot being at *A* (Fig. 1) and the point of maximum tension at *B*, that is, in the direction of one of the vertical fractures. The face of the plunger had originally been ground but had become a mat surface through use.

The helical fractures had most likely started at the tip where the carbide adhered. It is possible that this was due to diffusion of material (most likely cobalt) from the plunger into the oxide, since the tips of the cones were also slightly discoloured beneath the level of the adhering carbide. There was no apparent reason, however, for the diffusion to be more prominent in these four symmetrically arranged spots. Internal stresses arising through the rate of cooling and the dissimilar contraction coefficients of the plunger and oxide would no doubt be present apart from the bending stresses, but again could not account for the fourfold symmetry.

J. S. Jackson

Research Laboratory,
Associated Electrical Industries (Rugby), Ltd.,
Rugby,
Warwickshire.

Mode of Action of Soluble Matrix Antifouling Compositions

It has been demonstrated by Barnes[1] that the copper leaching-rates of antifouling compositions, based on the same soluble matrix, are proportional to the cuprous oxide content if the total matrix content remains constant.

Work being carried out in this laboratory has shown that the relationship is only correct when the antifouling compositions are stored in almost static sea water between leaching-rate determinations. If the sea water used for storage is agitated, then the leaching-rates of the compositions decrease with increasing agitation until they reach a constant minimum which is independent of the cuprous oxide content.

A possible explanation of these results is that under static conditions of storage the dissolution of copper is confined to particles of cuprous oxide partially embedded in the surface of the matrix; these particles produce a concentrated surface layer of copper ions which prevents any diffusion of copper ions from the matrix. Agitation reduces the ionic concentration of copper in the surface layer and also may remove all the particles of cuprous oxide exposed at the surface.

Under such conditions the leaching is due entirely to the diffusion of copper ions through and from the whole of the surface of the matrix (apart from areas occupied by fillers): it is independent of the cuprous oxide content and the rate depends mainly on the rate of reaction of the matrix. Increased agitation has little or no effect on the leaching-rate provided the compositions are suitably pigmented to reduce mechanical erosion to a minimum. By increasing the temperature of the agitated sea water it has been shown that it is possible to increase the rate of solution of the matrix until it exceeds the rate of diffusion of the copper ions.

Under these conditions the leaching-rates again become proportional to the cuprous oxide contents

These observations are considered to have an important bearing on the study of the performances of antifouling compositions on ships under way and in dock.

A. Partington

Research Laboratory,
Research Organization of Ships' Compositions
Manufacturers, Ltd.,
New Quay Road,
Hamworthy,
Poole.

[1] Barnes, H., *J. Iron and Steel Inst.*, 169, 164 (1951).

CHEMICAL ENGINEERING

Control of Reaction Rate in Dust Flames

Ever since Nusselt[1] introduced the boundary layer concept, about forty years ago, for calculating rates of heat and mass transfer to a spherical particle, it has been universally accepted (without proof) by subsequent theoretical work (see ref. 2) that the reaction-rate of particles in a dust flame is determined by the rate of supply of oxygen through a diffusional boundary layer surrounding the particles. That this might not in fact be so was first suggested[3] about five years ago, the alternative proposition being that the rate control was chemical, not physical; the source of the implied error is attributed to the misinterpretation of reaction data in terms of diffusion instead of chemisorption which, according to Brunauer[4], has been a common mistake in the past. Support for the alternative hypothesis, however, has now been provided by analysis of experimental results obtained recently from an anthracite flame.

The experimental furnace or reactor has been described in outline elsewhere[5]; the flame generated by it may be regarded as a vertical cylinder, 18 in. in diameter and 15 ft. high, in which the particles travel paraxially downwards. The residual coke, mainly carbon formed by expulsion of volatiles, is brought up to temperature by burning these volatiles in primary air; the reaction we are chiefly interested in is then initiated by the 'instantaneous' introduction of secondary air at an appropriate point, and the subsequent reaction is followed down the furnace by solid sampling. Since anthracite is non-caking, complications from swelling are eliminated.

For theoretical analysis the material is assumed to be pure carbon. On the respective hypotheses of physical (diffusional) and chemical reaction control, the equations for specific reaction-rate (R_s) may be written respectively:

$$R_s = k_D/d\ ;\quad R_s = k_c \qquad (1a,b)$$

where d is the particle diameter; and the factors k_D and k_c are both proportional to the concentration of the main stream of oxygen[6], and are both known functions of temperature (T). k_D contains the diffusion coefficient and therefore follows a T^2 law; and k_c contains the Arrhenius factor, $\exp(-E/RT)$. In the past, it has been assumed that k_c has a much greater temperature coefficient than has k_D. The source of this possible error was the wrong choice of value for E, the value of 40,000 cal. generally used being that for the decomposition of the adsorbed oxide film[7]. This decomposition process, however, only controls the reaction at low temperatures (less than 1,000° C.). At flame temperatures (greater than 1,000° C.) the rate of chemisorption becomes important, and if the assigned[3,4,5] value of the activation energy for this, namely, 4,000 cal., is valid, then k_c also approximates closely to a T^2 law.

Appropriate integration of equations (1) for a single particle in an infinite atmosphere gives the burn-out time (t_b) as a function of initial diameter (d_0); respectively, we get:

$$t_b = K_D.d_0^2\ ;\quad t_b = K_c.d_0 \qquad (2a,b)$$

where the burning constants K_D and K_c may be calculated from diffusion theory and kinetic theory respectively; their values are found to be of the order of 1,000 and unity. The validity of equation (2a), both with respect to the square law and to the value of the constant, has now been confirmed by experiments[8] on captive coal particles suspended in a radiation and low-intensity convection field, the particle sizes ranging from 300 microns to 4 mm.

In flames, however, a limited air supply increases the burning times. Following Nusselt[1] and others[10], the multiplying factors (F_D and F_c) for the two cases have been shown[9] to be calculable functions of excess air alone. These various functions have been

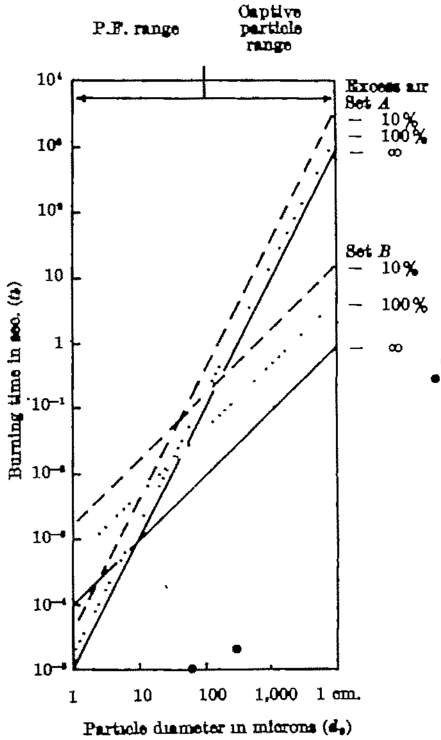


Fig. 1. Comparison of calculated burning times in a flame, at 1,500° C., on the hypotheses of diffusional and chemical reaction control respectively (hypothetical carbon flame). Set *A*, physical control: $t_b = F_D \cdot K_D \cdot d_0^2$; set *B*, chemical control: $t_b = F_c \cdot K_c \cdot d_0$

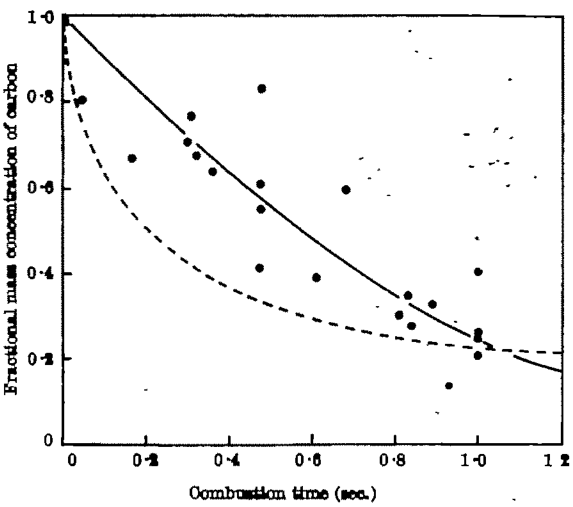


Fig. 2. Decay of carbon concentration in a dust flame with time. Comparison of experimental values (●) with predicted values assuming: (i) diffusional rate-control (dotted line); (ii) chemical rate-control (full line)

calculated[10], and Fig. 1 shows the burning times predicted from the two theories for a carbon dust flame at 1,500° C. at three levels of excess air: 10 per cent, 100 per cent and infinity (single particle). From this it is clear that, if the assumptions made are valid, we have two regimes as follows: (i) the 'captive particle' range of 100 microns to 1 cm., over which the diffusional processes have been proved to be dominant when the convection field is weak; and (ii) the pulverized fuel range of 1–100 microns, inside which, in real flames (less than 100 per cent excess air), the diffusion mechanism is unimportant.

The existence of the first regime in weak convection fields is now established; its continued existence in strong convection fields is at present under experimental examination. The question immediately at issue here is: Does the first regime extend also into the pulverized fuel range, or is it superseded by the second regime, as suggested by argument from Fig. 1? To test this, predictions have been made from the alternative theories derived as special cases of a general theory (Siddall, R. G., private communication) and these have been compared with measurements from the furnace. The starting equations used were in effect (1*a*) and (1*b*), but integrated to predict the time required to burn to varying degrees of incomplete combustion, the effect of distribution of particle size being allowed for in this. The results of these calculations are shown in Fig. 2. In this, fractional mass concentration has been plotted against time for (i) diffusional control (dotted line), and (ii) chemical control (full line); the final fit was adjusted by means of a somewhat arbitrary constant the value of which is difficult to calculate from absolute theory, but the shapes of these curves are determined by the diameter function which is predicted. For the experimental comparison, the full circles are the experimental points.

In our opinion, the chemical control theory gives a much better fit to the experimental results than does the physical control theory. While, therefore, this is not yet conclusive, we suggest that surface reaction at high temperatures plays a much bigger part than previously imagined, and it therefore deserves much greater attention than has been accorded to it in the past.

We acknowledge permission to submit this communication from the Electricity Supply Research Council and Prof. M. W. Thring.

J. M. Beér
R. H. Essenhigh

Department of Fuel Technology
and Chemical Engineering,
University of Sheffield.

[1] Nusselt, W., *V.D.I.*, 60, 102 (1916); 68, 124 (1924).

[2] (*a*) Burke, S. P., and Schumann, T. E. W., *Indust. Eng. Chem.*, 23, 406 (1931); 24, 451 (1932). (*b*) Hottel, H. C., *et al.*, *ibid.*, 26, 749, 889 (1934); 28, 1334 (1936). (*c*) Spalding, D. B., *Proc. Inst. Mech. Eng.*, 168, 545 (1954). (*d*) van der Held, E. F. M., Central Technical Institute T.N.O., Delft, Heat Section Report No. 39.

[3] Essenhigh, R. H., *Sheffield Univ. Fuel Soc. J.*, 6, 15 (1955).

[4] Brunauer, S., "Adsorption of Gases and Vapours", 10 (Oxford Univ. Press, 1945).

[5] Beér, J. M., Thring, M. W., and Essenhigh, R. H., *Combustion and Flame*, 3, 557 (1959).

[6] Essenhigh, R. H., and Perry, M. G., Inst. Fuel Conference "Science in the Use of Coal"; Introductory Survey, p. *D*1 (Sheffield, April, 1958).

[7] Gulbransen, E. A., and Andrew, K. F., *Indust. Eng. Chem.*, 44, 1034, 1039 (1952).

[8] Blyholder, G. D., and Eyring, H., U.S. Air Force Office of Scientific Research Report: Technical Note O.A. No. xx (August 1956).

[9] (*a*) Essenhigh, R. H., and Thring, M. W., Inst. Fuel Conference "Science in the Use of Coal", Paper 29, p. *D*21 (Sheffield, April 1958). (*b*) Essenhigh, R. H., thesis, University of Sheffield (1959).

[10] Hottel, H. C., and Stewart, I., *Indust. Eng. Chem.*, 32, 719 (1940). Traustel, S., *Feuerungstechnik*, 29, 105 (1941). Ledinegg, M., "Dampferzeugung", 238 (Springer-Verlag, Wien, 1952).

OCEANOGRAPHY

Alleged Occurrence of the Perchlorate Ion in Sea-Water

In a recent communication, Baas Becking, Haldane and Izard[1] claimed to have found up to 100 p.p.m. of perchlorate in sea and ocean waters, and between 100 and 1,000 p.p.m. in estuarine and inshore waters. They have suggested that this perchlorate is formed from chloride in the water by oxidation, and that the formation of perchlorate in this manner will reduce the chlorinity of the water to the extent of up to the second decimal per mille.

In view of this suggestion, we have re-investigated the occurrence of perchlorate in sea-water, using a new analytical method. The water sample is treated with potassium perrhenate and tetraphenylarsonium chloride; the precipitate of the slightly soluble tetraphenylarsonium perrhenate co-precipitates perchlorate from the sample. The dried precipitate is formed into a disk with potassium bromide and the amount of perchlorate is determined by measuring the optical density of the disk at 9·12µ. The method is sensitive to about 0·03 p.p.m. of perchlorate ion and has a coefficient of variation of about 9 per cent with 1·0 p.p.m. perchlorate ion. Neither periodate nor the ions normally present in sea water interfere.

We have examined surface and deep-water samples from 25 stations in the Arctic Ocean, North Atlantic, English Channel, Mediterranean, Indian Ocean, Red Sea and Persian Gulf. In no case have we been able to detect any trace of perchlorate. These negative results are confirmed by the observations of Klemperer[2] that the addition of as little as 0·05 p.p.m. of perchlorate to sea water reduces the rate of uptake of iodine by *Fucus ceranoides* by about 60 per cent.

It is suggested that the results obtained by Baas Becking *et al.*, using methods based on methylene blue, were in error owing to the interfering effects of many other ions, particularly sulphate[3] and chloride, and to the generally capricious nature of this reagent.

We thank Mr. J. Berkeley for making the infra-red measurements.

R. GREENHALGH
J. P. RILEY

Department of Oceanography,
University of Liverpool.

---

[1] Baas Becking, L. G. M., Haldane, A. D., and Izard, D., *Nature*, 182, 645 (1958).

[2] Klemperer, H. G., *Biochem. J.*, 67, 381 (1957)

[3] Nabar, G. M., and Ramachandran, C. R., *Anal. Chem.*, 31, 263 (1959).

CHEMISTRY

Covalent Super-Exchange in Solid State Physics

MAGNETIC coupling of next-to-nearest neighbours through a non-magnetic anion (super-exchange) has been explained by Anderson[1] by considering 'excited states' in which a single electron in a p-orbital of the anion is transferred to one of the neighbouring cations. Goodenough and Loeb[2] have emphasized correctly that such interactions are essentially covalent and have given the name 'semi-covalence' to Anderson's one-electron transfer. As stressed by Goodenough and Loeb, the increase in Curie or Néel temperatures in series such as MnO-FeO-CoO-NiO, or MnO-MnS-MnSe-MnTe, is evidence for the part played by covalence in magnetic coupling.

Anderson's theory leads to the prediction that super-exchange should be antiferromagnetic if the paramagnetic ion has its original d-shell half-full or more (manganese, iron, cobalt, nickel, copper) and ferromagnetic otherwise (titanium, vanadium, chromium). There are many exceptions to this rule, as shown in Table 1.

Table 1. FERROMAGNETIC AND ANTIFERROMAGNETIC COMPOUNDS OF ELEMENTS IN FIRST TRANSITION SERIES

	Ti	V	Cr	Mn	Fe	Co	Ni	Cu
MO	A(8)	A(8)		A(10)	A(10)	A(10)	A(10)	A
M_2O_3	A(8)	A(8)	A(8½)	A(10)	A(10)			
MO_2		A(8½)	F(9)	A(9½)				
MS		A(8)	F(9)	A(10)	A(10)	A(10)	A(10)	A(10)
MS_2*				F(7)		F(7)	F(7)	
MSe		A(8)		A(10)				
MTe			F(9)	A(10)				
MAs				F(9)				
MSb			A(8)	F(9)				
MBi				F(9)				

A, Antiferromagnetic; F, ferromagnetic; (n), number of electrons in covalent structure

* Only electrons in M-S bonds counted.

Numbers in parentheses in Table 1 refer to the number of electrons participating in covalent bonding; that is, the number of electrons in molecular orbitals surrounding an anion. Inspection of these numbers indicates that antiferromagnetism tends to occur when n is even, whereas ferromagnetic coupling occurs when n is odd.

To determine the number n, one must first consider the effect of crystal-field splitting on the $3d$-levels of the paramagnetic cation. Let n' be the number of electrons in the upper level (for example, 2 for manganese ions, 1 for chromium ions (Cr^{3+}), in an octahedral field). If p is the co-ordination number of the cation and q that of the anion, $n = n'\frac{q}{p} + n''$, where n'' is the number of valence electrons of the anion. It makes no difference whether n'' includes s-electrons or not, as the number of s-electrons is even. Thus for manganese sulphide, $p = q = 6$, $n' = 2$, $n'' = 8$ (or 6), $n = 10$ (or 8) and is even. In chromium sulphide (CrS), $n' = 1$, $n = 9$ (or 7) and is odd. Expressed in a different manner, n' is the number of $3d$-electrons of the cation participating in the formation of hybrid orbitals, the nature of the latter being deduced from the symmetry of the anionic arrangement around a cation (for example, d^2sp^3 in octahedral manganese sulphide, d^3p^3 in the distorted trigonal antiprism of α-Fe_2O_3).

Although no rigorous treatment can be carried out at this moment, a simple argument may suggest why the sign of super-exchange interaction depends on whether n is even or odd. Consider manganese sulphide, in which both cation and anion are in octahedral co-ordination. Both can use d^2sp^3 hybrid orbitals, and six bonding and six antibonding molecular orbitals can be formed around each sulphur. These orbitals contain 10 electrons, and so with respect to a fully covalent structure the compound is deficient in electrons. Four molecular orbitals will carry two electrons each; charge correlation requires that the two remaining electrons be as far apart as possible, that is, 180°. These will go into molecular orbitals on opposite sides of the anion, thus accounting for the large angle characteristic of super-exchange. These two molecular orbitals are not fully orthogonal because of overlap of the orbitals of the cation on either side of the central anion, and they may thus be considered to form two orthogonal three-centred orbitals of slightly different energies. The ground-state will be such that the two electrons in the bridge occupy the lowest of the 3-centre orbitals with spins antiparallel; these electrons in turn interact with the remaining t_{2g} electrons on the adjacent cations (as implied in ionic-covalent resonance), which will be coupled antiferromagnetically. The single electron in the 3-centre orbital of chromium sulphide must lead to ferromagnetic coupling.

A similar analysis can be carried out for other substances listed in Table 1. More complicated oxides (for example, ferrites) present an additional problem in that n is commonly not an integer (9·75 in Fe_3O_4). For fractional numbers between 9 and 10, one may hesitate to predict the sign of super-exchange; possibly in such cases a small amount of direct exchange between next neighbours is the determining factor. For example, chromium oxide (Cr_2O_3) is antiferromagnetic although it might be expected to be ferromagnetic ($n = 8½$). Neutron diffraction reveals ferromagnetic coupling between cations at large distances and at large Cr-O-Cr angles; only interactions at shorter distances and through smaller angles (hence presumably not super-exchange) are antiferromagnetic. In dioxides with the rutile structure (vanadium, chromium, manganese dioxides), further complications arise from the possibility of extensive π-interaction between oxygen p (the oxygen is in trigonal planar hybridization) and metal t_{2g} orbitals. It is worth noting that the present arguments predict that a solid solution of vanadium oxide (VO_2) and manganese dioxide in the ratio 1 : 1 would have the same electron number as ferromagnetic chromium oxide, and should accordingly also be ferromagnetic, although the two end-members are both antiferromagnetic.

W. S. FYFE
J. VERHOOGEN

Geology Department,
University of California,
Berkeley, California.

---

[1] Anderson, P. W., *Phys. Rev.*, 79, 350 (1950).

[2] Goodenough, J. B., and Loeb, A. L., *Phys. Rev.*, 98, 391 (1955).

Atomic Absorption Spectrophotometric Determination of Molybdenum and Strontium

RECENT work reported by Menzies[1] and Robinson[2] has suggested that atomic absorption flame methods[3,4] are not applicable to the determination of molybdenum and that the limit of strontium determination lies between 2 and 10 p.p.m. in solution.

Using a 10-cm. air-acetylene burner, a scale expansion device (suggested by Dr. J. B. Willis) and a modulated single-beam system[5], it has been found that the limits of estimation of molybdenum and strontium in solutions free from interfering ions are about 0·5 and 0·05 p.p.m. respectively. Molybdenum 3132 Å. (a^7S–y^7P°) was the strongest in absorption of the nine absorbing molybdenum lines found. Strontium measurements were carried out on strontium 4607 Å. The gain in sensitivity for strontium over those previously reported is a direct result of stability of hollow cathode emission, the use of a long burner and the use of an expanded scale on the measuring unit reading 0–20 per cent absorption over full scale. The determination of molybdenum was achieved by adjustment of the air and acetylene pressures to give reducing conditions in the flame and passage of the beam from the hollow cathode discharge tube through the flame at a point just above the cone of unburnt gases.

The concentration of free ground-state atoms of molybdenum in the flame was found to be critically dependent on the proportions of air and acetylene. No perceptible absorption resulted from spraying a 50 p.p.m. molybdenum (ammonium molybdate) solution into an air-rich flame, whereas adjustment of the proportion of air to acetylene to give a flame in which yellowing due to incandescent carbon particles was just visible at the base gave an absorption of 35 per cent. Provided that the beam from the hollow cathode tube was confined to the lowest possible level in the flame, no great gain in sensitivity resulted from the use of a highly luminous flame. Despite this dependence on reducing conditions, the presence of an oxidizing agent in the sample solution did not cause serious depression of molybdenum absorption (compare cols. 3 and 4, Table 1). The presence of the large excesses of extraneous elements in the samples examined had a greater effect than did nitric acid (compare cols. 4 and 5, Table 1), but this effect was not so great as to cause difficulty in analysis due to loss of sensitivity.

The results in column 5 of Table 1 were obtained by use of the 'addition' method. This procedure has been used in arc emission determination[6,7] of trace elements in samples of widely variable major element composition. However, poor precision and uncertainty regarding linearity of the relationship between emitted intensity and concentration impairs its value in arc analysis. Provided the equation of a non-linear curve is known, the use of the addition method is possible, but tedious.

Table 1. Concentrations of molybdenum in samples of molybdenized superphosphate (nominally 1·5 oz. molybdenum trioxide per cwt.) and stainless steel as calculated from atomic absorption analysis against standards in water, in 0·82 *N* nitric acid and by the 'addition' method. The analyses were carried out directly on portions of 200-ml. final volumes of nitric–hydrochloric acid solutions prepared from the samples

Sample	Weight taken (gm.)	Apparent molybdenum concentration using		Molybdenum concentration by addition method (per cent)
		Standards in water (per cent)	Standards in nitric acid (per cent)	
Superphosphate (1)	8·42	0·0317	0·0356	0·0575
(2)	10·0	0·0366	0·0412	0·0555
(3)	10·0	0·0366	0·0412	0·0526
Stainless steel (1)	2·930	0·159	0·179	0·266
(2)	2·933	0·171	0·192	0·278

By taking three equal aliquots of a sample solution, adding equal volumes of water to one and solutions containing known concentrations of the analysis element to the other two, then analysing all three using the apparatus described, it was found that the relationship between percentage absorption and concentration was linear up to about 15 per cent absorption. This test has been carried out for molybdenum in the samples cited in Table 1, for strontium in ammonium chloride extracts of soils and in nitric–perchloric–sulphuric acid digests of plant material and for calcium in solutions for microbiological culture.

The addition method was found essential to the analysis of plants for strontium because measurements on synthetically prepared solutions indicated that the interferences would be so difficult to control that the results of analysis against orthodox standards would be unreliable. Advantage may be gained from the general application of the addition method to atomic absorption analysis because, in using it, both sample and 'standard' are measured under exactly the same conditions of viscosity, surface tension and chemical interference and because modulated atomic absorption apparatus cannot measure anything but atoms of the analysis element in the flame.

Although insufficient sensitivity has been attained, as yet, in the direct atomic absorption analysis of solutions from plants and soils for molybdenum, the results in Table 1 indicate that advantages can be gained from its application to such analytical fields as those of the fertilizer and metallurgical industries. The specificity of the atomic absorption method employing a modulated system for measurement of the element sought gives it obvious advantages over flame emission methods in the analysis of soils, plants, bones and the like for natural strontium in 'fall-out' studies.

The results for molybdenum suggest the possibility of using reducing flame conditions to make possible atomic absorption analysis for other elements. They also suggest that further gains in sensitivity may result not only from designing burners to give high-temperature flames, but also from designing them to produce highly reducing conditions in the flame.

The apparatus used and the results of these and further investigations will be described in detail elsewhere.

D. J. DAVID

Division of Plant Industry,
Commonwealth Scientific and
Industrial Research Organization,
Canberra.

[1] Menzies, A. C., *Anal. Chem.*, **32**, 898 (1960).

[2] Robinson, J. W., *Anal. Chem.*, **32**, No. 8, 17*A* (1960).

[3] Walsh, A., *Spectrochim. Acta*, 7, 108 (1955).

[4] Russell, B. J., Shelton, J. P., and Walsh, A., *Spectrochim. Acta*, 8, 317 (1957).

[5] Box, G. F., and Walsh, A., *Spectrochim. Acta*, 16, 255 (1960).

[6] Oertel, A. C., *Aust. J. App. Sci.*, 1, 259 (1950).

[7] Foster, J. S., and Horton, C. A., *Proc. Roy. Soc.*, B, **123**, 422 (1937).

Determination of Nickel and Cobalt by Atomic Absorption

In the atomic absorption method of analysis, first described by Walsh[1], the solution to be analysed is sprayed into a flame, and with a hollow-cathode lamp which emits the line spectrum of the element being determined as the light source, the absorption of light by atoms of the element is measured at a characteristic wave-length.

To realize the full potentialities of the method, it is obviously important that the strongest absorption line be used. As at the temperature of commonly used flames all but a small proportion of the atoms are in the ground-state, only lines due to absorption by unexcited atoms need be considered, and of these lines it is usually assumed that the strongest absorption line will correspond to the strongest emission line. I have pointed out that while this is so in the simple spectra of the elements in Groups I and II, it is not necessarily the case in the more complex spectra of the heavier elements, and that as oscillator strengths for the various lines of these elements are generally not known, it is necessary to determine experimentally which line is the strongest in absorption[2]. Results were given for manganese and iron, showing that for these elements the strongest absorption lines were at 2794·8 Å. and 2483·3 Å. respectively.

The spectra of nickel and cobalt have now been investigated by the methods described previously. It has been found that the strongest absorption line for nickel is at 2320·0 Å. ($a^3F_4 - y^3G^\circ_5$), the absorption at this wave-length being about fifteen times that at 3415 Å., the wave-length of the strongest emission line. For cobalt, the strongest absorption line is at 2407·2 Å. ($a^4F_{4\frac{1}{2}} - z^4G^\circ_{5\frac{1}{2}}$), and this line is about fifty times as sensitive in absorption as is the strongest emission line at 3527 Å.

When these lines are used, the atomic absorption method can usefully be applied to the determination of nickel and cobalt, the sensitivity obtained being about the same as that already reported for iron.

I thank Mr. O. E. Clinton for his assistance with this work, full details of which will be reported elsewhere.

J. E. ALLAN

Rukuhia Soil Research Station,
Private Bag, Hamilton, New Zealand.

---

[1] Walsh, A., *Spectrochimica Acta*, 7, 108 (1955).

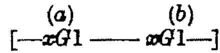
[2] Allan, J. E., *Spectrochimica Acta*, 15, 800 (1959).

BIOCHEMISTRY

Steric Factors affecting the Specificity of Polyglycosidases

The marked substrate specificity exhibited by enzymes has been related to a steric affinity between the molecule attacked and the attacking enzyme[1]. According to this concept, proper orientation of the substrate in the vicinity of the enzyme permits formation of an activated intermediate in which several points of contact may be established.

Enzymes which hydrolyse simple glycosides exhibit extremely high specificity for the glycosyl radical of the molecule, whereas the structure of the aglycone group usually is important in a quantitative, rather than qualitative, sense[2,3]. Glycosidases that degrade polysaccharides (I) appear to show high specificity for

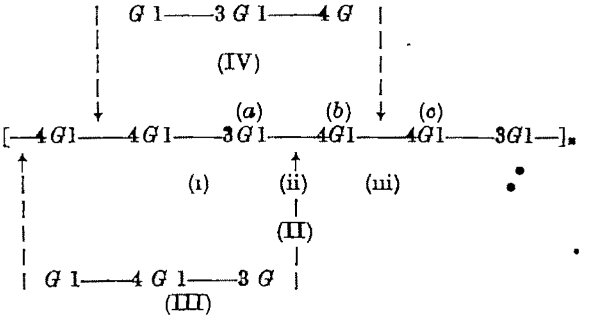


$$[\text{—}\overset{(a)}{xG1}\text{——}\overset{(b)}{xG1}\text{—}]_n$$

(I)

a particular type of linkage, as well as glycosyl unit. In evaluating such specificity, the enzyme is tested usually with several polysaccharides each of which contains only one type of sugar component and linkage (or as close as possible to this ideal); this procedure has become general since few polysaccharides of more complex structure are characterized in sufficient detail to be suitable as enzyme substrates. Cellulase, for example, degrades polymeric chains in which β-D-glucopyranose units are linked through positions-1 and 4 (I, G = D-glucopyranosyl; X = 4) but not when the linkages are β-(1→3), α-(1→4), etc., and is regarded as a β-(1→4)-poly-D-glucopyranosidase. In common usage, this terminology refers to the linkage cleaved, and implies that its position of attachment to unit I(b) has an important bearing on specificity. However, the glycosyl unit (a) is itself attached to a third unit (through the X-hydroxyl group), and the location of this linkage also might be expected to affect specificity through its influence on the stereochemistry of (a). Clearly, the relative importance of these steric factors is difficult to assess with polysaccharides of homogeneous structure. Recent observations[4] on the enzymolysis of a polysaccharide that contains mixed types of linkages suggest, however, that such questions should be taken into account in classifying polyglycosidases.

The polysaccharide examined is a soluble D-glucan from oats[5,6], the structure of which is represented[4,6] mainly by II, that is, a linear chain of β-D-glucopyranosyl units in which two (1→4) linkages (ii) and (iii) alternate repeatedly with a (1→3) linkage (i). Two different enzyme preparations have been found to degrade the glucan rapidly and extensively under conditions expected to minimize trans-glycosidation side-reactions. One of the enzymes has been classified as a β-(1→3) D-glucosidase, since it shows high specificity for laminarin and only low activity on other substrates tested[7]. With this polyglycosidase, the major product obtained from the oat glucan is trisaccharide III[4,6], showing clearly that hydrolysis is preferential for linkage (ii), that is, the glycosidic bond of a β-D-glycosyl unit (a) attached through positions-1 and -3 to adjacent units, rather than a β-(1→3) linkage (i). (In laminarin, of course, most of the glycosyl units possess this type of 1,3-relationship.)



The second enzyme used, a cellulase from *Streptomyces* sp. *QM B*814[8], degrades the glucan mainly to trisaccharide IV[4,6], showing that the hydrolytic action of this enzyme is preferential for linkage (iii). Now, linkages (ii) and (iii) of the polysaccharide are both of the β-(1→4) type, but glucosyl unit (*a*) is substituted at position-3; glucosyl unit (*c*) is substituted at position-4 but is attached to position-3 of an adjacent unit. Hence only glucosyl unit (*b*) is equivalent to a unit in a cellulose chain. The ready attack by the *Streptomyces* cellulase at this point indicates that the → 4-β-D-glucose relationship is at least as important for the enzyme action as is the β-D-glucose-(1→4) relationship.

These considerations are subject, of course, to the usual qualification that the enzymes used may not be pure—a difficulty which at present cannot be settled. However, they direct attention to the possibility that the current view of polyglycosidase stereospecificity is insufficiently broad. It may thus be desirable to regard cellulases, for example, as exhibiting (4→)-β-(1→4)-D-glucopyranosidase activity in recognition of the fact that the substrate attacked contains a *4-substituted* β-D-glucopyranosyl unit, and not a free β-D-glucopyranosyl unit. Such a term would be particularly apt for several known cellulases that degrade cellulose but do not attack cellobiose. The latter, it will be noted, contains the β-(1→4) linkage but the glycosyl unit itself is not substituted at position-4. Similar considerations could apply for other polyglycosidases (for example, β-amylases) that produce oligosaccharides, but not monomer, from polysaccharides.

We are grateful to Dr. E. T. Reese for permission to quote unpublished data from collaborative studies.

F. W. Parrish*
A. S. Perlin

National Research Council of Canada,
Prairie Regional Laboratory,
Saskatoon, Saskatchewan.

---

* National Research Council of Canada Postdoctorate Fellow, 1959–60.

[1] For example, "The Enzymes", ed. Boyer, P. D., Lardy, H., and Myrbäch, K., 1 (Academic Press, New York, 1959).
[2] Pigman, W. W., "Advances in Enzymology", 4, 41 (1944).
[3] Gottschalk, A., "Advances in Carbohydrate Chemistry", 5, 49 (1950).
[4] Parrish, F. W., Perlin, A. S., and Reese, E. T., *Can. J. Chem.* (in the press).
[5] Morris, D. L., *J. Biol. Chem.*, 142, 881 (1942).
[6] Peat, S., Whelan, W. J., and Roberts, J. G., *J. Chem. Soc.*, 3916 (1957).
[7] Reese, E. T., and Mandels, M., *Can. J. Microbiol.*, 5, 173 (1959).
[8] Reese, E. T., Smakula, E., and Perlin, A. S., *Arch. Biochem. Biophys.*, 85, 171 (1959).

'pH-Chromatography' of some Amphoteric Antibiotics

'*p*H-CHROMATOGRAPHY' is a paper chromatography method which can be used for simultaneous determination of the ionic character of antibiotics and of suitable *p*H values for their extraction[1]. The *p*H-chromatogram of an antibiotic is obtained by chromatographing on a series of strips of chromatographic papers buffered to *p*H values from 2 to 10. For the development of the strips by the ascending technique an organic solvent saturated with water is used. A suitable solvent is chosen by determining the solubility of the antibiotic being studied by paper chromatography[2]. In our reports on the *p*H-chromatography of antibiotics[1,3] we described three types of *p*H-chromatograms, depending on the ionic character of antibiotics:

(1) R_F values of *p*H-chromatograms of antibiotics of acidic nature give *S*-shaped curves, the maxima of which lie in the acidic range; with increasing *p*H values the R_F values diminish.

(2) The R_F values of *p*H-chromatograms of antibiotics of basic character give S-shaped curves of a reverse character; the maximum of the curves being in the basic and the minimum in the acidic range, respectively.

(3) *p*H-chromatograms of neutral antibiotics have practically the same R_F values along the whole range of *p*H values, giving a straight line parallel with the starting points.

The optimal *p*H for extraction of acidic or basic antibiotics is in the region of the maximal R_F value; the most suitable *p*H for re-extraction into water being that *p*H where the R_F on the *p*H-chromatogram is smallest.

We use *p*H-chromatography in seeking new antibiotics and sometimes obtain *p*H-chromatograms of a different type, which have so far not been described. The R_F values of this type of *p*H-chromatogram increase stepwise in the range of lower *p*H values and after reaching a certain maximum they begin to diminish. These compounds behave as bases from *p*H 2 to the point of their maximal R_F, and from this point on up to *p*H 10 they behave as acids. We presume that compounds belonging to this group are amphoteric.

We have run *p*H-chromatograms of some known amphoteric antibiotics, chlortetracycline, oxytetracycline, tetracycline, and mycostatin (nystatin) to verify this. The *p*H-chromatography of all these antibiotics was performed by the ascending technique in *n*-butanol saturated with water, the spots being detected microbiologically.

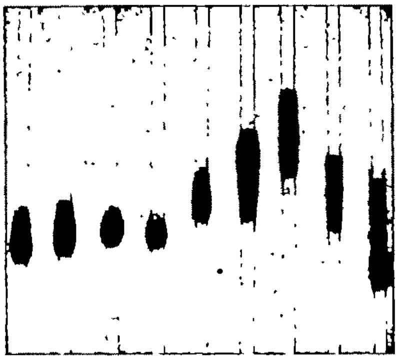


Fig. 1. *p*H-chromatogram of tetracycline in *n*-butanol saturated with water

In Fig. 1 a *p*H-chromatogram of tetracycline is presented. The R_F values of the spots increase stepwise up to *p*H 8, and successively diminish in the region of higher *p*H values.

The dependence of the R_F values of tetracyclines on *p*H values is depicted in Fig. 2. The R_F curves of chlortetracycline and tetracycline have a similar character and the maxima of both lie in the region of *p*H 8. The maximum of the R_F curve of oxytetracycline is in the region of *p*H 6, and the character of this curve is different from the character of the curves of previously mentioned antibiotics. We presume that the character of the curves is to some degree a function of the structure of the compounds studied, chiefly of the number of 'acidic' OH-groups present, chlortetracycline and tetracycline having five, and oxytetracycline six, OH-groups, respectively.

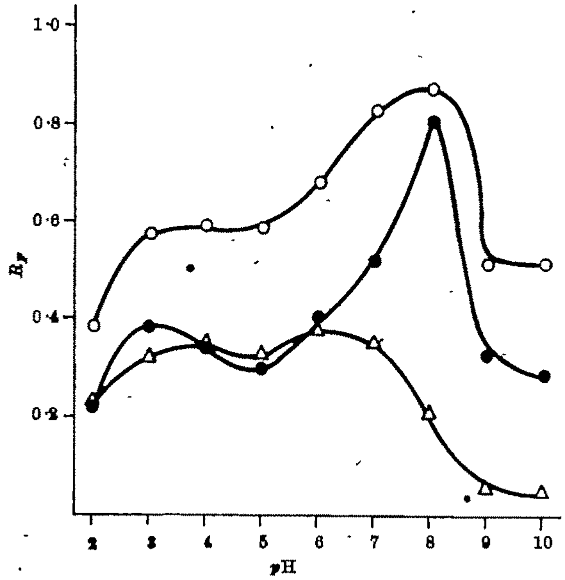


Fig. 2. Dependence of the R_F of tetracyclines on pH; solvent: *n*-butanol saturated with water. ○, Chlortetracycline; △, oxytetracycline; ●, tetracycline

In Fig. 3 the dependence of the R_F values of mycostatin on *p*H is shown; the curve having its maximum in the region of *p*H 8.

In all the cases presented the curves are not absolutely smooth; for example, they do not have the smooth character of the curves of acidic and basic antibiotics. Up to now we do not know the cause of this phenomenon; but we presume it could be caused by different chemical structure of the compounds studied.

We have also analysed by *p*H-chromatography the antibiotic *cycloserine* (oxamycin), the data of the ionic character of which differ in the literature. According to Harned *et al.*[4] this compound is a weak acid, whereas others[5] consider this compound to be amphoteric. The *p*H-chromatogram of this antibiotic (Fig. 4) proves it to be amphoteric.

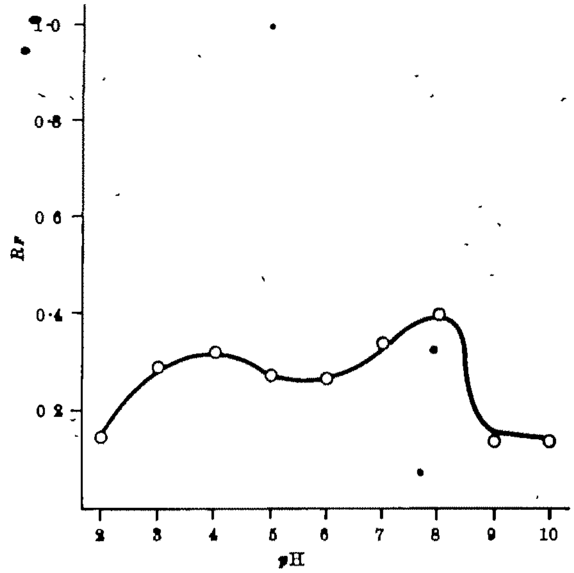


Fig. 3. Dependence of the R_F of mycostatin on pH; solvent: *n*-butanol saturated with water

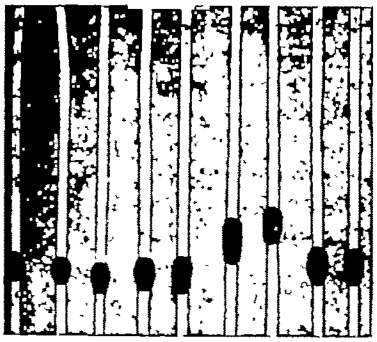


Fig. 4. pH-chromatogram of cycloserine in methanol

By the method described here, unidentified and, up to now, not even concentrated antibiotics can be divided into four groups according to their ionic character, that is, into acids, basic, neutral, and amphoteric compounds, and the suitable *p*H values for their extraction and eventual re-extraction into water can be determined. As the optimal *p*H value for the extraction of acidic and basic antibiotics lies in the range of that *p*H value where the R_F on the *p*H-chromatogram is greatest[1], we can presume that the same would be valid also for amphoteric antibiotics. Similarly, the region of the smallest R_F values indicates the most suitable *p*H for the re-extraction from the organic solvent into water.

We are of the opinion that the *p*H-chromatographic method can be used also for the determination of the ionic character of other compounds of biological origin and for the determination of suitable isolation procedures of these compounds.

VLADIMÍR BETINA
PAVEL NEMEC

Department of Technical Microbiology
and Biochemistry,
Chemical Faculty of the
Slovak Polytechnical University, Bratislava.

[1] Betina, V., *Nature*, 182, 796 (1958).

[2] Ševčík, V., Podojil, M., and Vrtišková, A., *Čsl. mikrobiol.*, 2, 175 (1957).

[3] Betina, V., *Chemické zvesti*, 13, 51 (1959).

[4] Harned, R. L., Hidy, P. H., and LaBaw, E. K., *Antibiotics and Chemotherapy*, 5, 204 (1955).

[5] Schull, G. M., and Sardinas, J. L., *Antibiotics and Chemotherapy*, 5, 398 (1955).

Interaction of Actinomycin with Deoxyribonucleic Acid

IN previous papers, Kawamata *et al.*[1,2] have reported the carcinogenic effect of actinomycin. In the course of investigating the mechanisms of action of actinomycin, evidence was obtained that this antibiotic shows a specific interaction with deoxyribonucleic acid. In the following experiments actinomycin *S* was used[3].

In order to examine the relation between nucleic acids of bacteria and actinomycin *S*, the extracts obtained from bacteria cultured in the presence or absence of actinomycin *S* were subjected to zone electrophoresis.

Bacillus subtilis strain NRRL-*B*558 was grown on a salt–glucose plus casein acid hydrolysate medium by shaking at 35° C. After culture for 6 hr. 10 μgm. of actinomycin *S* was added to the culture medium and incubated further for 1 hr. Then the bacteria were harvested and washed twice with chilled, distilled

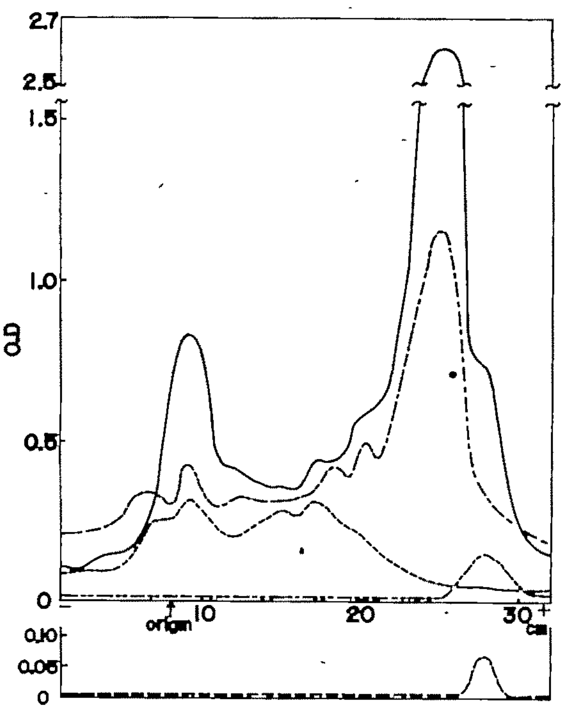


Fig. 1 Starch electrophoresis patterns of an extract of *B. subtilis*. Bacteria were grown at 35° C. with shaking in salt–glucose plus amino-acid medium. 10 μgm./ml. actinomycin *S* was added after 6-hr. culture. (———), ultra-violet absorption at 260 mμ; (– – – – – – –), Folin's reaction at 750 mμ, (— – — – —), orcinol–hydrochloric acid reaction at 660 mμ, (– – – – – – – –), diphenylamine reaction at 600 mμ, (— — — —), spectral absorption of actinomycin *S* at 440 mμ

water and an extract was prepared in 0·1 *M* phosphate buffer solution by grinding the precipitate of bacteria with alumina. Starch electrophoresis was performed in *p*H 8·8 borate buffer, ionic strength 0·1. The runs were made at 5° C. with constant current of 3 m.amp./cm.[2] for approximately 17 hr. The starch was then cut into 1 cm. sections, and each section was eluted with distilled water. The eluates were used for subsequent analyses. Total nucleic acid was estimated by readings of optical density at 260 mμ. The amounts of protein, ribonucleic acid and deoxyribonucleic acid were estimated by the Folin, orcinol, and diphenylamine methods respectively. Actinomycin *S* was estimated by readings of optical density at 440 mμ.

Results of analyses of a starch electrophoresis are shown in Fig. 1. Amounts of substances are plotted against distance travelled from the origin towards both electrodes. Actinomycin *S* was found to be distributed corresponding to the fraction of deoxyribonucleic acid. The same pattern was obtained when actinomycin *S* was subjected to zone electrophoresis together with the extract prepared from bacteria cultured in the absence of actinomycin *S*. Actinomycin *S* alone, however, travels to the cathode. Such an interaction was observed between actinomycin *S* and deoxyribonucleic acid prepared from calf thymus.

Table 1. Reversing Effect of Deoxyribonucleic Acid on Growth Inhibition of *B. subtilis* NRRL-*B558* by Actinomycin *S*

Actinomycin *S* in medium (μgm./ml.)	Time incubated (hr.)	Turbidity E_{530}			
		Deoxyribonucleic acid of calf thymus		Ribonucleic acid of yeast	
		none	0·05%	none	0·05%
0	0 2 4 6 8	0·055 0·075 0·240 0·570 0·700	0·055 0·072 0·250 0·560 0·730	0·040 0·072 0·370 0·700 0·790	0·040 0·060 0·300 0·720 0·810
0·01	0 2 4 6 8	0·055 0·060 0·075 0·085 0·090	0·055 0·075 0·240 0·560 0·710	0·040 0·055 0·075 0·080 0·090	0·040 0·082 0·107 0·120 0·150

Moreover, the inhibition of bacterial growth by actinomycin *S* was virtually abolished in the presence of thymus deoxyribonucleic acid in the medium, but not of yeast ribonucleic acid. The results are shown in Table 1.

In considering the fact that actinomycin has a potent anti-cancer activity, as well as marked carcinogenic effect in mice, the interaction shown between actinomycin *S* and deoxyribonucleic acid might play an important part in the mechanism of action. The mode of this interaction is now under investigation.

It is hoped that a full account of this work will be published elsewhere.

J. Kawamata
M. Imanishi

Department of Chemotherapy,
Research Institute for Microbial Diseases,
Osaka University, and
Institute for Cancer Research,
Osaka University Medical School,
Osaka.

[1] Kawamata, J., *et al.*, *Med. J. Osaka Univ.*, 8, 753 (1958).

[2] Kawamata, J., *et al.*, *Biken's J.*, 2, 105 (1959).

[3] Kawamata, J., and Fujita, H., *Med. J. Osaka Univ.*, 8, 737 (1958); *J. Antibiotics*, Ser. A. (in the press).

Biosynthesis of Sucrose by Preparations from Potatoes stored in the Cold and at Room Temperature

Perhaps the most pronounced and consistent metabolic response of potato tubers to stress situations, such as low and high temperatures, loss of water, and ionizing radiation, is the accumulation of sugars, especially sucrose. Although the relationship of sugar content to the so-called non-enzymatic browning of processed potato products has been amply documented[1], the biochemical events which create a milieu favourable to accumulation of sucrose are unknown. Conceivably, this increase in sucrose could arise as the result of changes in amounts of enzymes involved in sugar formation from starch, as compared with those involved in removal of sucrose.

Of these enzymes, the one most likely to be involved directly in sucrose metabolism would seem to be uridine diphosphoglucose → fructose-transglycosylase, first described by Leloir and co-workers[2] in wheat germ, maize germ, potato sprouts, pea seeds, beet shoots, etc., and demonstrated more recently in sugar beet leaves[3] and in soybeans and broad beans[4]. Although a net increase of sucrose has been demonstrated when fructose or glucose is administered to potato disks[5] and when potato tuber homogenates are incubated in the presence of glucose-1-phosphate, fructose, and dextran sucrase[6], demonstration of the presence of uridine diphosphoglucose → fructose-transglycosylase in potato tubers has not been reported.

We have now found that the potato tuber is a rich source of sucrose-synthesizing enzyme (Table 1). The enzyme fractions were prepared from 600 gm. of peeled Washington Russet tubers previously stored for 12 days at 25° C. or 2° C. The tubers were homogenized with 30 ml. of 0·1 *M* phosphate buffer of *p*H 7·0. After filtration through 'Celite', the filtrate was made 0·7 saturated with respect to ammonium sulphate. The precipitate was collected by filtration and dialysed against cold distilled water. The dialysed preparation (retentate) was centrifuged and the supernatant discarded after assays showed that it contained only minimal activity as regards synthesis of sucrose.

The precipitate obtained from dialysis of the preparation from potatoes stored at 25° C. was suspended in 62 ml. of water. By analysis, each millilitre had 1·97 mgm. of protein nitrogen and was equivalent to 9·7 gm. of fresh potato tissue. Corresponding values for the enzyme preparation from potatoes stored at 2° C. were 65 ml. total volume, 1·73 mgm. protein nitrogen per ml., and each millilitre of enzyme represented 9·2 gm. of fresh potato tissue. Sucrose was determined by the method of Rorem *et al.*[3], in which the residual colour and reducing sugars are eliminated by the addition of sodium borohydride prior to development of colour with resorcinol. The formation of sucrose in the enzyme reaction mixture was also demonstrated by paper chromatography.

The rates of synthesis of sucrose compare favourably with those of crude preparations from other plant sources. No significantly great differences were observed between the enzymatic activity of the protein fraction from tubers stored at 2° C., in which sucrose accumulates, and that from tubers stored at 25° C., in which sucrose does not accumulate. Both preparations exhibit the same apparent *p*H optimum for synthesis of sucrose and both possess invertase activity. The *p*H optimum for sucrose synthesis (Table 1) is probably not the true *p*H optimum of the enzyme, since at *p*H 8·1 we found that the invertase activity drops off rather sharply from that found at *p*H 7·1, thus allowing more sucrose to accumulate at the higher *p*H. It will be noted that the presence of invertase in the preparation from potatoes stored in the cold resulted in a decrease in sucrose in the enzyme reaction mixture at *p*H 7·1 after prolonged incubation. The presence of invertase in these preparations also vitiated attempts to establish the equilibrium of the reaction.

Additional experiments showed that these potato preparations can synthesize sucrose or sucrose-phosphate when fructose-6-phosphate is substituted for fructose in the enzyme reaction mixture. The possibility of conversion of the fructose-6-phosphate to free fructose by a phosphatase, however, has not been completely eliminated.

In two sets of experiments, enzyme preparations from the White Rose variety, known to be a good sugar former, synthesized sucrose at a rate 3–4 times as great as similar preparations from Washington Russet. These preliminary experiments suggest that varieties which tend to accumulate large amounts of sugar contain more enzyme than those with smaller accumulation of sugar.

Table 1. MICROMOLES OF SUCROSE SYNTHESIZED BY ENZYME PREPARATIONS FROM WASHINGTON RUSSET VARIETY POTATO TUBERS

*p*H	Enzyme from tubers stored at 25° C.			Enzyme from tubers stored at 2° C.		
	Incubation time 1 hr.	2 hr.	4 hr.	Incubation time 1 hr.	2 hr.	4 hr.
7·1	0·156	0·193	0·222	0·085	0·096	0·047
7·5	—	0·234	—	—	0·272	—
7·8	—	—	—	—	0·425	—
8·1	—	0·376	—	—	0·471	—
8·4	—	0·290	—	—	0·460	—

The enzyme reaction mixtures containing 3 micromoles uridine diphosphoglucose, 8 micromoles fructose, 0·002 ml. of 0·1 *M* magnesium chloride, 0·04 ml. of 1 *M* *tris* buffer and 0·68 ml. of enzyme in a total volume of 0·8 ml. were incubated at 37° C.

These results appear to eliminate the possibility of induced uridine diphosphoglucose → fructose-transglycosylase formation in response to the altered environment as a factor in the accumulation of sucrose in potato tubers stored at low temperatures. The absence of radical changes induced by temperature in content of other enzymes involved in carbohydrate metabolism of potatoes, namely, phosphatase and amylase[6], and phosphorylase[7], suggests alternate mechanisms of enzyme control or control at less purely biochemical levels.

SIGMUND SCHWIMMER
EDWARD S. RORE M

Western Regional Research Laboratory,
Western Utilization Research
and Development Division,
Agricultural Research Service,
U.S. Department of Agriculture,
Albany, California.

[1] Schwimmer, S., and Burr, H. K., in "Potato Processing", 12 (Avi Publishing Co., Westport, Connecticut, 1959).

[2] Cardini, C. E., Leloir, L. F., and Chiriboga, J., *J. Biol. Chem.*, 214, 149 (1955).

[3] Rorem, E. S., Walker, jun., H. G., and McCready, R. M., *Plant Physiol.*, 35, 269 (1960).

[4] Nakamura, M., *Bull. Agric. Chem. Soc. Japan*, 23, 398 (1959).

[5] Arreguin-Lozano, B., and Bonner, J., *Plant Physiol.*, 24, 720 (1949).

[6] Schwimmer, S., and Makower, R. U., *Fed. Proc.*, 13, 294 (1954).

[7] Schwimmer, S., Weston, W. J., and Makower, R. U., *Arch. Biochem. Biophys.*, 75, 425 (1958).

Optimal Protein Synthesis by Ascites Tumour Cells *in Vitro*

Warburg and Hiepler[1] have stated that ascites tumour cells show the highest metabolic rates when incubated in their own ascitic fluid. Littlefield and Keller[2] later showed that the incorporation of ^{14}C-amino-acids into mouse ascites cell proteins occurs at a rapid rate when the whole ascitic fluid is fortified with glucose and buffer salts and incubated in air. Incorporation is considerably greater than when buffer salts alone are used. More recently, Quastel, Bickis and Vas[3] reported that the sera of many different species of animals (rat, mouse, rabbit, guinea pig, ox) stimulate the incorporation of ^{14}C-glycine into the proteins of washed intact Ehrlich mouse ascites cells *in vitro*, in some cases by as much as fivefold. This stimulation of incorporation was also shown by the mouse ascitic fluid and by heated serum ultra-filtrates. The stimulation of incorporation of amino-acids into these cells by rat serum has now been investigated in greater detail and found to be due to the combined effects of glucose, glutamine, bicarbonate and amino-acids. These substances, used in the same concentrations as are found in the serum, can replace the serum fully (see Table 1).

Since the incorporations of different amino-acids were not stimulated to the same extent by rat serum under identical conditions (for example, glycine by 187 per cent, valine by 133 per cent, leucine and glutamic acid by less than 10 per cent), great care was taken to show that the stimulated incorporation occurred via the normal pathways for protein synthesis. Glycine incorporation was studied in detail in this respect. Techniques were employed

Table 1. INCORPORATION OF ^{14}C-GLYCINE INTO ASCITES CELL PROTEINS IN THE ABSENCE AND PRESENCE OF RAT SERUM AND SYNTHETIC SERUM MIXTURES

Additions	Specific activity of isolated protein (c.p.m./mgm.)	Activity relative to control
None (control)	41	1·00
0·28 m*M* glucose	69	1·68
0·66 m*M* glutamine	86	2·10
2·6 m*M* bicarbonate ($NaHCO_3$)	31	0·76
2·6 m*M* bicarbonate + 0·66 m*M* glutamine	96	2·34
0·28 m*M* glucose + 2·6 m*M* bicarbonate + 0·66 m*M* glutamine	104	2·54
0·28 m*M* glucose + 2·6 m*M* bicarbonate + 0·66 m*M* glutamine + amino-acids (0·5–45 μ*M*) (ref. 5)	144	3·51
Rat serum (0·3 ml.)	106	2·59
Rat serum + glucose + bicarbonate + glutamine (as above)	121	2·95
Rat serum + glucose + bicarbonate + glutamine + amino-acids (ref. 5) (as above)	124	3·02

Each incubation mixture contained 3·0 ml. (total volume) of a 3·3 per cent suspension of washed ascites cells (wet weight) in Krebs–Ringer phosphate buffer, *p*H 7·4. The initial concentrations of added glucose, bicarbonate and amino-acids are given and are equivalent to the addition of 0·3 ml. serum. The glutamine added was, in this case, equivalent to 3·0 ml. serum. The final concentration of glycine was 2·0 m*M* and contained 10^4 c.p.m. radioactivity.

in the isolation of 'protein' free of nucleic acid and lipids that are known to minimize the non-peptide bonding of amino-acids to protein[4]. The final products, when subjected to controlled acid hydrolysis, released radioactivity from the protein isolated from cells incubated in the absence or presence of heated serum ultra-filtrate at the same rate. When the samples were subjected to exhaustive acid hydrolysis (16 hr. in 6 *N* hydrochloric acid at 110° C.) and the products examined by two-dimensional chromatography and radioautography, carbon-14 activity was found only in the areas corresponding to the positions in which glycine and serine are found. About 20 per cent of the total label appeared as serine in both cases. Unlabelled serine depressed the labelling of the tumour-cell proteins by ^{14}C-glycine either in the absence or presence of the heated serum ultra-filtrate to the same extent, indicating that the glycine–serine interconversion was unaffected by the serum factors. When protein was isolated from the different cell fractions separated by ultracentrifugation in the usual manner[3], the debris—nuclei, mitochondrial, microsomal, supernatant, fractions soluble and insoluble at *p*H 5, though labelled to different extents, showed the same proportional increases when the cells were incubated in the presence of heated serum ultra-filtrates.

It would thus appear that 'stimulated incorporation' is not fundamentally different from ordinary incorporation. Some other explanation must be invoked to account for the different responses of different amino-acids to the serum-factors. One possibility is that there are different levels of the various ^{14}C-amino-acids in the 'pool' synthesized from the added amino-acid, which are afterwards utilized for incorporation. It may be also that considerably higher concentrations of some amino-acids are required to produce optimal levels of activated amino-acids for incorporation.

The responses of the ascites cells to the various components of the synthetic serum mixture are quite interesting. When a maximal stimulation of incorporation of ^{14}C-glycine by heated serum ultra-filtrate of 200–240 per cent was observed, 68 per cent of the effect could be obtained with glucose in the same amount as found in the rat serum, 110 per cent by glutamine alone, 134 per cent by glutamine plus bicarbonate, but only 154 per cent by combining all three. When an amino-acid mixture was also added, equivalent to the amounts found in human serum[5], a final stimulation of 200–250 could be obtained. Thus it appears that glutamine is a major factor in the serum and, since the mouse ascitic fluid is lacking in glucose, glutamine is probably a major factor in ascitic fluid for the stimulated incorporation of amino-acids. This effect of glutamine is well known[6], and probably results from the fact that washed ascites cells are deficient in glutamine due to the presence of a high intracellular glutaminase activity. There is little effect of glucose in combination with the other serum factors, yet it stimulates glycine incorporation by 68 per cent on its own, indicating that an 'energy source' is needed for optimal incorporation in these systems. It seems likely that glutamine can act indirectly through the actions of glutaminase and transaminase as an 'energy source' also. In every case the washed cells were incubated in Krebs–Ringer phosphate buffer, *p*H 7·4. The effect of adding bicarbonate alone (final concentration only 1–2 m*M*) was to depress the incorporation of glycine by 25 per cent. However, if added when glutamine is present, the stimulation due to incorporation of glycine is even greater than with glutamine alone. These effects are difficult to explain.

In summary, it can be said that the effects of serum, and probably of ascitic fluid also, in stimulating the synthesis of protein in ascites cells, are probably due to the presence of substances which lead to the production of increased levels of the activated amino-acids required for higher rates of protein synthesis. This can occur by supplementing the cells with deficient amino-acids and with 'energy sources' which can give rise to higher levels of adenosine triphosphate.

I thank Prof. J. H. Quastel for his suggestions and interest throughout this work, and the Rockefeller Foundation for a grant which made this work possible.

M. J. FRASER*

McGill–Montreal General Hospital
Research Institute,
3619 University Street,
Montreal, Quebec.

---

* Present address: Department of Biochemistry, Medical School, University of Manitoba, Winnipeg 3, Canada.

[1] Warburg, O., and Hiepler, E., *Z. Naturforsch.*, 7, *b*, 193 (1952).
[2] Littlefield, J. W., and Keller, E. B., *J. Biol. Chem.*, 224, 13 (1957).
[3] Bickis, I. J., Quastel, J. H., and Vas, S. I., *Cancer Research*, 19, 602 (1959).
[4] Loftfield, R. B., "Prog. Biophys. Biophys. Chem.", 8, 347 (1957).
[5] Meister, A., "Biochemistry of the Amino Acids", 50 (Academic Press, Inc., New York, 1957).
[6] Rabinovitz, M., Olson, M. E., and Greenberg, D. M., *J. Biol. Chem.*, 222, 879 (1956).

Effect of Heavy Water on Respiratory-chain Enzymes

DURING radiobiological work on bacteria it was found by one of us (H. L.) that the effect of ionizing radiation (X-rays) is greatly potentiated if the bacteria are irradiated in a medium in which water is replaced by heavy water[1]. Thus, for example, with *Escherichia coli B* and *Pseudomonas* 6009 the dose-reduction factor was approximately 2, that is, the X-ray dose required to produce a given reduction in the number of colony-forming bacteria on irradiation in deuterium oxide was one half that in water. This effect, however, occurred only if the bacteria were irradiated in presence of oxygen, but not, or only insignificantly, after irradiation under anaerobic conditions.

Heavy water has for some time been known to affect a variety of chemical reactions and biological processes[2], the rates of which, as a rule, are slowed down.

In the present experiments the respiratory-rate of the bacteria used was decreased by approximately 45 per cent and that of baker's yeast by 75 per cent in 95–98 per cent deuterium oxide, as compared with water medium, the inhibition becoming apparent immediately at the beginning of the experiment. The rate of anaerobic fermentation of *E. coli*, on the other hand, was not affected by deuterium oxide for the first 2 hr. (An inhibition developed after 2 hr.)

Similarly the rate of aerobic succinate oxidation in the Keilin and Hartree heart-muscle preparation was increasingly inhibited with increasing concentrations of deuterium oxide, maximal inhibition being between 45 and 50 per cent in 99 per cent deuterium oxide, while the rate of anaerobic oxidation of succinate with methylene blue as hydrogen acceptor was not affected.

In order to gain further insight into the mechanism responsible for metabolic effects of deuterium oxide as manifested, for example, in inhibition of respiration in intact cells and of oxidations in isolated enzyme systems, further experiments have been undertaken.

Table 1. EFFECT OF DEUTERIUM OXIDE ON RESPIRATORY-CHAIN ENZYMES IN HEART-MUSCLE PREPARATION

Enzyme activity	Inhibition (per cent) by 95–99 per cent deuterium oxide
Succinate-methylene blue	5
Succinate-ferricyanide*	26
Succinate-cytochrome *c*	37
Succinate-O_2	35
DPNH-methylene blue	3
DPNH-cytochrome *c*	34
DPNH-O_2	34
Cytochrome *c*-O_2	52

* In the presence of antimycin.
DPNH, reduced diphosphopyridine nucleotide.

The results given in Table 1 show that replacing the water in the medium by 90–99 per cent deuterium oxide inhibited the oxidation of succinate by oxygen, ferricytochrome *c* or ferricyanide, and the oxidation of reduced diphosphopyridine nucleotide by oxygen or ferricytochrome *c*, in the presence of heart-muscle preparation. The cytochrome *c* oxidase reaction was also inhibited (cf. ref. 3). On the other hand, oxidation of succinate or of reduced diphosphopyridine nucleotide by methylene blue with heart-muscle preparation was not appreciably inhibited.

Table 2. EFFECT OF DEUTERIUM OXIDE ON RATE OF OXIDATION OF SUCCINATE BY RAT-LIVER MITOCHONDRIA AND ON P : O RATIO (0·06 *M* SUCCINATE)

Exp.	Activity of control		Inhibition (per cent) by deuterium oxide	
	Q_{O_2}*	P : O	In absence of dinitrophenol	In presence of 3×10^{-4} *M* dinitrophenol
1	90	1·71	7	0
2	114	1·58	21	0
3	142	—	21	—
4	146	—	29	16
5	163	1·73	29	6
6	262	—	58	26

* µl. oxygen/mgm. protein/hr.

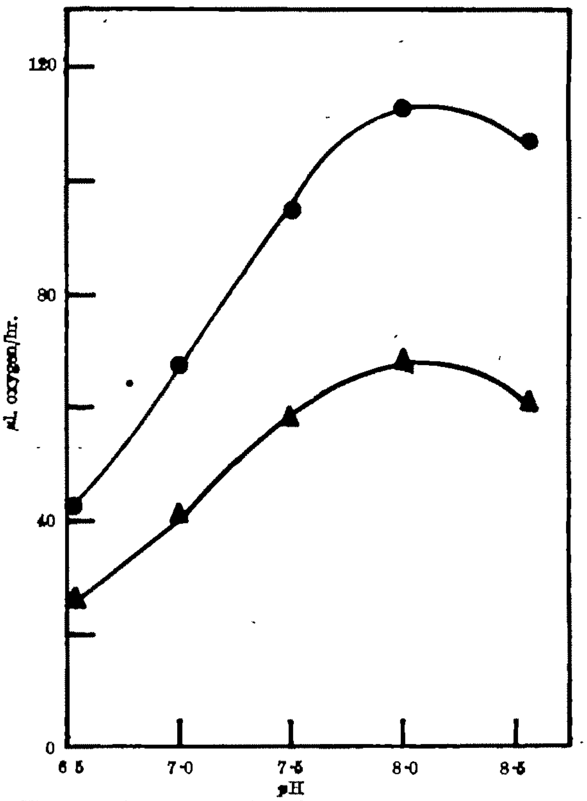


Fig. 1. Oxidation of succinate by heart-muscle preparation in (●) H_2O and (▲) D_2O medium as a function of *p*H

The inhibition of succinate oxidation catalysed by rat-liver mitochondria was variable, being greater with preparations having a higher activity (Table 2). The degree of inhibition was considerably decreased by the addition of 3×10^{-4} *M* dinitrophenol, which inhibited the rate of oxidation only slightly (7–34 per cent). Deuterium oxide decreased the P : O ratios only slightly, both in the presence and the absence of dinitrophenol.

The experiment described in Fig. 1 shows that replacement of water by deuterium oxide did not alter the *p*H optimum of the succinic oxidase activity of heart-muscle preparation and that the degree of inhibition was practically independent of *p*H (or *p*D) between 6·5 and 8·6. Thus the inhibition is not due to a possible difference in the degree of ionization of water or deuterium oxide or of the buffer in water and deuterium oxide.

The enzyme-catalysed reductions of methylene blue by reduced diphosphopyridine nucleotide and by succinate, which were not inhibited by deuterium oxide, represent probably a simple transfer of hydrogen atoms from substrate to methylene blue, catalysed by the respective dehydrogenases and intermediate carriers. These reactions are not accompanied by phosphorylation in mitochondrial preparations. However, those reactions which involve larger segments of the respiratory chain, and which are associated with phosphorylation in mitochondrial preparations are inhibited by deuterium oxide in the non-phosphorylating heart-muscle preparations.

The inhibitions given in Tables 1 and 2 were determined immediately after adding the enzyme preparations to the reaction mixture. They cannot, therefore, be due to a possibly decreased reaction-rate with deuterium-labelled substrate, formed by exchange reactions, since these are relatively slow[4] and could not become manifest at once.

We should like to suggest as explanation of these results that a protonolysis is a rate-limiting step of the respiratory chain in non-phosphorylating preparations, and that replacement of H+ by the heavier D+ slows down these reactions[2,3]. It seems particularly significant that the succinic oxidase of phosphorylating preparations is considerably less inhibited in the presence of dinitrophenol, which is believed to increase the rate of hydrolytic reactions[5].

As yet, however, no basis has been found for explaining the potentiation of radiation effects in deuterium oxide.

H. LASER*

Molteno Institute,
University of Cambridge.

E. C. SLATER

Laboratory of Physiological Chemistry,
University of Amsterdam.

July 6.

* Member of the Scientific Staff, Medical Research Council.

[1] Laser, H., *Int. J. App. Rad. Isotopes*, 6, 96 (1959).

[2] Bonhoeffer, K. F., *Ergeb. Enzymforschung*, 6, 47 (1933).

[3] Shibata, K., and Watanabe, A., *Acta Phytochimica*, 15, 169 (1949).

[4] Drysdale, G. R., *J. Biol. Chem.*, 234, 2399 (1959).

[5] Slater, E. C., *Nature*, 172, 975 (1953).

Influence of Different Types of Malnutrition on the ^{14}C-Lysine Metabolism in Young Rats

IN the usual laboratory animals the typical corollaries of chronic shortage of proteins, fats, and carbohydrates have been thoroughly studied. Very little is known, however, of the changes in the intermediary metabolism. Since we were interested from a pædiatric point of view in the problems of malnutrition, we have investigated weanling Wistar rats (body-weight 35 ± 5 gm.). Five groups of ten animals each received for one week or more a synthetic diet (adapted from György) of the composition shown in Table 1.

Table 1

	Group I	Group II	Group III	Group IV	Group V
Carbohydrates	69		5	85·4	74·3
Proteins	20	50	68	2	21·4
Fats	6·7	per cent	22·7	8·3	0
Salts, vitamins and 'Nestargel R'	4·3	of Group I	4·3	4·3	4·3

On the seventh, eighth, and ninth days two animals of each group were placed in a metabolism cage. After adaptation to the new surroundings, each animal was injected intraperitoneally with 10μc.^{14}C-lysine. Six hours later the animals were killed and the proteins of the different organs were isolated and their specific activity was determined in a methane flow counter as described in detail elsewhere[1].

A diminution of the calorie intake of 50 per cent did not influence the rate of incorporation of the labelled lysine into the proteins of any organ examined. This finding is in accord with the studies of Allison[2], and Cox *et al.*[3], which were based on results of experiments done with classical methods.

The results from our Groups III and V showed that there is no difference in the protein-sparing action of fat and carbohydrate, so far as it is possible to draw this conclusion from experiments with a single labelled amino-acid. But this finding agrees well with results obtained by the usual metabolic methods[4]. Of course only monosaccharides show a specific depression of the amino-acid-level in blood in experiments of short duration[5]. Fructose does not bring about higher retention of nitrogen than glucose[6] as has been claimed by others[7]. The specific activities of the organ proteins were in the same range as those of the group on a mixed diet (Group I). This is remarkable since the rats of Group III received a diet very rich in protein.

On the other hand, the animals on the diet almost free from protein, as is seen from Table 2, incorporated tagged lysine in several organs at a significantly higher rate than those of all the other groups. Since the carbon-14 dioxide production from lysine was only about 50 per cent of the other animals, one can postulate that the oxidative deamination of the amino-acid decreased in the protein-free animals in favour of protein synthesis.

Table 2. SPECIFIC ACTIVITY OF THE PROTEINS OF ORGANS OF PROTEIN-STARVED RATS COMPARED WITH NORMALLY FED ANIMALS (TAKEN AS 100 PER CENT)

Organs	6th day	8th day	9th day
Liver	137	222	412
Kidney	131	184	279
Heart	128	186	300
Brain	107	245	726
Intestines	109	116	280
Muscle	65	85	73
Skin	90	85	83
Plasma proteins	221	212	251
Erythrocyte stroma	26	10	23
Hæmoglobin	81	8	22

Recently, Russian authors[8], in work on dogs, and also Garrow[9] and Waterlow[10], made similar observations; their experiments were carried out with ^{35}S-methionine.

Since we believe that protein synthesis is possible only when all necessary amino-acids are available simultaneously, one may postulate that, in protein starvation, the size of the pool of amino-acids is increased in those organs in which a higher rate of incorporation of ^{14}C-lysine is detectable. This can of course occur through a decreased breakdown, as we found to be the case in our animals. Lysine as such is not able itself to accelerate protein synthesis.

The radioactivity on the deproteinized blood plasma of the protein-starved rats was lowest in all the groups. In the liver, nevertheless, we had a relatively high count. Kreuger and Wiss have found with the microbiological amino-acid method a high content of free amino-acid in this organ in starved animals. Since the carcass proteins apparently do not partake in the increase in the rate of incorporation of lysine, it is evident that re-direction of the protein metabolism takes place in favour of vital enzymes and structures in the intestinal organs.

This interpretation is supported by the work of Solomon and Tarver[11] and of Waterlow[10], who have also found a shift in the rate of incorporation between the peripheral organs and the intestines. The changes in protein metabolism due to a protein shortage in the diet of longer duration proceed apparently in two phases: first, labile proteins which have a very short half-life are mobilized from the liver, etc.; later the 'less vital' structure proteins of the carcass are broken down and erythropoiesis is slowed down, whereas in the liver, kidney, intestines, and surprisingly in the brain too, neosynthesis is very active. The effect of protein starvation on protein synthesis is somewhat similar to that of glucocorticoids, which according to Hess and Shaffran increase the specific activity of liver proteins and decrease the rate of incorporation into the connective tissue and muscles.

KURT SCHREIER
CORINNA KAZASSIS

Universitäts-Kinderklinik,
Luisenheilanstalt,
Heidelberg.

[1] Schreier, K., Zoller, H., Wasserianow, B. Vira, Noller, H. G., and Madsen, P. O., *Ärztl. Forsch.*, 10, 467 (1956).
[2] Allison, J. B., *Ann. N.Y. Acad. Sci.*, 47, 245 (1946).
[3] Cox, W. M., Ellingson, R. C., and Mueller, A. J., *Pediatrics*, 11, 435 (1953).
[4] Munro, H. N., and Wikramanayake, W., *J. Nutr.*, 52, 99 (1954). van Itallie, T. B., Waddell, W. R., Geyer, R. P., and Stare, F. J., *Arch. Int. Med.*, 89, 353 (1952).
[5] Munro, H. N., and Thomson, W. S. T., *Metabolism*, 2, 354 (1953).
[6] Schreier, K., Pluckthun, H., and Hauss, H., *Z. Kinderheilk.*, 73, 536 (1953/54).
[7] Albanese, A., Felch, W. C., Higgons, R. A., Vestal, B. L., and Stephanson, L., *Metabolism*, 20, 1 (1952).
[8] Davidova and Novakovskaya, *Biokhimiya* (*Russ.*), 17, 570 (1952).
[9] Garrow, J. S., *J. Clin. Invest.*, 38, 1241 (1959).
[10] Waterlow, J. C., *Nature*, 184, 1875 (1959).
[11] Solomon, G., and Tarver, H., *J. Biol. Chem.*, 195, 447 (1952).

PHYSIOLOGY

Dextran and Insulin in Rats

WHILE testing the effects of insulin on the circulatory reaction of laboratory rats to dextran, we found that many animals died after combined doses of the two agents which were not lethal when administered separately. The validity of this observation was put to experimental test. Male Sprague-Dawley rats weighing at least 150 gm. and fasted 24 hr. were subcutaneously injected with zinc insulin ('Iletin') at two dose-levels, 7·5 or 10 u./kgm. body-weight. An hour later dextran was administered by vein in a total volume of 10 ml./kgm. 0·85 per cent sodium chloride containing either 60 or 600 mgm. dextran ('Expandex'). Control animals received saline without dextran. Fatalities due to these amounts of dextran have not occurred in our work. The results of eight experiments are summarized in Table 1, which shows the incidence of survival after 24 hr. Animals that died exhibited convulsions usually within 3 hr. of insulin administration. Few signs of the dextran reaction characteristic of this species were noticed.

Table 1. EFFECT OF INTRAVENOUS ADMINISTRATION OF DEXTRAN ON SURVIVAL OF FASTED RATS AFTER INSULIN

No. survived/total number

Insulin u./kgm.	Dextran (mgm./kgm.) 0	60	600
7·5	16/20	5/20	13/20
10	13/26	4/26	20/26

The smaller dextran dose caused more stress than the larger at both insulin-levels. Comparison between the insulin doses (2 × 3 table) showed the results were not significantly different, so they were combined. The data were tested in 2 × 2 tables using χ-square with Yates's correction. Although not independent, these tests indicated that the decreased incidence of survival after 60 mgm./kgm. dextran was highly significant when compared with controls or with the number surviving after 600 mgm./kgm. The incidence of survival in the latter groups did not differ significantly from each other.

Aggravation of the dextran reaction in rats measured by oedema and blueing has been reported to follow insulin pretreatment[1,2]. We have found no previous mention, however, of the effect of dextran on this species' reaction to insulin, possibly because the observations were not continued long enough, or the insulin dose was too small. The occurrence of fatal convulsions after insulin doses which without dextran are subconvulsive may be due to indirect effects of dextran. One of these is severe and prolonged vasodepression[3], which would accentuate the already low glucose-level in the central nervous system. This situation could also prevail if vasoconstriction comparable to that seen in the mesoappendix and skin of the rat after intravenous administration of dextran[4] occurs likewise in the small vessels of the brain. Possible direct effects of dextran on resistance to insulin include changes in cellular permeability and blood sugar. Insulin in amounts too small to change the level of blood-sugar significantly has been reported to enhance oedema formation after subcutaneously administered dextran[5]. Our investigations of the manner in which dextran administered by vein affects insulin hypoglycaemia and the incidence of convulsions are continuing.

L. H. MARSHALL
C. H. HANNA

Laboratory of Physical Biology,
National Institute of Arthritis
and Metabolic Diseases,
National Institutes of Health,
Bethesda 14, Maryland.

[1] Adamkiewicz, V. W., and Langlois, Y. L., *Can. J. Biochem. and Physiol.*, 35, 251 (1957).
[2] Sanyal, R. K., Spencer, P. S. J., and West, G. B., *Nature*, 184, 2020 (1959).
[3] Marshall, L. H., and Hanna, C. H., *Amer. J. Physiol.*, 189, 209 (1957).
[4] Marshall, L. H., and Hanna, C. H. (unpublished observations).
[5] Jasmin, G., and Bois, P., *Proc. Soc. Exp. Biol. and Med.*, 101, 656 (1959).

Summative Action of Acetylcholine with Physiological Stimulus on the Generator Potential in the Lateral Eye of the Horseshoe Crab

THE action of acetylcholine on the electrical activities of various receptors has been studied by many authors[1]. Most of the investigations of its action were carried out on the responses of receptors in terms of impulses they discharge. In this communication the effect of acetylcholine on the retinal slow potential, which is regarded as a generator potential[2], was studied by means of intracellular micro-electrodes. The electrical activities arising within single ommatidia of the excised lateral eye of the horseshoe crab (*Tachypleus tridentatus*), which was immersed in the physiological saline solution[3], were led to a cathode follower through a micro-electrode filled with 3 *M* potassium chloride.

Having obtained the responses by illumination of a given intensity, duration and interval as controls (*a* in Fig. 1), the solution made by dissolving acetylcholine chloride in physiological saline solution was added by a micropipette to the external solution of a known volume. Then the responses by the same stimuli were successively recorded. The concentration of acetylcholine was calculated afterwards.

As seen in Fig. 1*b*, a remarkable increase in the amplitude of both the initial maximal and the successive less but steady depolarization was induced by the addition of acetylcholine. Moreover, prolongation of the falling phases of the initial maximal depolarization and the phase of repolarization following cut-off of the stimulus also occurred.

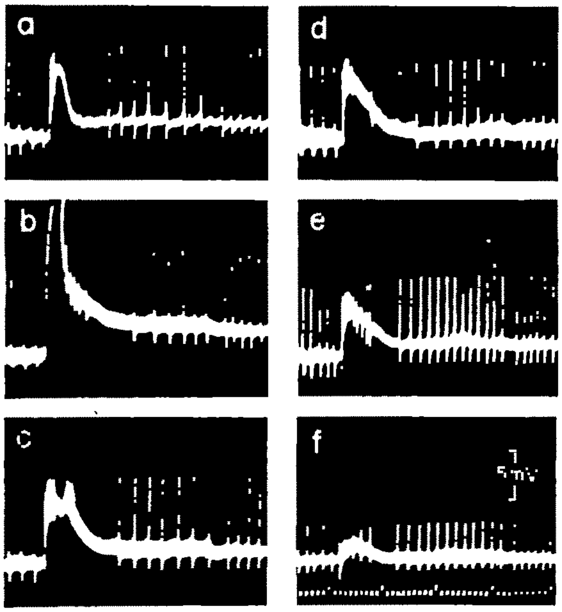


Fig. 1. Summative action of acetylcholine with illumination on the retinal slow potential. *a*, Control; *b–f*, records taken successively at every two minutes following addition of acetylcholine (5×10^{-4} mole). All records were obtained after 60 sec. in darkness. Pips indicate on- and off-signs. Time, 1 + 0·1 sec.

These effects could be obtained without any significant change in the resting potentials soon after the addition of acetylcholine. Sometimes two humps were formed as a result of the appearance of another hump at the falling phase of the initial maximal depolarization (Fig. 1c). This effect of acetylcholine on the generator potential of the eye of the horseshoe crab suggests that its summative action with natural stimuli reported in some other receptors may, at least, be partially due to its effect on their generator potentials.

The summative effect of acetylcholine was always followed by its depolarizing action (Fig. 1*d–f*), and the activity of the cell did not return to normal by application of normal saline solution.

Strychnine and 2,4-dinitrophenol elicited a reversible increase and a prolongation of the retinal slow potential of the horseshoe crab. But the effect of acetylcholine was more difficult to find, for an unknown reason, than that of the former two chemicals, though it was more remarkable at a lower concentration if it did appear. In most cases only the depolarizing action was exhibited following the addition of acetylcholine. The dosage differed from one preparation to another, as reported in other receptors[1], and the minimum effective concentration was 5×10^{-4} moles in our experiments.

In addition, the mode of action of acetylcholine is somewhat different from that of TEA. The latter compound belongs to the quaternary ammonium compounds as does acetylcholine, but it exhibited not only the summative action with natural stimulus but also induced spontaneous pulse-shaped prolonged potentials in the presence of sodium ions, as is reported in the giant axon of the squid[5].

Fuortes[4] suggests that the photoreceptor in the *Limulus* eye liberates a chemical product during illumination. But there remain difficulties in assuming that acetylcholine is the product in question according to our observations, since its summative action with natural stimulus could appear separately from its depolarizing action, and seemed not to be influenced by atropine or anticholinesterase in the experiments performed so far.

In any event, acetylcholine seems to have two actions on the sensory cells in ommatidia of the horseshoe crab; one is the summative action with physiological stimulus which may be explained as the sensitization of the chemical product or acceleration of its liberation during illumination, and the other is its depolarizing action on the cell membrane concerned.

R. Kikuchi
K. Naito
S. Minagawa

Department of Physiology,
Tokyo Women's Medical College,
Shinjuku-ku, Tokyo.

[1] Gray, J. A. B., Initiation of impulses at receptors in "Handbook of Physiology", 1 (Amer. Physiol. Soc., Washington, D.C., 1959).

[2] Tomita, T., *Jap. J. Physiol.*, 6, 326 (1956).

[3] Kikuchi, R., and Tanaka, I., *Annot. Zool. Japon.*, 30, 177 (1957).

[4] Fuortes, M. G. F., *J. Physiol.*, 148, 14 (1959).

[5] Tasaki, I., and Hagiwara, S., *J. Gen. Physiol.*, 40, 859 (1957).

*p*H Changes during Muscle Twitch and Tetanus

Dubuisson[1-3] has shown that *p*H variations during muscle activity can be recorded at the muscle surface with a glass electrode, using an electrometer and a sensitive galvanometer. Displaying the d.c. amplified electromotive force changes of the glass electrode, on the screen of a cathode-ray tube, reduces the recording delay to a few msec., and makes it possible[4] to estimate the time constant of the glass electrode (McInnes type), transmitting a *p*H step, to be about 30 msec.

The recordings during muscle activity are made with a small electrode (20 mm. long, diam. of flat sensitive membrane, 4 mm.). It is attached laterally to the hanging muscle, and a counter-weight arrangement makes it follow the muscle movements.

Fig. 1 shows the *p*H changes during single isometric twitches of a tortoise muscle at 22° C. The curves have been corrected[4] to take into account the diffusion time of carbon dioxide through the film of liquid and inert material (6μ) between the electrode and the muscle surface. The zero of the time-scale coincides with the beginning of the action potential, which is recorded in an attenuated form by the electrode. This introduces some uncertainty at the beginning of

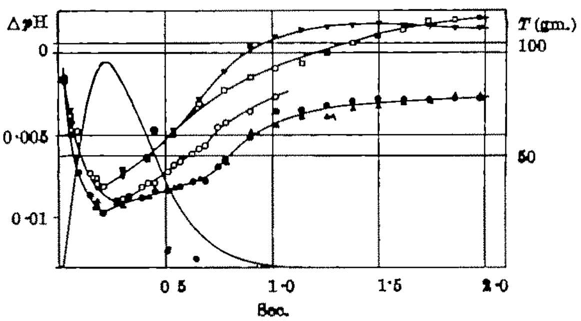


Fig. 1. *p*H variation during four successive isometric twitches (first twitch below, acidification downwards). Tortoise iliofibularis, *p*H 7·2, 22° C. Right ordinate: tension in gm.

the *p*H curves; but careful examination of hundreds of records leads to the conclusion that the initial acidification (phase *b* of Dubuisson) does start during the action potential. The much slower alkaline shift (phase *c* of Dubuisson linked to phosphagen breakdown) is often absent during the first twitches sustained by a muscle after a long rest and builds up gradually to a maximum during following twitches. The fast acid phase is always present. Its Q_{10} is high, ~ 3·2 for tortoise muscle and lies between 3·2 and 3·8 for frog muscles.

If this initial change in *p*H is assumed to be due to the hydrolysis of ~ P bonds, from adenosine triphosphate or any other carrier provided it liberates the same amount of H⁺ at a given *p*H according to its electrotitration curve, one can calculate the amount of split ~ P if one further knows the cellular carbon dioxide/bicarbonate ratio, the *pK'* of carbonic acid, and the retention factor which accounts for other buffer systems. Taking a minimum of 1·10 for this factor, values between 0·04 μmole/gm. and 0·1 μmole/gm. for tortoise muscles and 0·06 μmole/gm. and 0·18 μmole/gm. for frog muscles are found for the amount of ~ P split per twitch. The best results correspond to 60–70 per cent of the minimum expected change (0·25 μmole/gm. for frog muscle) estimated from myothermic data[5]. The discrepancy, if not real, might be due to an under-estimation of the retention factor which is calculated from equilibrium measurements.

The *p*H variations observed during a single twitch are summed during tetanus, giving rise to *p*H curves similar to that described by Dubuisson. Assuming that a diphasic *p*H change is produced at each stimulus, in the range of frequency investigated, the experimental records can be reconstructed by simple algebraic summation, as shown in Figs. 2 and 3. It is seen that in these particular cases the absorption of H⁺ overcompensates the H⁺ liberation after a few stimuli, and that a linear steady state is established, which abruptly ends when stimulation stops. The final alkaline burst is in fact made visible by the cessation of H⁺ production. The rate of H⁺ liberation, corresponding to the accumulation of the fast acid changes described for single twitches, can be calculated from the *p*H recordings, and one obtains the curves shown in the upper sections of Figs. 2 and 3, giving the carbon dioxide production in μmole per c.c. of extracellular liquid.

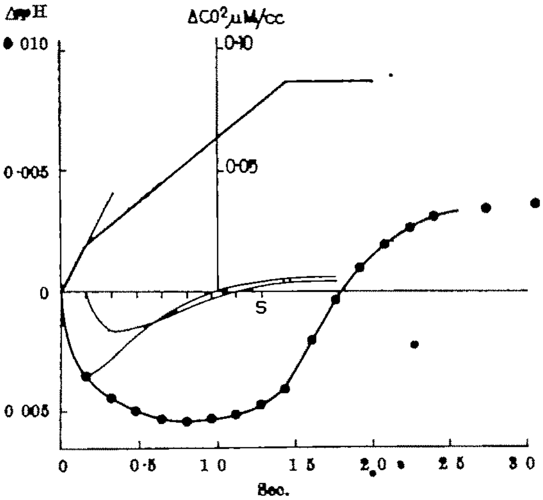


Fig. 2. *p*H change (full line downwards) during short tetanus. Tortoise ileofibularis, *p*H 7·0, 22° C. Stimulation ends at *S*. The circles are calculated by summing diphasic *p*H changes produced at each stimulus. Above: carbon dioxide production (μmole/c.c.) corresponding to the sum of the fast acid phases

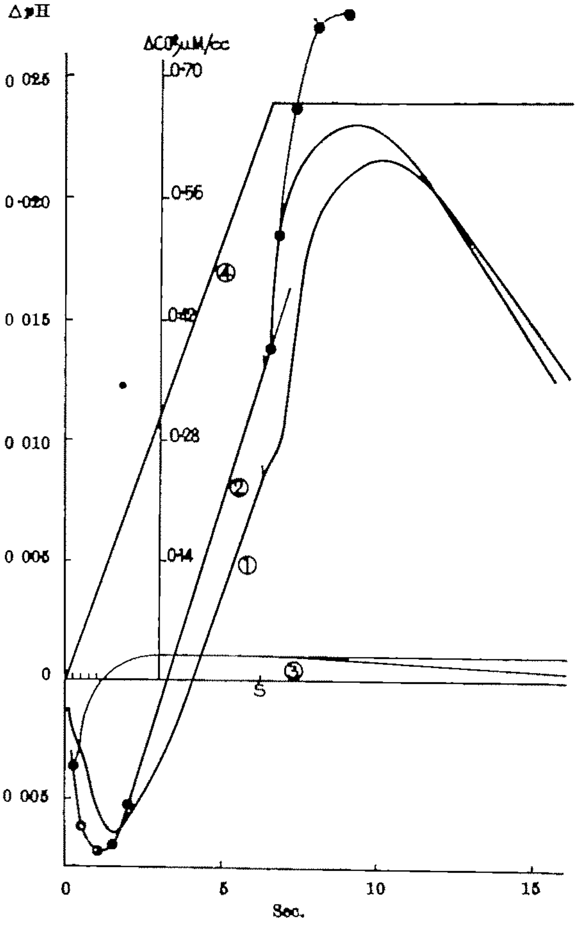


Fig. 3. (1) Recorded *p*H change (tetanus, tortoise ileofibularis, *p*H 6·8, 22° C.). (2) *p*H curve corrected for the lag due to diffusion. The circles result from the summation of 26 diphasic *p*H variations corresponding to a single twitch (curve (3)). Introducing a slow component in (3) leads to curve (2). Curve (4) represents the sum of successive fast acid phases, in μmole carbon dioxide/c.c.

If one admits that phase *b* of Dubuisson corresponds to an exothermic reaction (~ P splitting) and phase *c* to an isothermic process (~ P transfer), there is a good qualitative agreement between the H⁺ production and the heat production during tetanus[7]. Quantitatively, the calculated rates of liberation of energy are, however, too small to account for the whole of the maintenance heat in the same proportion as observed for single twitches.

The intensity of phase *b* is linked to previous work done by the muscle and depends on the initial length. Qualitative indications exist such that the H⁺ liberation during isotonic contractions depends on the amount of shortening.

A. DISTÈCHE

Laboratory of General Biology,
University of Liège.

[1] Dubuisson, M., *J. Physiol.*, 94, 461 (1939).
[2] Dubuisson, M., *Arch. Internat. Physiol.*, 50, 203 (1940).
[3] Dubuisson, M., "Muscular Contraction" (C. Thomas Pub., 1954).
[4] Distèche, A., and Dubuisson, M., *Rev. Sci. Instr.*, 25, 869 (1954).
[5] Hill, A. V., *J. Sci. Instr.*, 26, 56 (1949).
[6] Hill, A. V., *Proc. Roy. Soc.*, B, 136, 242 (1949).
[7] Hill, A. V., *Proc. Roy. Soc.*, B, 137, 268 (1950).

Metabolism of Oxygen-15

OXYGEN-15 has been prepared by deuteron bombardment of nitrogen molecules in the Medical Research Council cyclotron at Hammersmith Hospital. Gases labelled with this isotope, which has a half-life of only 2 min., can be inhaled into the lungs and detected by external scintillation counters. The initial counting-rate in a given region of the lung is proportional to the regional ventilation[1], and the rate of removal from the region during breath-holding is a measure of the regional blood-flow[2].

During some of these experiments the radioactivity in the blood was measured at intervals after the breath was taken. Blood samples were taken from a forearm vein in four subjects between 15 sec. and 4 min. after the beginning of the breath of air, the oxygen of which was labelled with oxygen-15. The samples were heparinized and centrifuged for 2 min. to separate the cells from the plasma. The radioactivity of 2-ml. samples of red cells and plasma was measured in a sensitive 'well' type crystal scintillation counter. In a further study, 20 ml. fresh blood at 37° C. was labelled with oxygen-15 by bubbling a stream of the isotope in air through it. A sample was taken from the blood immediately after labelling and after 5-min. incubation at 37° C. and the radioactivity in both red cells and plasma was measured.

A typical example of the changes in the radioactivity in the plasma and red cells for 4 min. following the breath of oxygen-15 (corrected for radioactive decay to a common zero time) is shown in Table 1. The radioactivity in the plasma increased rapidly and the red cell activity fell during the 4 min. of observation. In consequence the proportion of the radioactivity in the plasma increased from 10·6 per cent after 30 sec. to 53 per cent after 240 sec. The results in all four normal subjects followed a similar pattern.

When blood was labelled *in vitro* only 1 per cent of the radioactivity appeared in the plasma, and this proportion did not alter significantly after 5 min. incubation. This is the proportion which would be expected from the known partition of molecular oxygen between red cells and plasma.

The rising plasma radioactivity found *in vivo* must represent the return to the plasma of oxygen-15 which has been metabolized in the body cells. The results show in a striking way how rapidly this takes place. An appreciable fraction of the inhaled molecules of oxygen-15 is transported by the blood to the tissues, diffuses into the tissue cells, is metabolized and then diffuses back into the blood within 30 sec. of the beginning of the breath.

An attempt was made to fractionate the radioactivity in the plasma into carbon dioxide and water by acidifying and shaking under vacuum, but none of the radioactivity could be removed. This is because oxygen-15, which is metabolized to carbon dioxide, becomes freely exchangeable with the oxygen in water when bicarbonate is formed in the blood, and therefore cannot be separated.

Table 1. RED CELL AND PLASMA RADIOACTIVITY CORRECTED FOR RADIOACTIVE DECAY TO A COMMON ZERO TIME

Time after breath (sec.)	Red cell radioactivity (counts/min./ml.)	Plasma radioactivity (counts/min./ml.)	Ratio plasma/red cell activity (per cent)
30	102,000	10,800	10·6
60	104,000	12,500	12
120	78,000	21,600	28
240	55,000	29,000	53

C. T. DOLLERY
J. B. WEST

Department of Medicine,
Postgraduate Medical School of London,
Hammersmith Hospital,
Ducane Road,
London, W.12.

[1] Dyson, N. A., Hugh-Jones, P., Newbery, G. R., Sinclair, J. D., and West, J. B., *Brit. Med. J.*, i, 231 (1960).

[2] West, J. B., and Dollery, C. T., *J. App. Physiol.*, 15, 405 (1960).

The Membrane Potential of the Anterior Byssus Retractor Muscle of *Mytilus edulis*

As yet no reports of intracellular recording from the anterior byssus retractor muscle appear to have been made. The membrane potential can be measured with conventional glass micro-pipettes filled with 2·5 *M* potassium chloride, but satisfactory recordings have only been obtained with electrodes possessing tips of about 0·5μ or less in external diameter. Very few such electrodes are free from large tip potentials; but some satisfactory recordings have been obtained from the muscle *in situ*, using selected electrodes.

The animal was opened and the muscles of one side cut through leaving the byssus attached to one anterior byssus retractor muscle in one half of the shell. The shell was mounted horizontally and filled with sea water, and tissue covering the anterior byssus retractor muscle was carefully cleaned away, leaving the muscle exposed. The recording electrode was connected direct to the grid of a cathode follower (6*BS*7 selected for low grid current) through a silver–silver chloride/sea water–agar bridge. The sea water in the shell was earthed via a similar bridge. Calibration voltages were applied across a 50-ohm resistor between earth and the shell. Signals from the muscle were taken through a d.c. amplifier and displayed on a pen-writing oscillograph. Membrane potentials recorded fell within the range 30–50 mV., but potentials from the same muscle were within a range of 7 mV. or less. The mean value was 39 ± 2 mV. (*S.E.* of 14 observations).

D. H. PAUL

Department of Zoology and
Comparative Physiology,
The University,
Birmingham.

Effect of Size of Pupil on Visual Acuity

DENTON[1] has suggested that a possible function of the pupil light reflex might be to provide apertures optimum for visual acuity at different light intensities. At low levels of luminance visual acuity is probably limited by the rate at which light quanta activate the retinal receptors[2], and thus a large pupil admitting the maximum amount of light would appear to be advantageous. As the luminance is increased into the photopic range, loss of image contrast due to optical aberrations, diffraction, and stray light also tend to limit visual acuity, although the fineness of the retinal cone mosaic may[3] ultimately become the limiting factor. The decrease in pupil size which normally accompanies increase of illumination should reduce to some extent the deleterious effects on visual acuity of the optical aberrations. However, it has never been shown that the actual response of the pupil reflex to a given steady luminance does in fact result in an aperture giving maximum spatial resolution at this luminance. It was therefore decided to determine experimentally whether an optimum aperture existed at each luminance-level, by measuring the relations between pupil size, luminance, and visual acuity over a wide range.

In these experiments the pupil was dilated by instilling 2 per cent homatropine hydrobromide into the conjunctival sac. The instrument used to measure visual acuity at different luminances consisted of a tube 33 cm. long and 3 cm. in diameter. At one end of the tube was placed a disk, carrying apertures 1–8 mm. in diameter at 0·5 mm. intervals, which could be placed close to the eye so as to act as a variable entrance pupil. Close to this artificial pupil was placed an adjustable neutral wedge filter. At the other end of the tube was situated a circular ground-glass screen, subtending an angle of 5°, which was illuminated by an opal tungsten lamp of colour temperature 2,800° A. Luminances were measured with an *S.E.I.* photometer (Ilford) that was checked periodically against a calibrated standard lamp.

To measure visual acuity, a test pattern was placed in a holder in front of the ground-glass screen. The test pattern finally adopted contained a series of grating patterns with lines of different separation, each grating consisting of three opaque bars on a translucent background, the separation of the bars being equal to their width. All the different patterns are visible at the same time, avoiding the necessity of changing the pattern between each reading. The subject was instructed to look at a given pattern and then to increase the luminance by moving the wedge until the separate lines of pattern were just discriminated. Only vertical lines were used so as to eliminate the effects of uncorrected astigmatism. Lenses could be placed close to the eye to correct for refractive errors and also to allow for the proximity of the test pattern. The four subjects used were experienced at making visual observations of the type occurring in these experiments.

The results from a single typical run are shown in Fig. 1. Each curve represents the lowest luminance at which a given test pattern can be discriminated at various pupil sizes. For example, the largest test object used subtended an angle of 5·7 min., and it is clear that with increase of pupil diameter the test object is perceived at successively lower luminance-levels up to the maximum pupil size of 8 mm. However, for smaller test objects the minimum luminance occurs at pupil diameters less than 8 mm., and with reduction of test object size the optimum pupil diameter decreases progressively from 8 to 2 mm. All the curves show a rapid increase in threshold luminance as the pupil diameter is decreased below 2 mm., presumably due to the dominance of diffraction effects[3,4].

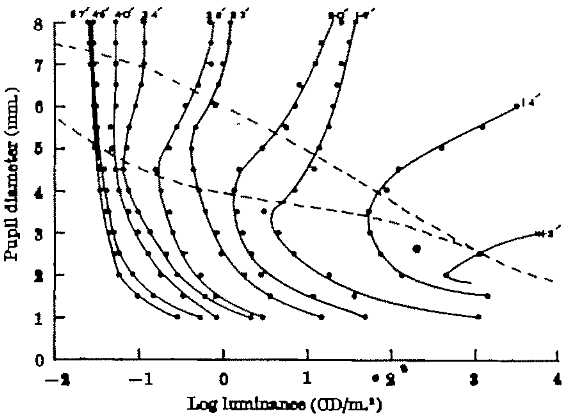


Fig. 1. Results of single run on subject A. H. G. Curves for different acuity patterns represent the lowest luminance at which the pattern is visible at various pupil sizes. Broken lines indicate natural pupil size as determined by Reeves (upper line) and Crawford (lower line)

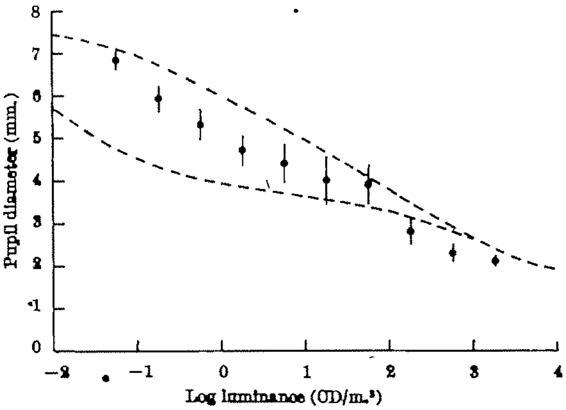


Fig. 2. Mean values of optimum pupil size from maxima of acuity curves such as in Fig. 1. Points represent means from 13 runs on 4 subjects, and extent of vertical lines indicates standard error of mean. Broken lines indicate natural pupil size as in Fig. 1

The smaller test patterns show a well-defined optimum pupil size, the threshold luminance increasing rapidly for pupil sizes on either side of this optimum value. For large test objects, the optimum pupil size is less well defined, and for even larger objects, involving parafoveal vision, the threshold will still be decreasing when the maximum available pupil diameter of 8 mm. is reached.

The results in Fig. 1 are from subject A. H. G. (age 23 years). Three other subjects, F. W. C., J. G. R., and R. R. (ages 35, 22, 26 years respectively) gave similar curves. To determine whether the type of test target influenced the results, F. W. C. performed two runs on each of three different targets (Landolt C, multi-bar grating, and three-bar grating). The optimum pupil size was found to be independent of the type of test target, but as the three-bar grating proved to be most convenient, this was used for the remaining subjects. Three runs were performed on A. H. G. and two each on J. G. R. and R. R. The mean optimum pupil sizes for these thirteen trials on four subjects are shown in Fig. 2, the means being taken over successive units of 0·5 log luminance. The vertical lines indicate the standard error of each mean.

Reeves[5] and Crawford[6] have published measurements giving the natural pupil size (with binocular viewing) at different luminance-levels, the subjects being fully adapted to each level. Their mean results, for seven and ten subjects respectively, are shown by the broken lines in both Figs. 1 and 2. The difference in their mean value is more marked at low luminance-levels, and may well be due to the dependence of maximum pupil size on age[7]. In Fig. 2 the mean optimum pupil sizes determined as above can be compared with the mean natural pupil sizes as measured by Reeves and Crawford. Although only a small number of subjects was used, the correspondence is good. We therefore conclude that the human pupil light reflex subserves the useful role of adjusting the aperture of the eye so as to optimize visual acuity over a wide range of luminance.

With the evidence at present available, it is difficult to decide whether the performance characteristics of the light reflex have been determined genetically by natural selection or by modification resulting from experience in each individual. Direct correlation between optimum pupil size and attained pupil size at different luminance-levels in a series of individuals might indicate the origin of the performance characteristics of the pupil.

Some of the apparatus used in this work was supplied by grants from the Royal Society and the W. H. Ross Foundation.

F. W. Campbell
A. H. Gregory*

Physiological Laboratory,
University of Cambridge

* Present address: Department of Psychology, University of Hull.

[1] Denton, E. J., *J. Gen. Physiol.*, 40, 201 (1956).
[2] Pirenne, M. H., and Denton, E. J., *Nature*, 170, 1039 (1952).
[3] Shlaer, S., *J. Gen. Physiol.*, 21, 165 (1937).
[4] Leibowitz, H., *J. Opt. Soc. Amer.*, 42, 416 (1952).
[5] Reeves, P., *Psychol. Rev.*, 25, 330 (1918).
[6] Crawford, B. H., *Proc. Roy. Soc.*, B, 121, 376 (1936).
[7] Kadlecová, V., Peleška, M., and Vaško, A., *Nature*, 182, 1520 (1958).

RADIOBIOLOGY

Labilization of Deoxyribonucleic Acid in Thymus Nucleoprotein after Whole-body Irradiation

The effect of total-body irradiation on the nucleoprotein in the sensitive organs can be demonstrated by a decrease of the viscosity[1]. Besides this, it has been shown that there is also a "labilisation of deoxyribonucleoprotein-moiety"[2] after a total-body irradiation and probably "the chromosome breaks may originate mainly in the junction of DNA particles with histone"[3]. To explain the effect of irradiation on nucleoproteins, it is probably necessary to study in more detail the binding between the deoxyribonucleic acid and the protein before and after irradiation.

The work of Kirby[4] provides a basis for such studies. According to this author, deoxyribonucleic acid can be extracted from tissues with 90 per cent phenol only in the presence of certain anions. These anions apparently break the bivalent metal linkages between the acid and protein. A small yield of deoxyribonucleic acid can be obtained with water; at increasing salt concentrations there is an increasing yield of deoxyribonucleic acid until all the acid becomes soluble. This phenomenon has been used in the present work as a measure of the firmness of binding the deoxyribonucleic acid to its protein.

Rats of an inbred strain of our own were irradiated with 200-kV. X-rays (10 m.amp., 210 r./min.). Desired tissues were taken immediately after decapitation, cooled on solid carbon dioxide, weighed, and homogenized with nine volumes of ice-cold water. To 2-ml. aliquots of the homogenate were added 2 ml. of trichloracetate of different concentrations (0–10 per cent). After 30 sec., 4 ml. of 90 per cent phenol were added and the mixture was shaken for 20 min. at room temperature, then centrifuged (15 min. at 0° C., at 15,000*g*). The clear supernatant was assayed for deoxyribonucleic acid by Dische's method[5]. A maximum yield of deoxyribonucleic acid was obtained with 2 per cent trichloracetic acid, which is noted as 'total deoxyribonucleic acid', as the extraction of the thymus with 5 per cent trichloracetic acid according to Schneider's method[6] gives no considerably higher acid values.

Table 1. AMOUNT OF DEOXYRIBONUCLEIC ACID EXTRACTABLE FROM THE THYMUS OF THE RAT WITH PHENOL-TRICHLORACETATE (MGM. ACID PER GM. TISSUE)

Trichloracetic acid final concentration	Normal thymus	Thymus 6 hr. after 800 r.	Thymus 12 hr. after 800 r.
(per cent)			
0	0·87 ± 0·202	2·33 ± 0·23	3·54 ± 0·83
0·5	0·89 ± 0·118	7·28 ± 0·69	8·85 ± 1·10
1·0	2·28 ± 0·28	18·42 ± 2·13	18·5 ± 0·1
1·5	27·1 ± 2·32	34·5 ± 0·85	28·4 ± 1·6
2·0	27·76 ± 0·78	32·65 ± 2·26	37·1 ± 2·5
5·0	20·8 ± 2·58	31·75 ± 1·5	42·2 ± 0·2

Each value represents 12–21 animals with standard deviation.

Table 1 presents the yields of deoxyribonucleic acid from normal thymus. After a whole-body irradiation, considerably more acid can be extracted from the thymus, especially with the more dilute trichloracetic acid solutions.

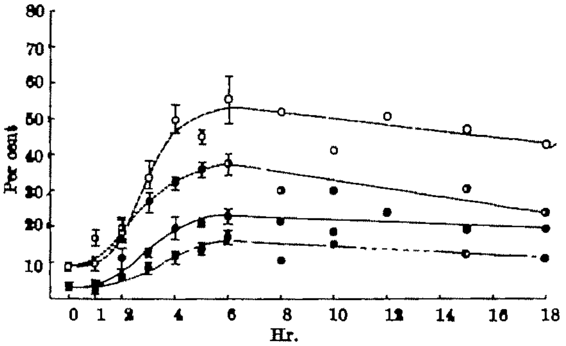


Fig. 1. Yield of deoxyribonucleic acid in extractions of thymus with phenol–trichloracetate after whole-body irradiation (yield in percentage of total acid). Time after irradiation. (Points with standard deviation represent 12–21 animals; single points represent three animals; trichloracetic acid final concentration in the supernatant). ---○---, 1·0 per cent trichloracetic acid, 800 r.; ---◑---, 1·0 per cent trichloracetic acid, 200 r.; ——●——, 0·5 per cent trichloracetic acid, 800 r.; -.-.-◐-.-.-, 0·5 per cent trichloracetic acid, 200 r.

The time relationships are more fully illustrated in Fig. 1. Since the total deoxyribonucleic acid per gm. of tissue changes after irradiation, the yield of deoxyribonucleic acid extracted with 0·5 and 1·0 per cent trichloracetic acid is calculated as percentage of the total deoxyribonucleic acid. After a lag period of about 1 hr., the yield increases for about 6 hr., after which it remains constant or decreases slightly.

The increase in yield of deoxyribonucleic acid extractable with dilute trichloracetic acid is dependent on the dose of irradiation. Table 2 demonstrates that the thymus of rats irradiated with as little as 50 r. differs significantly from that of controls.

The observed effect can be explained either by a break or weakening of some bivalent metal linkage

Table 2. YIELD OF DEOXYRIBONUCLEIC ACID IN EXTRACTIONS OF THYMUS 6 HR. AFTER WHOLE-BODY IRRADIATION WITH PHENOL-TRICHLORACETATE

Dose	Trichloracetic acid 0·5 per cent	Trichloracetic acid 1·0 per cent
Control	3·2 ± 0·41	8·47 ± 1·32
50 r.	7·8 ± 1·57	22·6 ± 1·64
100 r.	9·8 ± 0·43	29·4 ± 2·2
200 r.	16·9 ± 1·93	37·55 ± 3·03
400 r.	21·9 ± 0·6	53·6 ± 1·5
800 r.	22·8 ± 1·77	55·3 ± 6·74

Each value represents 9–18 animals. Yield (per cent) of the total acid.

between deoxyribonucleic acid and protein, as suggested by Kirby[4], or by a higher concentration of deoxypolynucleotides in the thymus. As the increase of deoxypolynucleotides has been observed only for a short period after irradiation[2], whereas the increased yield of deoxyribonucleic acid remains constant for a longer period, the first assumption seems more likely. To obtain further evidence on this point, nucleohistone was extracted from the thymus with 1 *M* sodium chloride, precipitated by dilution to 0·14 *M* sodium chloride and used for further treatment with phenol–trichloracetic acid. As will be published later in detail, a similar irradiation effect can be observed as in the whole organ. From thymus-nucleohistone, prepared from animals 6 hr. after 800 r., 50 per cent of the deoxyribonucleic acid is extracted in 0·5 per cent trichloracetic acid, whereas from nucleohistone of normal animals, only 10 per cent deoxyribonucleic acid can be obtained in 0·5 per cent trichloracetic acid. This indicates a labilization of the deoxyribonucleic acid from the protein, probably due to a break in bivalent metal linkages.

This labilization occurs in an early post-irradiation period, that is, 1–6 hr. after irradiation. Histological observations demonstrate death of some cells at this time, although the weight of the organ and the deoxyribonucleic acid content per gm. of tissue begin to decrease later, namely, 6–10 hr. after irradiation. It seems probable that the labilization of deoxyribonucleic acid from protein occurs prior to histologically observable death of a cell. The distinct lag period of 1 hr. before labilization begins, however, suggests that some other processes in the nucleus are involved with it or responsible for it. In particular, the possibility must be investigated of a preliminary degradation of the deoxyribonucleic acid chain.

I am indebted to Dr. R. N. Feinstein, of the Argonne National Laboratory, Lemont, Illinois, for helpful comments and corrections of the text.

ULRICH HAGEN

Biophysikalische Abteilung,
Heiligenberg-Institut,
Heiligenberg, Baden.

[1] Feinstein, R. N., and Butler, C. L., *Proc. Soc. Exp. Biol. Med.*, 79, 181 (1952).

[2] Cole, L. J., and Ellis, M. E., *Rad. Res.*, 5, 252 (1956); 7, 508 (1957).

[3] Butler, J. A. V., *Rad. Res.*, 4, 20 (1956).

[4] Kirby, K. S., *Biochem. J.*, 66, 495 (1957); 70, 260 (1958).

[5] Dische, Z., *Mikrochemie*, 8, 4 (1930).

[6] Schneider, W. C., *J. Biol. Chem.*, 161, 293 (1945).

Localization of a Halogenated Porphyrin in Mouse Tumours

SCHWARTZ *et al.* observed that certain commercially obtainable hæmatoporphyrin preparations were contaminated by a porphyrin capable of becoming localized in experimental tumours[1,2], and that pure hæmatoporphyrin was unable to do so. These findings gave the impetus to the present work on halogenoporphyrins. The premise on the basis of which halogenoporphyrins were chosen was the assumption that the aforementioned impurity represents an intermediate formed in the course of the synthesis of hæmatoporphyrin from hæmin. One such intermediate could be *bis*-(2-bromo-ethyl)deuteroporphyrin. Since iodine-131 is a more convenient isotope for the purpose of labelling than isotopes of bromine, the iodine-131–labelled analogue was synthesized.

When given parenterally, *bis*(2-iodoethyl-^{131}I) deuteroporphyrin became localized selectively in transplanted adenocarcinomata of *Dba*1 mice and in spontaneous mammary adenocarcinomata of *C3H* mice. This conclusion is based on the following experimental findings. All tumours when examined 6 hr. after injection or later exhibited the red fluorescence characteristic of porphyrins; the fluorescence was non-uniformly distributed within these tumours. In contrast, none of the other tissues exhibited this phenomenon. Although extracts of organs from mice injected with *bis*(2-iodoethyl-^{131}I)deuteroporphyrin contained no porphyrins, radioactivity, probably due to products of porphyrin catabolism, was found to be present. When tumours or other tissues were extracted with a mixture of ethyl acetate/acetic acid (4 : 1, v/v), only the extracts of tumours contained detectable amounts of a single porphyrin. This porphyrin was identical with *bis*(2-iodoethyl-^{131}I)deuteroporphyrin with respect to its specific radioactivity. Furthermore, when the aforementioned tumour-extracts were chromatographed on paper strips and the developed chromatograms scanned for radioactivity, the radioactivity of the porphyrin-containing spot accounted for all the activity initially placed on the strip.

When sections prepared from a transplantable mammary carcinoma were examined after fixation in formaldehyde and after removal of paraffin with benzene, fluorescence typical of porphyrin was observed within the tumour cells. In the limited number of observations made, fluorescence was found to be present only in intact tumour cells.

The mechanism underlying the selective accumulation of *bis*(2-iodoethyl-^{131}I)deuteroporphyrin in the tumours studied remains to be established and is now being investigated.

This work was performed under contract with the United States Atomic Energy Commission at the University of Rochester Atomic Energy Project, Rochester, New York.

K. I. ALTMAN
K. SALOMON

Departments of Radiation Biology and Biochemistry
University of Rochester School of Medicine and
Dentistry,
Rochester,
New York.

[1] Schwartz, S., Absolon, K., and Vermund, H., *Univ. Minn. Med. Bull.*, 27 (Oct. 15, 1955).

[2] "Progress thru Research", 1956 (General Mills Inc., Minneapolis, Minn.).

Synthesis of Diphosphopyridine Nucleotide in Irradiated Rats

WHEN suspensions of nuclei from thymus or spleen are incubated *in vitro*, adenosine monophosphate in the nuclei is phosphorylated to the triphosphate[1]. This phosphorylation appears to be abolished following low doses of X- or γ-radiation, given either *in vitro* or *in vivo*[2]. However, the net synthesis of diphosphopyridine nucleotide *in vivo* following intraperitoneal injection of 0·5 gm. nicotinamide/kgm. (ref. 3) was not abolished when rats were exposed to X-radiation in doses up to 1,500 r. 3–60 min. before nicotinamide injection (Table 1); in these experiments, the pyridine nucleotide content of the tissue extracts was measured by the alcohol dehydrogenase method[4]. Since the synthesis of this nucleotide is restricted to the nucleus of the cell[5] and

Table 1. INCREASE IN CONCENTRATION OF DIPHOSPHOPYRIDINE NUCLEOTIDE (DPN) IN RAT TISSUES 2 HR. AFTER INJECTION OF NICOTINAMIDE

Tissue	Increase in concentration (μmol. DPN/100 gm. tissue)	
	Control	After exposure to 1,500 r.
Liver	135·0 ± 6·9	124·0 ± 12·5
Spleen	21·3 ± 1·4	20·1 ± 1·3
Thymus	8·4 ± 0·7	8·1 ± 1·5

requires adenosine triphosphate[4], the above result suggests that appreciable amounts of adenosine triphosphate are still available to the cell nuclei during the first two or three hours after irradiation.

The absence of phosphorylation *in vitro* following irradiation[5] might be due to diffusion of nucleotides and other water-soluble materials, for example, catalase[5], from the irradiated thymus and spleen nuclei into the suspending medium. An analogous loss of nucleotides and soluble enzymes does in fact occur during the isolation of nuclei from non-irradiated liver cells[7] and is probably responsible for the reported absence of nucleotide phosphorylation from suspensions of normal liver nuclei[2].

D. K. MYERS

Biology Branch,
Atomic Energy of Canada, Ltd.,
Chalk River, Ontario.

[1] Osawa, S., Allfrey, V. G., and Mirsky, A. E., *J. Gen. Physiol.*, 40, 491 (1957).

[2] Creasey, W. A., and Stocken, L. A., *Biochem. J.*, 72, 519 (1959).

[3] Kaplan, N. O., Goldin, A., Humphreys, S. R., Ciotti, M. M., and Stolzenbach, F. E., *J. Biol. Chem.*, 219, 287 (1956).

[4] Ciotti, M. M., and Kaplan, N. O., in "Methods in Enzymology", edit. by Colowick, S. P., and Kaplan, N. O., 3, 890 (1957).

[5] Hogeboom, G. H., and Schneider, W. C., *J. Biol. Chem.*, 197, 611 (1952). Morton, R. K., *Nature*, 181, 540 (1958).

[6] Kornberg, A., *J. Biol. Chem.*, 182, 779 (1950).

[7] Stern, H., and Mirsky, A. E., *J. Gen. Physiol.*, 37, 177 (1953). Keir, H. M., and Davidson, J. N., *Arch. Biochem. Biophys.*, 77, 68 (1958).

HÆMATOLOGY

Isolation of Material with Proactivator Activity from Human Serum

IN the scheme proposed by Astrup[1] to represent the stages in the activation of human plasminogen to plasmin by streptokinase, the substance designated 'proactivator' has hitherto been a hypothetical one, postulated to account for certain observations made by Astrup and his co-workers, but never isolated by them. American workers, notably Sherry *et al.*[2], have doubted the existence of proactivator, pointing out that all procedures available for the purification of human plasminogen result in parallel purification of the proactivator activity. Ablondi and Hagan[3] think that proactivator and plasminogen are probably identical.

By a process of acidification of serum to pH 3·3, followed by ether extraction after neutralization, we have obtained material ('A.E.S.') which has powerful proactivator activity but has no activator activity and contains no plasminogen.

We have found Astrup and Mullertz's[4] bovine fibrin plate method convenient for studying this material. Spotted on the fibrin plates by itself, it produces no lysis of the fibrin, that is, it does not activate the bovine plasminogen present in the fibrin, nor is it of itself proteolytic. On addition of streptokinase to the material, however, it causes marked lysis of bovine fibrin (Fig. 1). This activated material is not proteolytic for casein, showing that plasminogen is absent. Further proof that plasminogen is absent is given by the fact that addition of urokinase does not result in the appearance of proteolytic activity which would occur if plasminogen were present, as urokinase is a direct activator of plasminogen.

The bulk of the proactivator activity is precipitated by 40 per cent saturation with ammonium sulphate. The material obtained forms a very fine suspension on dialysis against distilled water, and does not go into solution on adjusting the salt concentration to 0·15 M sodium chloride. However, the greater part of the activity dissolves in borate (0·05 M) buffered saline at pH 7·4.

Following activation with streptokinase, the activator activity is also precipitated by 40 per cent saturation with ammonium sulphate, but the activator precipitate is highly soluble in borate (0·05 M) buffered saline pH 7·4.

Proactivator prepared in this way is an extremely stable substance, withstanding boiling at pH 1·5 for 30 min. without loss. Preliminary data suggest it is a cholesterol-containing protein. Activator is much less stable than proactivator, and is most stable in the pH range 6·0–9·0. 50 per cent of its activity is lost at pH 7·5 in 3 hr. at 37° C.

Tentatively, it is suggested that proactivator is activator bound to an inhibitor, the inhibitor being cholesterol or a lipoprotein containing cholesterol. This may provide support for the hypothesis that lipoproteins have an inhibitory effect on fibrinolysis[5] and an explanation of the observed inhibition of fibrinolysis by alimentary lipemia[6].

Thanks are due to the director of the South African Institute for Medical Research (Dr. James Gear) and to the deputy director (Prof. J. F. Murray) for their encouragement and help in this work. Thanks are also due to Dr. A. Zoutendyk of the Serum Laboratories for abundant supplies of human serum, to Dr. J. Ploug (Leo Pharmaceuticals, Copenhagen, Denmark) for a generous gift of urokinase and to Mr. M. Ulrich for the photograph. This work was carried out with financial aid from the Council of Scientific and Industrial Research, Pretoria,

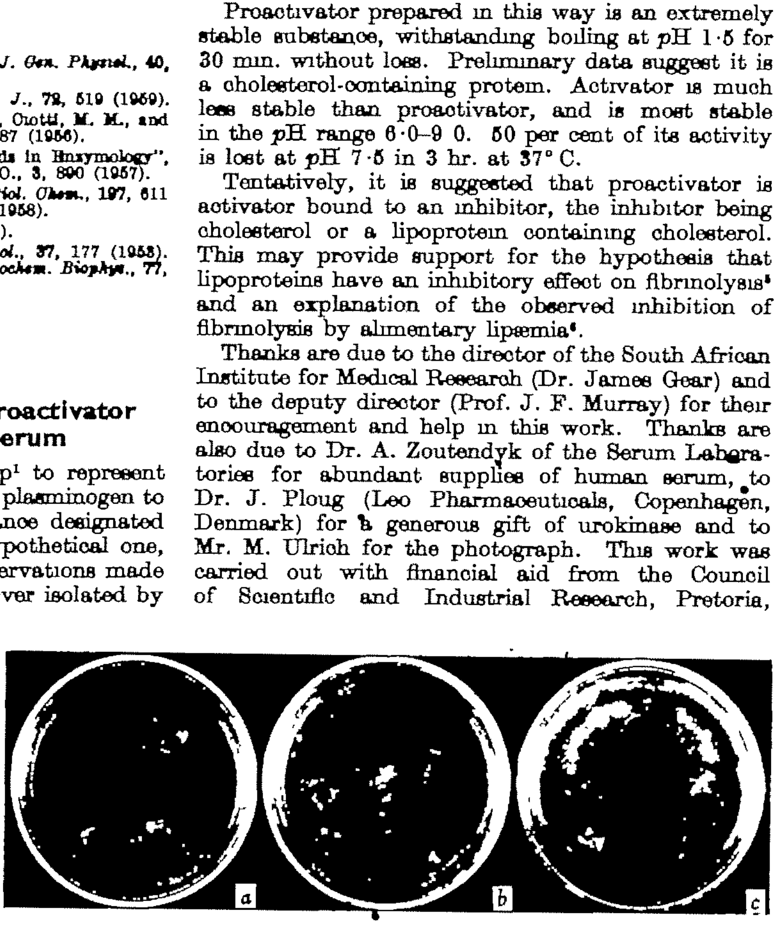


Fig. 1. (*a*) 30λ of a suspension of a 40 per cent saturated ammonium sulphate precipitate ('Fr. 40') of 'A.E.S.' spotted on an unheated fibrin plate (after Astrup and Mullertz). 18 hr. incubation at 22° C. No lysis. (*b*) 30λ of a 100 u./ml. solution of streptokinase ('Varidase', Lederle). 18 hr. at 22° C. Minimal superficial lysis only. (*c*) 30λ of an activated sample of 'Fr. 40'. 0·9 ml. 'Fr. 40' is incubated with 0·1 ml. streptokinase solution containing 100 u. for 10 min. at 37° C., then 'spotted' on the plate. 18 hr. at 22° C. Marked lysis: mean area 122 sq. mm

South Africa, with the permission of which it is published.

H. B. W. GREIG
ELSIE M. CORNELIUS

Department of Hæmatology,
South African Institute for Medical Research,
P.O. Box 1038,
Johannesburg.

[1] Astrup, T., *Blood*, 11, 781 (1956).
[2] Sherry, S., Fletcher, A. P., and Alkjaersig, M., *Physiol. Rev.*, 39, 343 (1959).
[3] Ablondi, F. B., and Hagan, J. J., *Proc. Soc. Exp. Biol. Med.*, 95, 195 (1957).
[4] Astrup, T., and Mullertz, S., *Arch. Biochem. Biophys.*, 40, 346 (1952).
[5] Greig, H. B. W., and Runde, I. A., *Lancet*, ii, 461 (1957).
[6] Greig, H. B. W., *Lancet*, ii, 16 (1956).

Serum Iron and Total Iron-binding Capacity in Certain Mammals

DATA in the literature concerning transport of serum iron in animals are very sparse, especially those which may be directly comparable.

In previous work[1], we studied serum iron in six species of mammals and in hens.

It is well known how iron travels bound to a fraction of β-globulins (siderophilin or transferrin), and how its concentration in serum may be expressed as the maximum quantity capable of being bound (total iron-binding capacity). In man it amounts to about 340γ per cent[2] and in absolute values it represents 0·2–0·32 gm. per cent proteins[3]. Human serum normally shows its siderophilin saturated only to 30–40 per cent, while in pathological cases extreme values may occur. In certain conditions (pregnancy, ferropenia, etc.) the content of siderophilin is also clearly increased.

We have studied serum iron and the total iron-binding capacity in eight mammal species, human included, using Ramsay's techniques[4,5] and the results obtained are given in Table 1. The differences between average values have been submitted to a test of statistical significance (Student's *t*).

Thanks to statistical analysis it has been possible to show that serum iron does not show any intersexual or interspecific differences which are significant. But it must be pointed out that an intersexual difference in sheep is significant; however, we must disregard it for want of homogeneity in the ages of the males.

On the contrary, in the values regarding the total iron-binding capacity, there exist evident differences between species. The comparisons between sexes in each species have not proved statistically significant, and for this reason the values for males and females have been mixed up in order to carry out the interspecific comparison.

The values for total iron-binding capacity in the porcine species give an average of 476·8γ per cent, which proves statistically significant when compared with the other species.

We may also point out the low values obtained in donkeys, with an average of 263γ per cent which is also significant as regards the other species, except in mules. Goats have given, however, the lowest values (233γ per cent), but due to the lack of data about the males, goats have not been included in the comparison.

The differences between the average value of the total iron-binding capacity for cows and man, and for man and mule, are also significant.

A comparison between species of the corresponding saturation coefficient for serum iron proves significant only in the case of porcine species.

We therefore have a series of mammals, several of which show specific values of total iron-binding capacity, although their serum iron cannot be statistically differentiated. These differences in the total iron-binding capacity must be attributed either to quantitative variations of a definite siderophilin or to the existence of specific siderophilins, which would not constitute any exceptional fact if we

Table 1. AVERAGE VALUES FOR SERUM IRON, TOTAL IRON-BINDING CAPACITY (TIBC) AND SC* WITH CORRESPONDING EXTREME VALUES, TYPICAL DEVIATIONS AND ERRORS OF THE AVERAGE FOR THE SPECIES CONCERNED, WITH SEPARATION OF SEXES, SHOWING NUMBER OF SPECIMENS IN EACH GROUP

	Males				Females			
Species	No.	Serum iron γ Fe (per cent)	TIBC γ Fe (per cent)	SC per cent	No.	Serum iron γ Fe (per cent)	TIBC γ Fe (per cent)	SC Per cent
Human	5	101·4 ± 11·4 (78–135) σ = 22·8	355·6 ± 12·5 (322–390) σ = 25·0	29·7 ± 3·4 (21·8–40·6) σ = 6·9	5	119·0 ± 13·0 (87–166) σ = 26·0	352·4 ± 14·2 (324–404) σ = 28·5	34·0 ± 3·7 (25·4–50·0) σ = 7·4
Porcine	6	104·0 ± 4·5 (85–102) σ = 11·0	496·5 ± 26·6 (375–562) σ = 58·7	21·4 ± 2·0 (15·1–29·8) σ = 4·4	5	113·0 ± 11·9 (75–152) σ = 23·9	453·2 ± 50·8 (303–600) σ = 101·6	24·9 ± 1·0 (21·1–27·7) σ = 2·1
Bovine	5	142·4 ± 22·1 (95–225) σ = 44·3	377·6 ± 34·1 (292–487) σ = 68·2	38·3 ± 3·9 (27·7–46·2) σ = 7·8	8	117·0 ± 4·7 (63–167) σ = 31·8	366·7 ± 34·0 (247–491) σ = 88·5	32·2 ± 4·2 (13·3–40·8) σ = 11·0
Sheep	6	114·5 ± 4·8 (100–135) σ = 10·7	283·5 ± 41·2 (187–442) σ = 91·0	44·4 ± 6·0 (24·4–61·4) σ = 13·3	5	136·4 ± 8·3 (117–157) σ = 16·7	291·8 ± 16·5 (243–336) σ = 33·1	47·7 ± 5·0 (34·5–59·6) σ = 10·1
Donkey	5	86·6 ± 4·5 (80–100) σ = 9·1	253·8 ± 3·8 (243–262) σ = 7·6	34·1 ± 1·8 (28·2–38·1) σ = 3·8	5	85·0 ± 14·5 (50–100) σ = 28·5	272·5 ± 19·8 (225–322) σ = 39·7	31·3 ± 3·3 (21·5–41·3) σ = 6·6
Equine	5	110·8 ± 11·0 (73–140) σ = 22·1	328·4 ± 20·6 (274–402) σ = 41·2	34·7 ± 4·5 (18·1–43·4) σ = 9·1	5	104·2 ± 11·1 (65–130) σ = 22·2	331·2 ± 20·1 (285–393) σ = 40·2	32·5 ± 4·8 (18·4–44·5) σ = 9·7
Mule	7	108·5 ± 9·7 (95–163) σ = 25·3	294·4 ± 18·6 (225–367) σ = 44·8	37·8 ± 4·5 (28·1–62·2) σ = 10·8	7	105·7 ± 6·3 (85–125) σ = 16·7	275·5 ± 20·0 (219–371) σ = 48·2	39·0 ± 3·1 (32·0–54·6) σ = 7·5
Goat	-				5	102·4 ± 8·5 (75–120) σ = 17·1	233·6 ± 24·4 (180–326) σ = 48·9	44·3 ± 4·3 (36·8–52·2) σ = 8·6

* SC = Serum iron × 100/total iron-binding capacity.

consider the existence of different genetic forms in man[6,7].

JOSE PLANAS
SISINIO DE CASTRO

Laboratorio de Biologia,
Facultad de Ciencias,
Universidad de Valladolid,
Spain.

[1] Planas, J., and de Castro, S., "V Jornadas Bioquímicas Latinas" (Barcelona, Mayo, 1959).
[2] Dreyfus, J. C., and Schapira, G., "Le Fer" (L'Expansion, Paris, 1958).
[3] Laurell, C. B., "Eisenstoffwechsel", 103 (G. Thieme, Stuttgart, 1959).
[4] Ramsay, W. N. M., *Clin. Chim. Acta*, 2, 214 (1957).
[5] Ramsay, W. N. M., *Clin. Chim. Acta*, 2, 221 (1957).
[6] Smithies, O., *Nature*, 180, 1482 (1957); 181, 1204 (1958).
[7] Harris, H., Robson, E. B., and Siniscalco, M., *Nature*, 182, 452 (1958).

Chromatography of Blood Thrombokinase on 'DEAE'-Cellulose

THROMBOKINASE, prepared from bovine plasma, has been obtained in a highly purified state by repeated electrophoretic fractionations[1]. However, a more efficient method was promised by anion-exchange chromatography, provided that the kinase could be separated from its accompanying impurities by stepwise elution in one day[2].

Fig. 1 illustrates an exploratory experiment in which purified kinase[3] from 21 litres of plasma was applied to a column of 2 gm. 'DEAE'-cellulose. Thrombokinase emerged in the last major band to be eluted by a series of potassium phosphate solutions. This opened up the possibility of recovering the kinase without appreciable dilution, if it were displaced by a strong eluant after protein impurities had first been removed by a weaker eluant. Such an experiment is presented in Fig. 2, where more than 90 per cent of the kinase in the original 19·2 ml. was recovered in the 20·5 ml. of the two best fractions. This was the product from 19·2 litres of plasma. Protein was estimated by the method of Lowry *et al.*[4]; and the total recovery was 91·3 per cent of the 44·4 mgm. put into the column.

The thrombokinase so obtained was diluted for some tests and dialysed for others, to avoid interference by phosphate. It could activate prothrombin in the presence of oxalate[5]; but it was much more effective when accompanied by calcium, cephalin and bovine barium carbonate-treated serum. In the latter system, the peak kinase fraction of Fig. 2 was assayed at a dilution of 1 to 1,200,000, corresponding to a protein concentration of 0·00088 μgm. per ml. The kinase activity of the fraction was 103 times that of the working standard. Because of the high dilution, and for other reasons[3], the assay cannot be considered precise. Nevertheless, the coincidence of protein and kinase data in the second band of Fig. 2 suggests an approach to homogeneity.

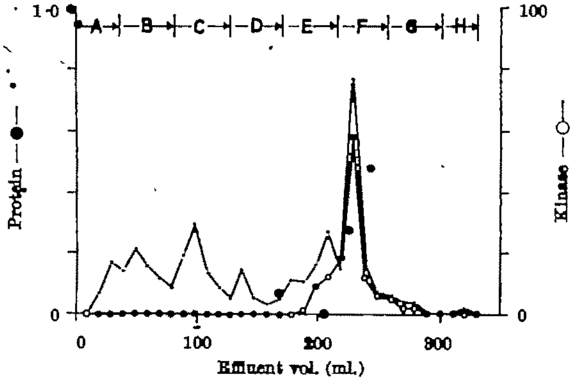


Fig. 1. Exploratory chromatography of thrombokinase. 4° C. Flow-rate 55 ml. per hr. *A*, thrombokinase in veronal, ionic strength 0·02, pH 8·6; *B*, 0·025 *M* phosphate, pH 7·84; *C*, 0·05 *M* phosphate, pH 7·88; *D*, 0·1 *M* phosphate, pH 7·88; *E*, 0·2 *M* phosphate, pH 7·90; *F*, 0·4 *M* phosphate, pH 7·95; *G*, 1·0 *M* phosphate, pH 8·20; *H*, 0·3 *M* phosphate, pH 4·40

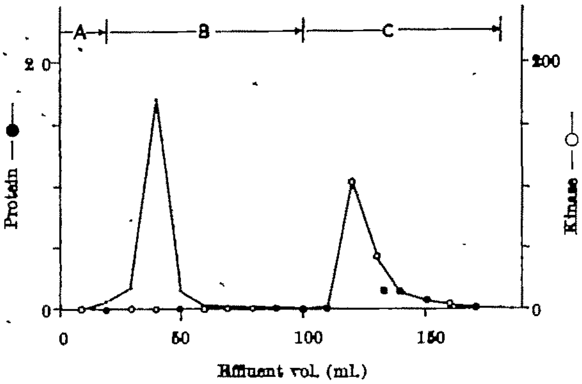


Fig. 2. Simplified chromatography of thrombokinase. 2 gm. 'DEAE'-cellulose. Column 1 cm. diam., 15 cm. high. 4° C. Flow-rate 27 ml. per hr. *A*, Thrombokinase in veronal, ionic strength 0·02, pH 8·6; *B*, 0·1 *M* phosphate, pH 7·88; *C*, 1·0 *M* phosphate, pH 8·20

This suggestion is furthered by a comparison with the results of continuous-flow paper electrophoresis. In a third serial run by that method, almost all the protein appeared in a single peak[1]. There was a close correspondence of the data for protein and kinase, and also for tosyl-arginine methyl ester esterase, indicating that tosyl-arginine methyl ester is a substrate for thrombokinase. For the five chief fractions, the data for esterase units[6] per mgm. protein were 329, 359, 338, 333 and 325, with an average value of 337. Corresponding data for the two chief kinase fractions of the present Fig. 2 were 349 and 345. Although the agreement is good, further tests for homogeneity will be desirable, particularly since the present method was designed for preparative isolation rather than analysis. For the present, it may be noted that about the same amount of thrombokinase at this degree of purity was obtained in the experiment of Fig. 2 in one day as was previously obtained by electrophoresis, applied to the product from 738 litres of plasma over the course of several weeks.

Tosyl-arginine methyl ester esterase also occurred in the first band of Fig. 2; but this was associated with thrombin, which was found in the first band but not the second. Thus, the procedure separated thrombin from thrombokinase. In harmony with the findings of others[6], the tosyl-arginine methyl ester esterase associated with thrombin was not inhibited by crystallized soy bean trypsin inhibitor at a concentration of 1 mgm. per ml.

In parallel tests, the tosyl-arginine methyl ester esterase of the kinase band was mostly, but not quite entirely, inhibited. It has previously been shown that the trypsin inhibitor suppressed activation of prothrombin by blood thrombokinase in the presence of oxalate[7]. The general anti-thromboplastic effect of the inhibitor in the presence of calcium has long been known[8]; and recently it has been reported[9] that thromboplastin-generating systems exhibited tosyl-arginine methyl ester esterase activity which was markedly inhibited by soy bean trypsin inhibitor.

It appears that thrombokinase, as described here, is an enzyme with some resemblances to trypsin. Its properties offer a unifying correlation for many diverse observations. The manner in which cephalin or platelet material augments the effect of thrombokinase is not completely understood. However, it is well to recall the suggestion of Macfarlane[8]: "It is possible in fact that cephalin, supposed by various workers to represent 'pure thromboplastin', is no more than a cofactor with calcium and a proteolytic enzyme (thrombokinase), potentiating the digestion of prothrombin and consequent release of thrombin".

Nadia Oulianoff, Harriet F. Brown and Thomas R. Saxton assisted in this investigation, which was supported by Research Grant *H* 3906 from the National Heart Institute, U.S. Public Health Service.

J. H. MILSTONE

Department of Pathology,
Yale University School of Medicine,
New Haven, Connecticut.

[1] Milstone, J. H., *Proc. Soc. Exp. Biol. and Med.*, 103, 361 (1960)

[2] Sober, H. A., Gutter, F. J., Wyckoff, M. M., and Peterson, E. A., *J. Amer. Chem. Soc.*, 78, 756 (1956).

[3] Milstone, J. H., *J. Gen. Physiol.*, 42, 665 (1959).

[4] Lowry, O. H., Rosebrough, N. J., Farr, A. L., and Randall, R. J., *J. Biol. Chem.*, 193, 265 (1951).

[5] Mellanby, J., and Pratt, C. L. G., *Proc. Roy. Soc.*, B, 128, 201 (1939).

[6] Sherry, S., and Troll, W., *J. Biol. Chem.*, 208, 95 (1954).

[7] Milstone, J. H., *J. Gen. Physiol.*, 38, 757 (1955).

[8] Macfarlane, R. G., *J. Physiol.*, 106, 104 (1947).

[9] Arscott, P. M., Koppel, J. L., and Olwin, J. H., *Nature*, 183, 758 (1959).

PATHOLOGY

Mast Cells and 5-Hydroxytryptamine in Precancerous Mouse Skin

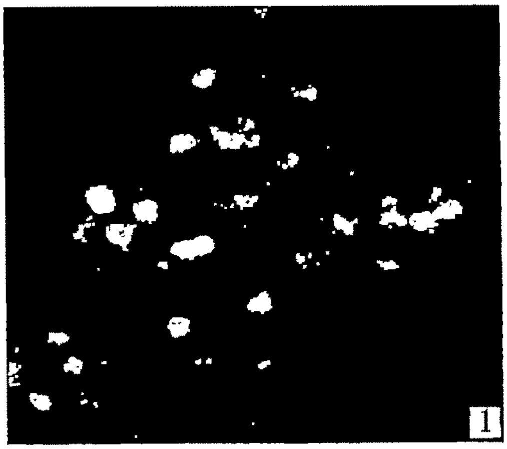


Fig. 1. Fluorescent mast cells at base of mouse skin papilloma. (× 400)

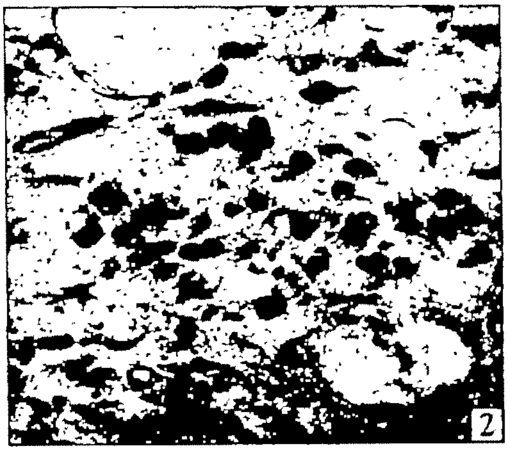


Fig. 2. Same field stained with toluidine blue. (× 400)

A CURIOUS feature of carcinogenesis in the skin of the mouse is the intense mast-cell reaction which gradually develops in the dermis immediately under the painted hyperplastic epidermis. Cramer and Simpson[1] observed that some of these new mast cells exhibit a golden-brown fluorescence in ultra-violet light, providing that the frozen section has also been treated with formaldehyde.

Mast cells in the mouse (and rat) normally contain not only histamine[2] but also 5-hydroxytryptamine[3]. Riley[4] suggested that the golden-brown fluorescence exhibited by some mast cells, in formol-fixed sections, may indicate an abnormally high content of 5-hydroxytryptamine.

Attempts to localize the 5-hydroxytryptamine in pre-cancerous mouse skin by direct assay of tissue slices, though giving only a rough guide to the location of the amine (Cass and Riley, unpublished work), suggest that it occurs predominantly in the upper dermis. In the present work, histochemical methods applied to sections of precancerous mouse skin demonstrate with precision that the 5-hydroxytryptamine is concentrated in the granules of those mast cells which exhibit primary fluorescence in sections in fixed formol.

The dorsal skin of albino mice (Tucks) was painted on two occasions seven days apart with 0·5 per cent 9 : 10-dimethyl-1 : 2-benzanthracene dissolved in acetone. Animals which developed ulceration of the skin were discarded: the remainder recovered almost completely from an initial epilation and gradually developed papillomas or carcinomas over the next eight months. Animals were killed at varying intervals by cervical dislocation. The skin was fixed in formol–saline, formol–calcium or formol–dichromate buffered to pH 6. Frozen and paraffin sections were examined either in ultra-violet light (Leitz primary filter, 4 mm. *U.G.*1, secondary filter 2·5 mm. Euphos.) for fluorescence or in visible light after staining with

Table 1

	Chromaffin reaction	Toluidine blue	New methylene blue	Alkaline diazonium	Indophenol	Schmorl	Fluorescence
Precancerous mast cell granules	+ (faint)	+ + + metachromatic	+ + + metachromatic	+ +	+ +	+ +	+ + + golden yellow
Normal mast cell granules	–	+ + + metachromatic	+ + + metachromatic	–	–	–	–

+ + +, Strong reaction; –, no reaction.

one of the following methods: toluidine blue, New methylene blue, diazo-coupling with Garnet *GBC* salt or fast red *TR* at *p*H 9·2, treating with 2 : 6-dibromoquinonechloroimide (indophenol reaction[5]) or with Schmorl's ferri-ferricyanide mixture[6]. The most sensitive histochemical method, though not entirely specific for 5-hydroxytryptamine, was the Schmorl reaction applied to formol–calcium-fixed sections. However, it was often possible to apply more than one technique to the same section and so demonstrate convincingly that the specific staining reactions, described below, do occur in mast cells and not in other types of dermal cells with cytoplasmic granules. The results, which will be published in detail elsewhere, are summarized in Table 1. The methods referred to, except the chromaffin reaction, were all performed on formol–calcium fixed material.

The above findings, together with the results of direct assay (Cass and Riley, unpublished work), indicate that 5-hydroxytryptamine is concentrated in the mast cell granules. The number of positive cells increases during the induction period. A strongly positive reaction is most commonly seen in mast cells at the base of papillomas (Figs. 1 and 2), though a positive mast cell is occasionally seen elsewhere in the treated dermis. It is thus clear that the high level of 5-hydroxytryptamine in precancerous mouse skin is due not only to an increase in the number of mast cells in the area but also to a progressive increase in content of 5-hydroxytryptamine in certain of these cells.

R. E. COUPLAND

Department of Anatomy,
Queen's College,
Dundee.

J. F. RILEY

Department of Radiotherapy,
The Royal Infirmary,
Dundee. April 25.

---

[1] Cramer, W., and Simpson, W. L., *Cancer Res.*, 4, 601 (1944).

[2] Riley, J. F., and West, G. B., *J. Physiol.* (Lond.), 120, 528 (1953).

[3] Benditt, E. P., Wong, R. L., Arase, M., and Roeper, E., *Proc. Soc. Exp. Biol.* (*N.Y.*), 90, 303 (1955).

[4] Riley, J. F., *Experientia*, 12, 141 (1956).

[5] Gomori, G., "Microscopic Histochemistry", 128 (Univ. Chicago Press, 1952).

[6] Pearse, A. G. E., "Histochemistry—Theoretical and Applied", second edit., 925 (Churchill, 1960).

A Transplantable Spontaneous Osteogenic Sarcoma observed in the Muscle Tissue of an Albino Mouse

OSTEOGENIC sarcomas attached to bone tissue have been reported in animals of different species. In 1936, Brues[1] described a case of spontaneous osteogenic sarcoma in the jaw of a three-year-old grey rabbit. Barrett *et al.* reported an osteogenic sarcoma attached to the left femur of a *C3H* female mouse[2]. Osteogenic sarcomas have also been induced by radioisotopes such as radium-226, strontium-90, calcium-45 (ref. 3) and strontium-89 (ref. 4). One case of osteogenic neoplasm arising from muscle tissue has been reported in man[5]. This tumour found in the thigh muscle had developed over a period of ten years and was believed to have followed an abscess in the muscle.

The tumour to be described was found in the soft tissue of the lateral neck region of a full-grown female mouse from our breeding colony. This colony was derived from *CF*1 mice of Carworth Farms. The host was a multiparous mother approximately six months of age. The neoplasm was situated between the muscle layers of the right sternohyoideus and sterno-cephalicus muscles and the skin. It was approximately 1 c.c. in volume. This tumour has been designated *H*-7. An attempt was made to transplant it into the same strain of mouse as the host. The neoplasm was excised and macerated in a sterile mortar, adding an equal amount of normal sterile physiological saline. An injection of 0·1 ml. of the suspension was made into the subcutaneous tissues of the right hind leg of 5 male and 5 female mice. A satisfactory growth was obtained in 6 of the 10 mice of the first generation. At eight weeks tumour tissue was removed from these mice for a second transplantation using aseptic technique. Suspensions of the first-generation tumour found to be microbiologically sterile were injected into 16 male and female mice of the same strain. The growth-rate of the second generation tumour was increased and the tumour-take was 100 per cent. The tumour was removed at six weeks for resuspension and injection into the third generation.

Histologically the tumour presented the classical picture of osteogenic sarcoma with abundant bone formation. It is apparently as difficult to determine the exact site of origin of osteogenic sarcomas in animals as in man. The primary tumour in this case did not seem to have grossly an intimate fusion with bone. For this reason, the actual site of origin of the tumour is uncertain. Studies are at present being made of the cytology, histology and enzymatic characteristics of *H*-7 as well as its transplantability in homogeneous and heterogeneous host animals, detailed results of which will be published later.

R. G. HERNE
M. GREGOIRE
G. RONA

Ayerst Research Laboratories,
Montreal.

---

[1] Brues, A. M., *Amer. J. Cancer*, 28, 587 (1936).

[2] Barrett, M. K., Dalton, A. J., Edwards, J. E., and Greenstein, J. P., *J. Nat. Cancer Inst.*, 4, 389 (1943–44).

[3] Finkel, M. P., and Biskis, B. O., *Unio Int. Contr. Cancer*, 15, 99 (1959).

[4] Skoryna, S. C., and Kahn, D. S., *Cancer*, 12, 306 (1959).

[5] Vasilescu, C., Hristu, C., and Ivanitescu, G., *Bull. et mém. Soc. méd. d. hôp. de Bucarest*, 17, 174 (1935).

Treatment of *Leishmania donovani* Infections with Surface-active Agents

'TRITON *W.R.* 1339', an arylalkyl polyoxyethylene ether of phenol, prepared by Rohm and Haas Co., Philadelphia, is a non-toxic surface-active agent, and was shown to exert a suppressive effect in experimental tuberculosis of mice[1]. 'Macrocyclon' is the polyoxyethylene ether containing on average 12·5 ethylene oxide units per chain, formed by reaction of ethylene oxide with a macrocyclic phenol and possesses similar antituberculous activity[2].

In view of these favourable results obtained, it appeared that the same drugs might be of value in treating other infections, such as kala-azar, in which development of the infecting agent also occurs in the white cells of the host.

Twenty golden hamsters were infected intraperitoneally with a strain of *Leishmania donovani* isolated from an Indian seaman and afterwards maintained by passage in these animals in which the infection is invariably fatal[3]. Six weeks later, biopsies were made and the number of parasites per oil immersion field determined in smears of spleen. Intraperitoneal treatment with the two drugs named above in dosage of 125 mgm. was given on days 2, 5, 9 and 15 after biopsy to groups of six animals and a similar number of untreated animals were used as controls. They were killed three weeks later and counts were again made of the number of parasites in spleen smears. Although no cures had been effected the results indicated that the drugs had controlled the infection.

A second experiment was carried out in which thirty hamsters were infected as before. Treatment with 125 mgm. drug per animal was started on the day of infection and repeated 2, 6 and 9 days later. Five animals received similar treatment with each drug in absence of infection and survived. The infected animals were killed 8 weeks later and parasite-counts were made in smears of spleen. The results obtained are shown in Table 1.

Table 1. *Leishmania donovani* BODIES PER OIL IMMERSION FIELD

Controls	'Macrocyclon' 4 × 125 mgm.	'*W.R.* 1339' 4 × 125 mgm.
120	15	20
100	6	8
100	5	1
50	3	<1
30	2	<1
20	1	<1
10	1	—
—	<1	—
—	<1	—
—	<1	—

In a further experiment thirty hamsters were infected and intraperitoneal treatment with 125 mgm. of each drug was given 4, 7, 11, 14, 18 and 20 days later. The animals were killed 7 weeks after infection. Five uninfected animals received similar treatment with each drug and survived. The results obtained are shown in Table 2.

Table 2. *Leishmania donovani* BODIES PER OIL IMMERSION FIELD

Controls	'Macrocyclon' 6 × 125 mgm.	'Triton *W.R.* 1339' 6 × 125 mgm.
200	<1	<1
200	<1	<1
150	<1	0
100	<1	0
100	<1	0
50	<1	0
30	0	0
20	0	0
—	0	—

Cultures were made from spleen on Locke-serum-agar medium and all were positive, showing that infection had been controlled but not eradicated as the result of drug treatment.

Similar results have been obtained by Dr. F. C. Goble, Ciba Pharmaceuticals, Ltd., Summit, New Jersey, with 'Triton-*W.R.* 1339', and will be reported elsewhere.

J. D. FULTON

National Institute for Medical Research,
Mill Hill,
London, N.W.7.

---

[1] Cornforth, J. W., Hart, P. D'A., Rees, R. J. W., and Stock, J. A., *Nature*, 168, 150 (1951).

[2] Cornforth, J. W., Hart, P. D'A., Nicholls, R. J., Rees, R. J. W., and Stock, J. A., *Brit. J. Pharmacol. and Chemotherap.*, 10, 73 (1955).

lton, J. D., *Ann. Trop. Med. and Parasitol.*, 38, 147 (1944).

BIOLOGY

Delayed-type Hypersensitivity in Premature Neonatal Humans

IT has been shown[1] that guinea pig embryos could be induced to develop the delayed-type of hypersensitivity[1]. The possibility that the premature new-born human could be similarly sensitized was therefore investigated. Successful sensitization of new-born humans to poison ivy has been reported[2].

Ten premature infants (average birth-weight 1,255 gm.) and five neonatal infants of normal weight were sensitized percutaneously during the first week of life with 0·02–0·04 ml. of a 10 per cent solution of 2,4-dinitrofluorobenzene in acetone. As controls, five infants between the ages of 2 and 12 months were similarly sensitized. 2–4 weeks later patch-testing was carried out with 0·01 molar 2,4-dinitrofluorobenzene in corn oil–acetone. The patches were removed at 48 hr., at which time the reactions were read.

Table 1. CONTACT SENSITIVITY TO 2,4-DINITROFLUOROBENZENE IN HUMAN INFANTS

Group	Contact reactions	
	2 weeks*	3–4 weeks*
Infant (2–12 months)	5/5	Not done
Full-term neonatal	1/4	2/5
Premature neonatal	2/10	3†/10

* Time after sensitization.
† Birth-weights were 1,390, 1,060 and 1,650 gm. The first two of these infants received two sensitizing doses nine days apart.

As can be seen in Table 1, this sensitization procedure induced contact skin reactivity in all five of the older infants, two of five normal neonatal infants and three of ten premature new-born infants. The positive reactions of the neonatal infants appeared similar to those elicited in the older infants, but were usually less intense. There was no detectable relationship between the weight of the premature neonatal infant and its capacity to be sensitized. This is strikingly illustrated by one of the smallest infants in the experiment, who weighed 1,080 gm. at birth (indicating a gestation period of approximately 30 weeks) and yet showed a contact reaction at age three weeks. Moreover, the neonatal infants of normal weight did not appear to become sensitized any more readily than did the premature new-born infants.

Punch biopsy of a representative contact reaction at 48 hr. was performed in a premature infant. Histological examination of serial sections revealed an accumulation of lymphocytes and histiocytes in the dermis with invasion of the epidermis and resultant

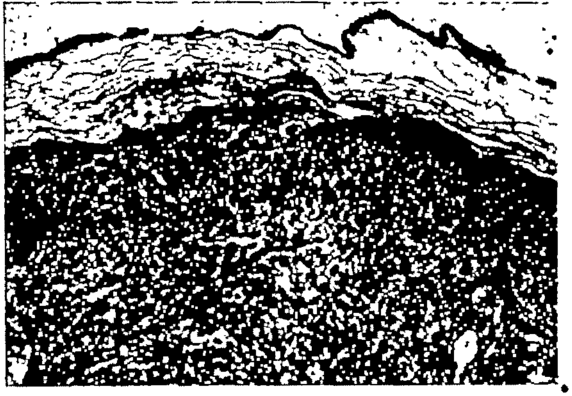


Fig. 1. Contact reaction at 48 hr. in a premature neonatal infant, three weeks of age. Hematoxylin and eosin. (× 200)

loss of the basement membrane (see Fig. 1). Microvesicles, spongiosis and an increase in mitosis were seen in the epidermis. The histology is consistent with that seen in contact dermatitis in the adult[3]. Patch testing 2–6 weeks after birth of unsensitized neonatals (six premature and six full-term) gave negative results. Punch biopsy with histological examination of a patch test area at 48 hr. in an unsensitized premature neonatal, aged three weeks, also failed to show an inflammatory reaction.

Our findings show the following striking similarities to previous work on antibody formation in new-born infants[4]: (*a*) delayed-type hypersensitivity and antibody formation can both be induced in premature infants during the first month of life; (*b*) new-born infants are inconsistent in their capacity to develop these two types of immune response; (*c*) premature infants become sensitized and form antibodies as efficiently as normal new-born infants.

This work suggests that the older human fœtus might be capable of an immune response if an appropriate antigenic stimulation could be administered *in utero*. The possibility is not excluded, however, that separation from the placenta is an essential step in the maturation of the immune mechanism.

We thank Dr. Philip Prose, of the Department of Pathology, for his assistance in the processing and interpretation of the skin biopsies.

This work was aided by grants from the Association for the Aid of Crippled Children, the National Institutes of Health (*E* 1821 (*C*-2)) and the Commission on Immunization of the Armed Forces Epidemiological Board.

JONATHAN W. UHR
JOSEPH DANCIS
CHARLOTTE GRANTZ NEUMANN

New York University School of Medicine,
and Bellevue Hospital,
New York.

[1] Uhr, J. W., *Nature*, 187, 957 (1960).

[2] Straus, H. W., *J. Allergy*, 2, 137 (1931).

[3] Allen, A. C., in "The Skin", 204 (C. V. Mosby Co., St. Louis, 1954).

[4] Dancis, J.; Osborn, J. J., and Kunz, H. W., *Pediatrics*, 12, 151 (1953).

The Polychæte Family Longosomidae in New Zealand

IN 1944 Hartman[1] described a new polychæte species *Longosoma catalinensis* from off Long Point, Catalina Island, southern California, founding a new family, the Longosomidae, to contain it. The original description was based on a single specimen, but afterwards in 1957 she reported 34 specimens from three stations off southern California in depths of 7–45 fathoms. According to Hartman[2] the species may have its affinities with the Paraonidae; but the possession of long, paired, grooved palpi, resembling those of spioniform annelids, allies it to the disomid and magelonid families.

The genus and family have not been recorded to date from other than the original locality, hence it was of great interest to obtain specimens of a polychæte, which at first were thought to be specifically identical with *L. catalinensis*, from such a distant locality as Hawke's Bay, New Zealand. The New Zealand specimens, numbering 27, were obtained in August 1956 from twelve stations, in depths of 8–64 fathoms, by Dr. D. Hurley of the New Zealand Oceanographic Institute, and I am indebted to him for the opportunity to report on this interesting discovery. On a recent visit to California, the New Zealand specimens were compared with the type of *L. catalinensis* and Dr. Hartman agrees that the differences justify the founding for them of a new species of the genus *Longosoma*. As in *L. catalensis* they have the body divided into an anterior region of nine short setigerous segments and an abdomen with greatly prolonged cylindrical segments, the abdominal parapodia consisting of ridges with double rows of simple setæ. The New Zealand species differs in its larger size, the largest posteriorly incomplete specimen of *L. catalinensis* with four abdominal segments measuring 25 mm., whereas a comparable specimen of the former measures 55 mm. They are also much more robust, with the thorax measuring up to 3 mm. across, and with the thoracic setæ heavier and more numerous. The proportionate length of the abdominal segments also differ, but the greatest difference is to be seen in the arrangement of the abdominal parapodia. In *L. catalinensis* the abdominal parapodia are low ridges encircling two-thirds to three-quarters of the body and leaving the ventrum plain, while in the New Zealand species the ridges are much more prominent and completely encircle the body. A full description of the species will be published separately.

It is of interest to note that Hartman records her specimens from similar depths in very fine sand and silt and in temperatures of about 14·9° C. The bottom sediments from the stations where the New Zealand specimens were obtained are recorded as ranging from fine grey sands to fine sandy muds with bottom temperatures in the region of 13·0–13·3° C. According to Hartman, *L. catalinensis* is associated with other polychætes, a maldanid, *Axiothella rubrocincta* (Johnson) and a nephthyid *Nephthys ferruginea* Hartman, and a cumacean, probably *Diastylopsis tenuis* Zimmer. Some thirty-six species of polychætes have been recorded from Hawke's Bay in association with *Longosoma*, among the dominant being a nephthyid, *Aglaophamus verrilli* (McIntosh), and two species of maldanids of the genus *Asychis*. Other dominants include the cumaceans *Diastylopsis elongata* Calman and *D. crassior* Calman (belonging to the same genus as the cumacean associated with *L. catalinsis*), the holothurian *Cucumaria ooonoides* (Dendy), ophiuroids of the genus *Amphiura* and the bivalves *Dosinia lambata* (Gould) and *Maorimacta ordinaria* (Smith).

The present recorded distribution of the family Longosomidae, southern California and northern New Zealand, represents a very disjunct distribution. In both localities the representatives of the family are not uncommon, and it is therefore surprising that it has not been recorded elsewhere. Additional distributions will, however, probably be recorded when similar shallow bottom areas of the Pacific basin are studied in detail, as has been done for the areas off southern California and Hawke's Bay, New Zealand. It is of interest that similar techniques were used in processing the bottom samples from the two regions. A similar disjunct distribution is recorded for the species of the echiuroid genus *Urechis*, which has been recorded from southern California, southern Chile, New Zealand, and Japan[3].

G. A. KNOX

Department of Zoology,
University of Canterbury,
Christchurch,
New Zealand.

[1] Hartman, O., Rep. Allan Hancock Pacific Exped., 10, 321 (1944).

[2] Hartman, O., Rep. Allan Hancock Pacific Exped., 15, 335 (1957).

[3] Knox, G. A., *Trans. Roy. Soc. N.Z.*, 85, 141 (1957).

Mouth and Blastopore

By the Haeckelian view of early development, gastrulation by invagination reflects the evolutionary history of primitive Metazoa. It is a corollary of this theory that gastrulation by ingression is a derived form of emboly. Nevertheless ingression, the method of endoderm formation among the lower cnidarians, is probably the more primitive mode of gastrulation, as observed by Metschnikoff[1,2], Hyman[3,4] and others. The diploblastic level of organization probably arose in early Metazoa by a process resembling ingression, or some other type of delamination, giving rise to solid planula-like forms. It is therefore probable that invagination is merely a developmental expedient, which has arisen secondarily and independently in the more advanced Cnidaria and other metazoan groups.

The blastopore results from invagination, narrowing as gastrulation progresses. In keeping with Haeckel's interpretation, it is generally thought to represent the primitive mouth. It may nevertheless be merely a product of the mechanics of development, without especial phylogenetic significance. The Cnidaria in which gastrulation occurs by ingression, while possessing a mouth and coelenteron, have no blastopore or archenteron during development. It appears from the embryology of these coelenterates that mouth and blastopore were independently acquired in early Metazoa. Furthermore, a mouth may have formed before the origination of embolic gastrulation and a blastopore. Following the evolution of embolic gastrulation, the blastopore preceded the mouth in embryonic development, for it relates to the fundamental process of germ-layer formation. Similarly, it appears that enteron and archenteron were independently evolved. Terms such as protostoma, Protostomia and archenteron are therefore strictly inapt.

The mouth in some non-coelomate animals and Protostomia does not coincide with the blastopore or its point of closure. Also, in many higher coelenterates, non-coelomate groups and Protostomia the blastopore does not persist as a mouth, but closes before the mouth forms. This possibly signifies the evolutionary independence of the two structures.

It is generally agreed that the embryonic axis corresponds with the polar axis of ancient Metazoa, the animal pole representing the primitive perceptive and dominant region, directed forward in locomotion. Biologists who support the ingression theory, but identify the blastopore with the primitive mouth, believe that the mouth arose at the more inert end in a solid, diploblastic ancestral metazoan. This entails the puzzling conception of a structure for the selection and ingestion of food separated from the dominant, sensitive region of the body. It seems more probable that the mouth originally occupied an antero-ventral position.

In coelenterates the mouth typically forms at the posterior end of the swimming larva, in the blastoporal region when gastrulation is by emboly, and does not change position during development. This may be a special feature correlated with the sessile habit of the polyp.

Typically, in cases of gastrulation by invagination, the gastrula presents two centres of high metabolic activity of different kinds: the animal pole, corresponding with the controlling and perceptive region of original Metazoa and larval forms; and the blastopore, a zone of rapid cell division, and a focus of developmental activity and organization. Among the Protostomia, the mouth arises in the blastoporal field, later coming to occupy an antero-ventral position. The mouth thus develops in a region of high formative activity, and may form from the blastopore, a ready-made aperture. This may be merely a developmental convenience. (By a similar short cut in development, in some Protostomia and Deuterostomia a persistent blastopore forms the anal opening.) In the embryonic development of many annelids, the blastopore elongates and constricts into two. One of the apertures so formed, the mouth, separates to its definitive ventral anterior position. The second aperture, remaining at the vegetal pole, soon closes. The anus later arises at this point. The division of the blastopore has been interpreted as separation of the mouth from a transitory anal pore. It more probably represents dissociation of the mouth from the blastopore.

Among the Deuterostomia, the mouth typically originates at an antero-ventral point. This is believed to indicate that the mouth has evolved anew and assumed the function of the primitive mouth, homologous with the blastopore. It is more probable that the mouth in the Deuterostomia occupies the original position, and the blastopore at no time functioned as mouth.

JOAN B. WILLIAMS

London School of Hygiene
and Tropical Medicine,
Keppel Street, London, W.C.1.

May 11.

---

[1] Metschnikoff, E., *Z. Wiss. Zool.*, 36 (1882).

[2] Metschnikoff, E., "Embryologische Studien an Medusen" (1887).

[3] Hyman, L. H., "The Invertebrates". 1. "Protozoa through Ctenophora" (New York and London, 1940).

[4] Hyman, L. H., *Biol. Symposia*, 8, 1 (1942)

Softening Chitin for Histology

The chitinous integument of many invertebrates consists not of chitin alone but also incorporates much structural protein. In the more highly sclerotinized arthropod shells, indeed, this may far exceed the true chitin. The methods frequently used for softening 'chitin' for histological purposes make use of this fact, and none of them actually alters the chitin itself, acting instead on the protein moiety of the integument. 'Diaphanol', for example, the most widely used agent for softening 'chitin', acts by breaking benzene rings in the aromatic amino-acid residues of the proteins[1]. Inevitably such an action is accompanied by extensive damage to the tissues of the specimen, for not only is the protein of the skeleton digested but also the proteins of the tissues which we wish to examine. The use of diaphanol, or of other agents which digest the protein moiety of the chitinous integument, is therefore incompatible with precise histological or cytological investigation. If the integument consists mainly of structural protein, then we have no way out of the dilemma except to dissect the tissues free from all traces of the offending shell. If, however, as in the less-sclerotinized shells, it consists chiefly of true chitin, then it is possible to attack the chitin enzymically, leaving the tissues untouched.

Possibly the best source of a suitable chitinase is the unripe puff-ball, *Lycoperdon* spp. Tracey[2] advocates this source of the enzyme for biochemical analysis. He suggests that the puff-balls should be torn up and pressed to yield a juice which, when buffered at pH 5 with acetate buffer, will readily digest chitin. This juice may be stored for a year or more in a refrigerator under toluene. I have used this extract for softening chitin for histological purposes, but it contains also a number of other enzymes which damage the tissues that are under examination. Moreover, puff-balls are not readily obtainable. The common mushroom of commerce also contains large amounts of chitinase, and may be obtained at any time of year. The extraction outlined below may be applied to either mushrooms or to puff-balls, and yields a liquid which will keep for a year or more in the refrigerator and is relatively free from other enzymes that might detract from its histological usefulness.

100 gm. mushrooms are roughly torn up and steeped overnight in 100 ml. 35 per cent w/v sodium chloride solution. The chitinase is soluble in this saline, while most of the other enzymes are salted out and are present in the residue which is centrifuged off. This stock solution may be kept in the refrigerator without the addition of any preservative, as the salt concentration is above the limit for bacterial or fungal growth. For use it is diluted to an appropriate salt concentration either with acetate buffer at *p*H 5 or more simply with distilled water, relying on the atmospheric carbon dioxide to produce approximately the correct *p*H. For marine organisms a dilution of 1 : 10 seems appropriate, giving a solution nearly isotonic with sea water. The fixed specimens are washed well with running tap-water overnight to remove the last traces of the fixative, which might inactivate the enzyme. They are then incubated with the diluted enzyme preparation for 12–24 hr. at 37°. A little toluene may be added to prevent bacterial action, particularly if the chitin is thick and it is desired to continue incubation for a longer period. After incubation the specimens may be prepared for sectioning in the usual way. This technique has proved successful with the copepod *Calanus*, the prawn *Palaemon* and the insect *Locusta*. It is useless with heavily sclerotinized integuments, which have a high protein content and low chitin content.

D. B. Carlisle

The Laboratory,
Citadel Hill,
Plymouth.

---

[1] Kennaugh, J., *Nature*, 180, 238 (1957).

[2] Tracey, M. V., in Paech, K., and Tracey, M. V., "Modern Methods of Plant Analysis", 2 (Springer-Verlag, Berlin, 1955).

An Improved Feed for Experimental Fish

It is well known that minced liver is an excellent food for brown trout (*S. trutta*) kept under hatchery conditions or under experimental conditions in aquaria[1]. In aquaria with a low water-flow the minced liver very quickly fouls the water. It has been found that if the liver is mixed with gelatine this difficulty can be avoided. As many workers now use these fish as experimental animals, it is felt that it would be useful to publish this fact.

The minced liver, previously salted with 5 gm. of salt per pound of liver, is mixed with 120 c.c. of a 33 per cent solution of gelatine. The whole is allowed to set and then reminced before feeding.

D. R. Swift

Freshwater Biological Association,
The Ferry House,
Ambleside, Westmorland.

---

[1] Brown, M. E., *J. Exp. Biol.*, 28, 473 (1951).

Survival of Woody Plants at Extremely Low Temperatures

There are a number of things that should be pointed out in connexion with the communication by A. Sakai[1]. Various kinds of plant material have been cooled to these temperatures and even lower, yet they have survived[2–4]. My own work[5] revealed that leaves of *Pinus strobus* could be cooled to −90° C. in winter without apparent damage, and it was later shown that leaves of this same species could be cooled to −189° C. without damage as indicated by the tetrazolium test made several days after treatment[6,7]. Recently I have cooled buds of various deciduous trees to −80° C. at the rate of cooling and warming indicated in Table 1, and although some survived, others did not.

Table 1. Cold Resistance* of Tree Foliage in Deg. C. at New Haven, Connecticut, in January

Rate of cooling about 4° C. change per hr.; rate of warming about 8° C. change per hr. Most plants became still hardier in February

Plant	Origin	Resistance* ° C.
Abies guatemalensis†	Costa Rica	−6
Cupressus lusitanica†	Costa Rica	−10
Cryptomeria japonica	Japan	−20
Pinus palustris†	Northern Florida	−25
Ilex opaca	unknown	−35
Chamaecyparis pisifera	Japan	−42
Taxus baccata	unknown	−42
Tsuga canadensis	New Haven, Conn.	−45
Juniperus virginiana	Branford, Conn.	−52
Picea excelsa	Germany	−58
Tsuga canadensis	Branford, Conn.	−58
Pinus sylvestris†	Germany (?)	−62
Pinus strobus	New Haven, Conn.	> −189

* The lowest temperature which the leaves could withstand without being killed.

† Seedlings 1 to 6 years old.

I thus feel that Sakai's findings are generally in accord with my own and those of others. On the other hand, one gains the impression from Sakai's communication that if a plant can be cooled to −30° C. without damage it can be cooled on down far below this without any damage. Yet the winter resistance of several conifers can range all the way from a few degrees below freezing to below −189° C. (Table 1). But the rates of cooling and warming are most important in such work and should not be changed.

Finally, it should be understood that nearly any criterion of life or death can be at fault if not used in the correct way. Several days after the treatment is made, the tissue may die while controls survive. This error is particularly involved in plasmolysis tests which indicate the intactness of the outer vacuolar membranes but do not prove that the cytoplasm itself has not been injured. Judging by the tetrazolium test, enzymes may become less active over a period of time and finally show no activity, while untreated cells continue to reduce tetrazolium salts. The more severe the injury the more rapidly this change comes about after warming. In our experiments the time-lag effect in dying is a serious source of error in cold-treated leaves. Some leaves which survived in a moist chamber at 22° C. for two weeks died in the third week, while controls survived for at least three months.

Johnson Parker

Greeley Memorial Laboratory,
Yale University School of Forestry,
New Haven, Connecticut.

---

[1] Sakai, A., *Nature*, 185, 393 (1960).

[2] Luyet, B. J., 8me Cong. Int. de Bot., Sec. 11 and 12, 259 (1954).

[3] Becquerel, P., 8me Cong. Int. de Bot., Sec. 11 and 12, 260 (1954).

[4] Sun, C. N., *Bot. Gaz.*, 119, 230 (1958).

[5] Parker, J., *For. Sci.*, 5, 56 (1959).

[6] Parker, J., Ninth Int. Bot. Congress, 2, 296 (1959).

[7] Parker, J., *Bot. Gaz.*, 121, 46 (1959).

JENSEN[1] has also claimed that the ability to plasmolyse in onion cells is not a reliable index to their viability, because he observed some abnormal cells in which vacuoles were normally stained by neutral red solution and tonoplasts still retained their permeability, having the cytoplasmic layers torn outside the tonoplasts. In a previous report[2] I stated that such abnormal cells have not yet been observed during several years study in the parenchyma cells of the cortex in woody plants, but some parenchyma cells are found in which the ectoplasts still retain their semi-permeability though their tonoplasts are torn and their cytoplasmic layers are mixed with vacuolar content (see plate1,2 ref. 2) However, such abnormal cells are easily distinguishable from the normal by their appearance. Thus, in the parenchyma cells in twigs of woody plants, unlike the case of onion cells, it may be possible to determine the relative degree of viability in parenchyma cells, upon the basis of both their vital staining with neutral red solution and the appearance of plasmolysed cells, at least in one and the same series of experiments. However, judging[3] of the intactness of twig as a whole cannot be made only on the basis of plasmolysis test in parenchyma cells just subsequent to, or even after, many days of thawing, because inner cortex, pith ray, and pith periclinal tissue are less resistant to freezing than parenchyma cells of cortex. Accordingly, to demonstrate the intactness of a treated twig as a whole, it was planted in moist sand and its capacity tested to continue normal development at least for three months after planting, as mentioned in my reports[4]. Even in the tetrazolium[5] test used by Parker, it may be said that judging the intactness in plants means only determination of a relative value of viability of certain tissues in twig or leaf without testing the whole of it as is done by the plasmolysis method.

In my previous communication in *Nature* (and ref. 4) it was stated that almost all the easily freezable water in a cell may be drawn from the cell interior by extracellular freezing at about −30° C., and that the cells and tissues in this state are not injured even when immersed directly in liquid nitrogen, provided they can sufficiently withstand such pre-freezing at −30° C. Moreover, it was reported that below this temperature the intensity of cold seems not to exert any important effect upon woody plants, at least as long as the intense cold does not extend over a long period. Against this view, Parker has pointed out that one gains the impression from my article that if a plant can be cooled to −30° C. without damage, it can be cooled down far below this without any damage. As a result of Parker's experiment the winter resistance of several conifers could range all the way from a few degrees below freezing to below −190° C.

In the pre-freezing method, to cool plant material to −30° C. does not mean that the temperature of the material only reaches −30° C., but that its material attains at least the state of equilibrium at −30° C. and the state in which almost all the easily freezable water in a cell is drawn from the cell interior. To assure this condition, in the case of freezing in comparatively large material as a twig, I pre-froze it for 16 hr. (overnight) in all cases as mentioned in previous papers[4,6]. In the cooling method used by Parker, when a certain temperature-level was reached in the flask containing a shoot from branch, the flask was removed from the chilling apparatus, then rewarmed. In such cooling method, even if plant material is cooled to −30° C., it is doubtful whether almost all the freezable water in the cell interior can be drawn out or not within such short period of time.

The grade of frost resistance of a woody plant differs according to the manner in which it is estimated. If the grade of frost-resistance is represented by the lowest temperature at which the twigs are able to survive freezing for an hour, especially when the cooling-rate in a temperature-range below −30° C. is comparatively slow as 4 deg. C./hr., there can be found fairly great differences in the grade of frost injury in the twigs treated at an arbitrary different temperature below −30° C. This is particularly the case of less hardy species. However, when the grade of frost resistance is represented by the minimum temperature at which the twigs are able to survive freezing for a full day, there is found, in many cases, scarcely any difference in the grade of frost resistance between the material treated at −30° C. and that at −70° C. (ref. 7). It may be said, therefore, that the discrepancy between our two points of view is due mainly to the difference in the manner of representation of the grade of frost resistance. However, to clarify this problem, it seems necessary to continue further work in many woody plants.

AKIRA SAKAI

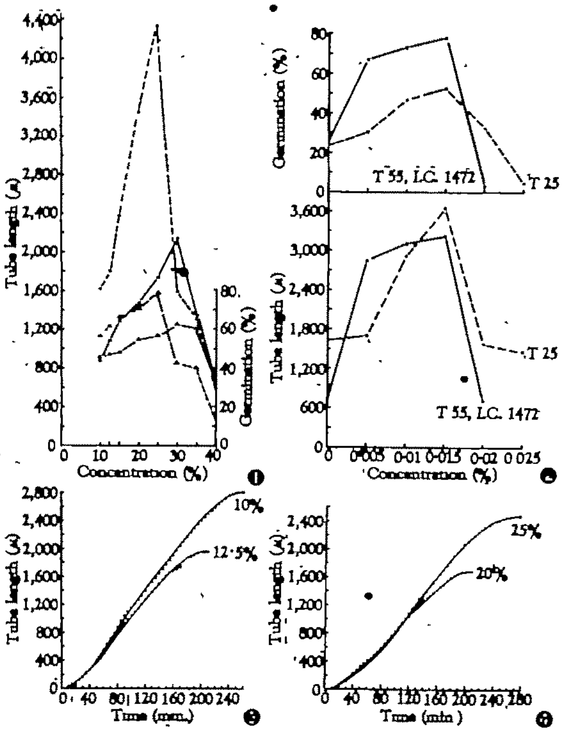
Institute of Low Temperature Science,
Hokkaido University,
Sapporo, Japan.

[1] Jensen, A. B., *Protoplasma*, 36; 195 (1942).
[2] Sakai, A., *Low Temp. Sci.*, Ser. B., 17, 21 (1959).
[3] Sakai, A., *Low Temp. Sci.*, Ser. B., 13, 43 (1955).
[4] Sakai, A., *Low Temp. Sci.*, Ser. B., 14, 17 (1956).
[5] Parker, J., *Bot. Gaz.*, 121, 46 (1959).
[6] Sakai, A., *Nature*, 185, 393 (1960).
[7] Sakai, A. (unpublished work).

Pollen Germination in some Gramineae: *Pennisetum typhoideum*

POLLEN of grasses is notoriously difficult to culture, and even in Nature fertilization usually fails if pollen is not transferred directly from the anthers to the stigma[1,2]. Several previous attempts to germinate the pollen grains of the Gramineae have been unsuccessful[1–4]. In this laboratory attempts were made to germinate pollen grains of *Pennisetum typhoideum* (varieties *T*.25 and *T*.55, *I.C*.1472), *Zea mays* (*T*.41 var. Kanpur) and several varieties of *Hordeum vulgare*, *Sorghum vulgare* and *Triticum aestivum* by the hanging-drop technique (for details of technique see Vasil[7]). Best germination was obtained in *Pennisetum typhoideum*, while in the remaining plants pollen tubes longer than 600µ could not be obtained even after the addition of hormones, vitamins, mineral salts and stylar and ovarian extracts.

The pollen grains of *P. typhoideum T*.25 germinate within 10 min. of their inoculation in 10–40 per cent sucrose solutions and the optimum germination (62 per cent) occurs in 30 per cent sucrose where the tubes attain a length of 2,132µ (Fig. 1). With the addition of 0·01 per cent boric acid best growth is obtained in 25 per cent sucrose. In this medium 78 per cent of the grains germinate and the pollen tubes attain a length of 4,320µ (Fig. 1). Pollen grains of the variety *T*.55, *I.C*.1472 require lower concentrations of sugar: in 12·5 per cent sucrose there is 40 per cent germination and the tubes are 316µ long. Here also the percentage of germination is improved on the addition of 0·01 per cent boric acid, and



Figs. 1–4. *Pennisetum typhoideum*. Fig. 1, variety *T.*25, pollen germination and growth of tubes in different concentrations of sucrose supplemented with 0·01 per cent boric acid; for 3 hr. at 30° C. (——, without boric acid; – – –, with boric acid; ●, tube length; ▲, per cent germination). Fig. 2, varieties *T.*25 and *T.*55, *I.C.*1472, pollen germination and pollen tube growth in 25 per cent (*T.*25) and 12·5 per cent (*T.*55, *I.C.*1472) sucrose supplemented with different concentrations of boric acid; for 4 hr. at 29° C. Fig. 3, variety *T.*55, *I.C.*1472, growth curves of pollen tubes cultured in 10 and 12·5 per cent sucrose supplemented with 0·01 per cent boric acid; at 22° C. Fig. 4, variety *T.*25, same as in Fig. 3 but in 20 and 25 per cent sucrose with 0·01 per cent boric acid; at 18° C.

increases to 76 per cent while the tubes elongate to 3,125μ. The pollen tubes exhibit typical sigmoid growth curves (Figs. 3 and 4).

Among the various sugars tested, sucrose proved to be the best. In dextrose (with 0·015 per cent boric acid) the percentage of germination is 82, a figure higher than that in sucrose, but the length of the tubes is only 2,160μ.

The effect of boric acid is well marked in both the varieties (Fig. 2). In the pollen of *T.*55, *I.C.*1472, a concentration of 0·015 per cent boric acid with 12·5 per cent sucrose gives the best results (78 per cent germination and 3,216μ long pollen tubes). Higher concentrations prove toxic, and 0·02 per cent boric acid brings down the germination to less than 5 per cent and the tube-length to 702μ. Similarly, in the variety *T.*25, a concentration of 0·015 per cent boric acid with 25 per cent sucrose gives 53 per cent germination and 3,636-μ long tubes. Here satisfactory germination occurs with even 0·02 per cent boric acid, but concentrations higher than this cause a marked inhibition of germination as well as tube growth.

The pollen tubes grow very rapidly, show a high rate of protoplasmic streaming and attain a length of about 4,000μ or more during 2–4 hr. growth *in vitro*. Callose plugs develop frequently in the tubes, and in abnormal cases branching tubes were also recorded. Swelling of the pollen-tube tips and other morphological abnormalities are observed at higher temperatures and in supra-optimal concentrations of sucrose and boric acid.

To the best of my knowledge, this is the first report of a successful germination of the pollen of Gramineae *in vitro*. The length of pollen tube obtained here (4,320μ) is similar to that required to affect fertilization in Nature. The present work once again proves the vital and useful part played by boron in pollen germination and pollen tube growth.

I am grateful to Prof. P. Maheshwari and Dr. B. M. Johri for advice and encouragement.

I. K. Vasil

Department of Botany,
University of Delhi.
Delhi 6.

[1] Anthony, S., and Harlan, H. V., *J. Agric. Res.*, 18, 525 (1920).
[2] Nagao, S., and Takano, T., Comm. Papers, Thirtieth Anniver. N. Akemine, 88 (1938).
[3] Bair, R. A., and Loomis, W. E., *Science*, 94, 168 (1941).
[4] Loo, T., and Hwang, T., *Amer. J. Bot.*, 31, 356 (1944).
[5] Sen, B., and Varma, G., Proc. Forty-second Indian Sci. Congr. (Baroda), 261 (1955).
[6] Visser, T., *Meded. LandbHoogesch., Wageningen*, 55, 1 (1955).
[7] Vasil, I. K., *Amer. J. Bot.*, 47, 239 (1960).

Toxicity of Gibberellin to Seedless and Seeded Varieties of *Vitis vinifera*

Experiments in 1957 at the University of California showed that gibberellic acid (hereinafter referred to as gibberellin) affected set of fruit, berry size, elongation of cluster parts, fruit composition, and vegetative growth of grapes[1,2]. In the spring of 1958 delayed foliation and dead buds were noted on certain seeded varieties that had received high concentrations in 1957. Observations were therefore continued for two more seasons to determine the damage and to see whether production would return to normal.

The five seeded varieties, being similar in response, are represented here by Red Malaga, various vines of which were sprayed in 1957 with gibberellin at one of three stages (pre-bloom, full-bloom, and after berry shatter). Shoots and clusters were counted in April of 1958 and 1959, and crop weights were measured in September or October. Since the results were essentially alike, regardless of spray date, only the full-bloom spraying is represented here (Table 1). Gibberellin applied in 1957 decreased the shoot and cluster count in 1958 on vines that received 25 p.p.m., and significantly decreased crop weight on vines that received 5 or 25 p.p.m. By 1959, however, recovery was complete. A good yield in 1959 on vines that received 25 p.p.m. in 1957 was probably a result of the low crop in 1958. Thus, injured vines had recovered within two seasons.

The seedless varieties used were Thompson Seedless (Sultanina) and Black Corinth. On June 10, 1957

Table 1. Response of Red Malaga Grapes to Various Concentrations of Gibberellin Sprays applied on June 4, 1957

Concentration of gibberellin (p.p m.)	Shoot count (No. per vine) 1958	Shoot count (No. per vine) 1959	Cluster count (No. per vine) 1958	Cluster count (No. per vine) 1959	Crop weight (lb. per vine) 1958	Crop weight (lb. per vine) 1959
0	26·8	22·0	19	13	30·2	16·3
0·1	24·2	27·0	19	16	27·9	18·9
1	22·8	24·0	17	12	24·9	12·8
5	20·3	21·0	16	8	12·4	11·8
25	2·0	24·0	0	18	3·6	24·0
d 0·05	5·3	N.S.	3·9	N.S.	8·5	4·0

(after berry shatter), Thompson Seedless vines, four per treatment, were sprayed with gibberellin at 0, 5, 20, or 50 p.p.m. The same vines were similarly sprayed in 1958 and 1959 at the same physiological stage of development. Table 2 shows the harvest results for 1957 and 1959. Gibberellin at 20 and 50 p.p.m. produced greatly enlarged berries in 1958 but had much less effect in 1959, probably because the crop was unusually heavy. The percentage of total soluble solids (degrees Balling) in 1959 was typical of other years. This experiment shows that gibberellin is non-toxic to Thompson Seedless grapes.

Table 2. RESPONSE OF THOMPSON SEEDLESS GRAPES TO VARIOUS CONCENTRATIONS OF GIBBERELLIN SPRAYS APPLIED IN JUNE 1957

Concentration of gibberellin (p.p.m.)	Average weight fruit per vine (lb.) 1959	Average weight per berry (gm.) 1957	1959	Degrees Balling 1957	1959
0	19·5	1·59	2·30	22·4	22·2
5	32·1	1·91	2·62	23·2	22·6
20	37·1	2·71	2·89	18·9	21·4
50	44·3	3·15	2·59	17·6	17·3
d 0·05		0·13		0·7	

One Thompson Seedless and one Black Corinth vine, sprayed after flowering in two consecutive years, showed no visible injury from 1,000 p.p.m. and 100 p.p.m., respectively. Thus, high concentrations are non-toxic to the seedless varieties although far lower concentrations are highly toxic to the seeded varieties studied. A generalization must await tests with more varieties.

The difference between seeded and seedless grapes in sensitivity to gibberellin probably relates to differences previously noted[3,4]. Girdling shortly after flowering greatly enlarges seedless grapes but has little effect on seeded varieties[3]. Thinning, in contrast, ordinarily increases berry size in seeded grapes but not much in seedless grapes[4]. Gibberellin increases size of seedless fruit, but has little or no effect on seeded grapes. It is interesting, therefore, that natural gibberellins have been found in seedless, but not in seeded, varieties[5].

This work was supported in part by grants from Merck and Co., Inc., Rahway, New Jersey, and from Abbott Laboratories, North Chicago, Illinois.

ROBERT J. WEAVER

Department of Viticulture and Enology,
University of California,
Davis, California.

[1] Weaver, R. J., *The Blue Anchor*, 34, 10 (1957).
[2] Weaver R. J., and McCune, S. B., *Hilgardia*, 28, 297 (1959).
[3] Jacob, H. E., Univ. Calif. Agric. Ext. Serv. Circ. 56 (1931).
[4] Winkler, A. J., Univ. Calif. Agric. Exp. Sta. Bull. 519 (1931).
[5] Coombe, B. G., Ph.D. thesis, University of California (Davis) (1959)

ENTOMOLOGY

Breeding of the Rabbit Flea, *Spilopsyllus cuniculi* (Dale): Requirement of a 'Factor' from a Pregnant Rabbit for Ovarian Maturation

A STUDY of the biology of the European rabbit-flea (*Spilopsyllus cuniculi*) was commenced by this department when it became apparent that it was an important vector of myxomatosis in Great Britain. A technique for the laboratory culture of the flea was required, but was not rapidly forthcoming. It was repeatedly found that fleas released on domestic or wild rabbits kept in various types of hutches failed to produce eggs. However, Miriam Rothschild[1] reported that the flea bred when rabbits were kept under semi-natural conditions in an outdoor enclosure, and with her encouragement a study was made of ovarian development in the flea (Mead-Briggs, A. R., unpublished work).

Recently we found that if the fleas were placed on pregnant does the ovaries of the fleas matured and eggs were laid in the nest shortly after the young were born, whereas the ovaries of fleas kept on non-pregnant rabbits did not develop. In one experiment to follow the maturation of the ovaries up to ovulation, thirty-five female and twenty-five male virgin fleas were released on each of four rabbits housed in similar two-compartment hutches, one compartment being dark for nesting. The rabbits were: (1) a non-pregnant adult doe; (2) a doe pregnant 1–2 days; (3) a doe pregnant 11 days; (4) a doe pregnant 20 days. Samples of three female fleas were removed periodically (after a minimum of 10 days on the rabbits), and the reproductive systems dissected out. The degree of development of the ovaries was assessed by measurement of the length of the proximal oocyte follicle in one of the ovarioles. (In one individual there is little variation in this dimension between the several ovarioles until shortly before ovulation; then the final stage of egg maturation and subsequent ovulation occurs in only half the ovarioles at a time (Mead-Briggs, A. R., unpublished work).)

The results for fleas from rabbits 1 and 2 are shown in Fig. 1, each point being a mean obtained from the measurement of three dissected specimens. The absence of change in size (from that of immaturity) of the first oocyte follicle of the fleas kept for up to 28 days on the non-pregnant rabbit is contrasted with the increase occurring among fleas fed on the pregnant rabbit.

The rate and period of growth of the ovaries of the fleas fed on the three pregnant rabbits is indicated in Fig. 2. Maximum development is reached at the time of parturition when the fleas immediately leave the adult and are to be found only in the nest or on the nestlings. Development of the ovaries appears to commence about 10 days prior to parturition although the size of the eggs produced may be influenced by

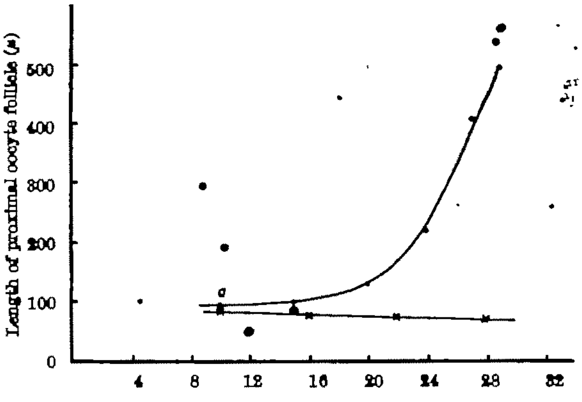


Fig. 1. Development of proximal oocyte follicle of fleas fed on pregnant and non-pregnant rabbits. Point *a* corresponds to the eleventh day of pregnancy. ●, Fleas from rabbit 2; ×, fleas from rabbit 1

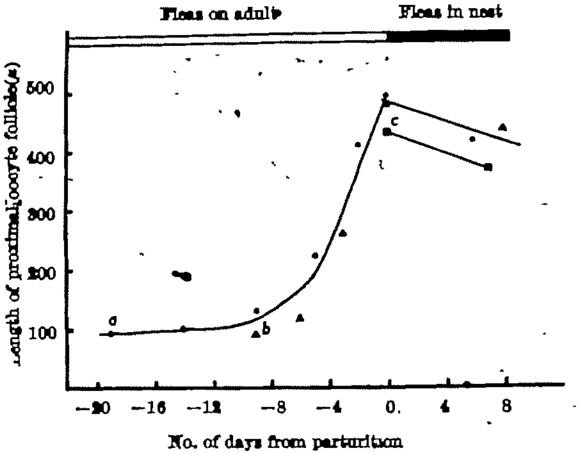


Fig. 2. Development of proximal oocyte follicle of flea related to time of parturition by host. Points *a*, *b* and *c* correspond to stage of development after 10 days feeding on respective rabbit. ●, Fleas from rabbit 2; ▲, fleas from rabbit 3; ■, fleas from rabbit 4

the feeding life of the flea. Thus fleas from rabbit 4 which could only feed for 10 days before commencing egg laying had relatively small eggs (although they were fully fertile) compared with fleas that fed for 19 and 29 days (rabbits 3 and 2 respectively).

At present the nature of the factor initiating ovarian development of the fleas fed on pregnant does is uncertain. Various controls have precluded it being related to nest-building habits by the pregnant rabbits. A likely hypothesis is that it is a factor, perhaps nutritional, present only in the blood of a pregnant rabbit and perhaps only at the required level during the later stages of pregnancy. Buxton[2] compared the production of eggs by *Xenopsylla cheopis* when fed on baby and adult mice and found that with the baby mice eggs were produced in smaller numbers and only after an unusual delay. He suggested this might result from the lack of mammalian sex hormones normally obtained in the blood of adult mice.

Wigglesworth[3] has shown that in a number of blood-sucking arthropods a small amount of hæmoglobin is absorbed into the hæmolymph without digestion, and some of this hæmoglobin is transferred with little change to the yolk of the developing eggs. He concluded that some of the normal protein constituents of egg yolk may perhaps be formed elsewhere in the insect body and merely transmitted to the yolk via the follicle cells and not synthesized in them. This could be the case in fleas which have simple, panoistic ovarioles lacking any trophic tissue other than the follicle epithelium. While flea eggs do not contain any pigmented hæmoglobin derivatives, variation in the serum proteins of the host could be important. Hence, in the present case, it may be significant that Brambell *et al.*[4] found marked differences between the sera of non-pregnant, adult rabbits and rabbits 25 days pregnant, both in respect of the total protein concentration and, in the proportions of the components.

So far as we are aware *Spilopsyllus cuniculi* is the only flea shown to require a pregnant host for egg maturation, but failures to breed a few species of flea in captivity may indicate others have similar requirements. The most important result of this mechanism which produces perfect synchronization between maturation of eggs by the flea parasite and parturition by the host is that the eggs are immediately ready to be laid in a microclimate ideal for further development provided by the rabbits' breeding nest.

A. R. Mead-Briggs
A. J. B. Rudge

Ministry of Agriculture, Fisheries and Food,
Infestation Control Laboratory,
Tangley Place,
Worplesdon,
Near Guildford,
Surrey.

[1] Rothschild, M., *Entomologist*, 90, 204 (1957).

[2] Buxton, P. A., *Parasitol.*, 39, 119 (1948).

[3] Wigglesworth, V. B., *Proc. Roy. Soc.*, B, 131, 313 (1943).

[4] Brambell, F. W. R., Hemmings, W. A., Henderson, M., and Kekwick, R. A., *Proc. Roy. Soc.*, B, 141, 300 (1953).

Experimental Breeding of *Anopheles gambiae* Giles in Papyrus Swamps

In Uganda, *Anopheles gambiae* Giles does not breed in the interior of papyrus swamps, in their natural, undisturbed state. But a considerable amount of breeding may occur at the periphery, outside the papyrus zone, particularly in hoof-prints, cattle-drinking places, and open natural pools[1]. Also, where papyrus swamps have been drained and the land used for cultivating such crops as *Colocasia*, larvæ may be found in the shallow, sunlit pools between cultivation-mounds. On the whole, the swamps are not a potent source of malaria[2].

The composition and nature of the breeding water have a twofold influence on the mosquito, affecting not only the larvæ present in the water, but also the gravid adult female looking for a place to deposit its eggs[3]. However, although it seems quite clear that the ecological distribution of larvæ in Nature is largely a result of the different oviposition habits of the adult mosquito[4], it is also generally accepted that the absence of mosquito larvæ from a particular breeding place admits of two alternative interpretations: either (*a*) the females do not oviposit there at all; or (*b*) they do rather indiscriminately and that larvæ will develop in certain types of water and not in others. The preliminary observations reported in this communication were made to investigate alternative (*b*), that is, whether the absence of *A. gambiae* larvæ from the interior of papyrus swamps, in Uganda, is because they cannot develop in such habitats.

The observations were made in two papyrus swamps near Kampala. Cages made of nylon gauze or from iron drums were planted in the swamps. All predators were removed or prevented from entering the cages. This made the breeding conditions less natural; but it excludes the factor of predators from consideration of the results. Larvæ of *A. gambiae*, in various stages of development, were then placed in swamp water, in the cages, and all adults emerging afterwards were recorded and removed. The results of seven experiments are summarized in Table 1. Experiments 1 and 3 were made at the periphery of the swamp, just outside the papyrus zone; 5, just inside the papyrus zone; 4, 6 and 11, inside the swamp among tall papyrus and under considerable shade; and 10, inside the swamp, but in an exposed previously cut papyrus area.

Table 1 shows that 93·7 per cent of the 1,120 *A. gambiae* larvæ introduced into the papyrus swamps

Table 1. RECOVERY OF ADULT *Anopheles gambiae* GILES FROM LARVAE PLACED IN PAPYRUS SWAMPS

Exp. No.	No. and stage (in brackets) of larvae	Days since larvae were placed in swamp		Total of adults emerged	
		First adult emergence	Last adult emergence	No.	Percentage
1	140 (I, II, III, IV)	3	20	30	21·4
3	100 (I)	26	28	3	3·0
4	140 (I, II, III, IV)	4		1	0·7
5	140 (I, II, III, IV)	3	23	7	5·0
6	200 (I, II, III, IV)	8	8	12	6·0
10	200 (IV)	3	9	10	5·0
11	200 (IV)	5	8	7	3·5

Totals: Larvae, 1,120; adults emerged, 70, that is, 6·3 per cent.
(N.B. In column 2, the numbers are totals of all the respective stages shown.)

did not complete their development to the adult stage. The detailed records indicate a very high mortality among the early stages. Generally, it would thus seem that the interior of papyrus swamps is extremely unfavourable for the development of *A. gambiae* larvae. Also, the duration of the larva–adult period appeared to be considerably longer than one usually finds in the favoured natural breeding places.

The water in papyrus swamps is characterized by a very high degree of organic pollution and by extreme deoxygenation[5,6]. It has been suggested that suitable larval food is absent from swamp waters[7] and that the middle of the swamp does not provide breeding facilities for *A. gambiae*, owing to the high degree of organic pollution of the water which obtains there[1]. Several authors have directed attention to the absence of larvae from water with large organic content[8]; although Harvey and Symes[9] report to the contrary. It is also known that *A. gambiae* may tolerate a considerable degree of animal pollution, but it is very sensitive to organic pollution of vegetable origin[3]. Pollution in papyrus swamps is caused by decaying vegetation, and *A. gambiae* would thus be very sensitive to it. The view that an increase in the proportion of organic matter in natural breeding-places slows down the development of *A. gambiae* larvae[10] is supported by the present observations. But, how far the predominantly anaerobic conditions of the swamp waters affected the results of our observations is not very clear. Since the larvae depend on atmospheric air and are not forcibly prevented from periodically rising to the surface to breathe, lack of oxygen in the medium is not a respiratory problem. But it can influence the length of time during which the larvae are submerged and this seems to be ecologically important.

L. K. H. GOMA

Nuffield Swamp Research Scheme,
Department of Zoology,
Makerere University College,
Kampala,
Uganda.

[1] Hopkins, G. H. E., *E. Afr. Med. J.*, 17, 189 (1940).
[2] Goma, L. K. H., *Bull. Ent. Res.*, 51 (in the press).
[3] Muirhead-Thomson, R. C., "Mosquito Behaviour" (Arnold, 1951).
[4] Bates, M., "The Natural History of Mosquitoes" (Macmillan, 1949).
[5] Carter, G. S., "The Papyrus Swamps of Uganda" (Heffer, 1954).
[6] Beadle, L. C., *J. Exp. Biol.*, 35, 556 (1958).
[7] Hancock, G. L. R., *J. Anim. Ecol.*, 3, 204 (1934).
[8] de Meillon, B., "The Anophelini of the Ethiopian Geographical Region", Pub. S. Afr. Inst. Med. Res., 10 (1947).
[9] Harvey, D., and Symes, C. B., *Bull. Ent. Res.*, 22, 59 (1931).
[10] Holstein, M. H., "Biology of Anopheles gambiae", W.H.O. Monogr., No. 9 (1954).

Taxonomic Significance of Spermathecal Structure in Some Species of *Tribolium*

RECENT examination of spermathecae in tenebrionid beetles associated with stored products has revealed that there are two distinct types of structure which are termed here the 'tenebrio' type and the 'chamber' type. Their basic plan and relationship to the rest of the female reproductive system are similar; but there are certain differences which, in regard to the genus *Tribolium*, are considered to be of some phylogenetic significance. In both types a duct of varying width and length, which terminates in the main sperm storage region, arises from the common oviduct. In *Tenebrio molitor* this duct is short and wide and ends in a group of convoluted, thin-walled tubes bound together by a tough membrane. Arising from their common base is a single, longer structure which may be glandular, having large-celled walls and a restricted lumen. Dissection of fertilized females has shown that the convoluted tubes carry sperm. In the chamber type, found in *Gnathocerus*, *Alphitobius*, *Alphitophagus* and some *Tribolium* species, there is a similar duct which runs to a strongly chitinized chamber in which motile spermatozoa are easily detected. This is variously shaped and arising either from the end opposite the duct entrance or from the side is a more-or-less elongate glandular region. In *Palorus* species this basic pattern is modified, associated with a muscular bursa.

The genus *Tribolium* has been divided on external morphological features into five species groups, namely, *brevicornis*, *confusum*, *alcine*, *castaneum* and *myrmecophilum*, associated with the following geographical regions, America, Africa, Madagascar, Indo-Australia and the Malay peninsula and East Indies respectively[1]. The spermathecae of five species from the *castaneum* and *confusum* groups have recently been examined in some detail, and it was found that the structure in *T. castaneum* and *madens* (*castaneum* group) closely resembled that of *Tenebrio* whereas *T. confusum*, *anaphe* and *destructor* (*confusum* group) had the more common chamber type of spermatheca. In the former species the duct was very short, terminating in a number of long, convoluted tubes invested in a tough, elastic membrane. These tubes were found to contain spermatozoa. Connected to the common base of the tubes by a chitinized collar was a short, glandular region. In the latter species the duct was again short and wide, but terminated in a junction, one arm of which entered a strongly chitinized S-shaped chamber, while the other arm ran into a glandular region which was long in *anaphe* and *destructor* but shorter in *confusum*.

The present evidence supports the maintenance of the *confusum* (African) and *castaneum* (Indo-Australian) groups while further work is required to indicate similar associations between the other species groups mentioned here. Also, with regard to the suggestion that *T. molitor* and *obscurus* originated in Europe or Asia and were only later transported to Africa and America[2], possible affinities between the *castaneum* group and *tenebrio* species, and the evolutionary significance of the structures described here, must be considered.

GORDON SURTEES

Pest Infestation Laboratory,
London Road, Slough, Bucks.

[1] Hinton, H. E., *Bull. Ent. Res.*, 39, 13 (1948).
[2] Leclercq, J., *Bull. Mus. Hist. Nat. Belge*, 24, 1 (1948).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, September 26

Oliver Bird Trust; British Society for Immunology; and the Society for the Study of Fertility (in the Large Lecture Theatre, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5 p.m.—Dr. Albert Tyler (California Institute of Technology): "Immunological Approaches to Fertility Control" (Fourth Oliver Bird Lecture).*

Society of Chemical Industry, Pesticides Group (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. H. H. Colhoun: "Interpretations of Insecticidal Action".

Tuesday, September 27—Thursday, September 29

Department of Scientific and Industrial Research (at the Connaught Rooms, Great Queen Street, London, W.C.2), at 10 a.m. daily—Conference on "Ergonomics in Industry".

Wednesday, September 28

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Discussion on "The Land Colour Theory with Particular Reference to its Applications to Colour Television".

Oil and Colour Chemists' Association (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 7 p.m.—Mr. W. F. Jenkins, Mr. A. Mott and Dr. R. J. Wicker: "Unsaturated Polyesters for Surface Coatings".

Society for Psychical Research (in the Court Room, Caxton Hall, London, S.W.1), at 7 p.m.—Dr. W. Grey Walter: "Neurophysiological Aspects of Hallucinations and Illusory Experiences" (Myers Memorial Lecture)*.

Thursday, September 29—Friday, September 30

Worshipful Society of Apothecaries of London, Faculty of the History of Medicine and Pharmacy (at Apothecaries Hall, Black Friars Lane, London, E.C.4 (mornings), the Royal Society of Medicine, 1 Wimpole Street, London, W.1, on Thursday afternoon, and at the Royal College of Physicians, Pall Mall East, London, S.W.1, on Friday afternoon)—First British Congress on the History of Medicine and Pharmacy.

Society of Chemical Industry, Surface Activity Group (at the Royal Institution, 21 Albemarle Street, London, W.1)—Symposium on "Powders in Industry—Properties and Principles of Application".

Saturday, October 1

Association of Clinical Biochemists (joint meeting with the Association of Clinical Pathologists, at the Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2), at 9.30 a.m.—Annual General Meeting and Symposium on "Malabsorption".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Senior Technical Assistant (with experience in the use of transistors, and preferably familiar with nuclear instrumentation) in the Physics Department, to help in the design and construction of electronic and other instruments to be used in artificial Earth satellites—The Secretary and Registrar, The University, Southampton (September 28).

Assistant Lecturer, Grade B (with a good honours degree) in the Department of Pure and Applied Physics, to teach up to degree level—The Registrar, Royal Technical College, Salford 5, Lancs (September 30).

Plant Physiologist (with a good honours degree in botany and research experience), for investigation of effects of temperature, oxygen and carbon dioxide on the respiration of apples—The Director, Ditton Laboratory, Agricultural Research Council, Larkfield, Maidstone, Kent (September 30).

Lecturer (with an honours degree, and preferably with a higher degree in chemistry with postgraduate experience of academic or industrial research) in Physical Chemistry—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3 (October 1).

Lecturer (with special qualifications or interests in cytogenetics or experimental taxonomy) in Botany in St. Salvator's College—The Joint Clerk to the University Court, College Gate, St. Andrews (October 1).

Assistant Lecturer (preferably with a degree or National Diploma in Horticulture and an interest in forestry, and sound experience in practical work and, if possible, in teaching) in Horticulture at the Cumberland and Westmorland Farm School, Newton Rigg, near Penrith, and for lecturing, demonstration and advisory work in the two counties—The Director of Education, 5 Portland Square, Carlisle (October 3).

Lecturer or Assistant Lecturer in Pharmacy in the Department of Pharmacology, The Registrar, The University, Leeds (October 3).

Lecturer (preferably medically qualified) in the Department of Physiology—The Secretary, The University, Aberdeen (October 3).

Senior Lecturer/Lecturer (with an appropriate honours degree or equivalent qualifications) in Polymer Science at the University of New South Wales, Australia—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2, and The Bursar, University of New South Wales, Box 1, Post Office, Kensington, New South Wales, Australia (October 3).

Computing Assistant (Administration) (preferably with an honours degree in mathematics or in a pure or applied science, and either a Diploma in Electronic Computing, or appropriate experience in data processing by electronic computer, or, preferably, both), to work jointly in the Electronic Computing Laboratory and in the office of the Registrar—The Registrar, The University, Leeds 2 (October 4).

Assistant Lecturer (with special qualifications in physical chemistry) in Chemistry—The Registrar, The University, Manchester 13 (October 15).

Laboratory Technician (holding either A.M.I.L.T. or the Advanced City and Guilds of London Institute Certificate for Laboratory Technicians or equivalent qualification) at the Technical College, Bulawayo, Federation of Rhodesia and Nyasaland, for demonstration assistance to the Lecturing staff in the laboratories and maintenance and preparation of equipment—The Secretary (*R*), Rhodesia House, 429 Strand, London, W.C.2 (October 15).

Lecturer in Organic Chemistry in the Department of Chemistry and Chemical Engineering, University of Natal, Durban, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, October 15).

Lecturer or Assistant Lecturer (with a registrable medical qualification) in Anatomy at the University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (October 15).

Senior Lecturer and a Lecturer (with a degree in science or in agriculture, followed by postgraduate training in biochemistry, and previous experience in teaching or research) in Biochemistry at Canterbury Agricultural College, University of New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, October 15).

Demonstrators in Biochemistry, Botany and Physics at the University of Adelaide—The Registrar, University of Adelaide, Adelaide, South Australia (October 20).

Assistant Lecturer or Lecturer in the Department of Veterinary Pathology—The Registrar, The University, Liverpool (October 31).

Chair of Anatomy, and Chair of Physiology in Monash University, Clayton, Victoria, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer in Chemistry at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, October 31).

Lecturer/Senior Lecturer in Zoology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, October 31).

Senior Lecturer or Lecturer in Physics at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, October 31).

Lecturer in Education at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, November 1).

University Lecturer (with at least an honours degree in psychology and some knowledge of statistical methods) in Psychology—The Secretary, Cambridge University Department of Education, 17 Brookside, Cambridge (November 3).

Chair of Philosophy—The Registrar, The University, Hull (November 30).

Research Fellow (Organic Chemist) in the Department of Medical Chemistry, John Curtin School of Medical Research, Australian National University, to work with Prof. A. Albert or Dr. D. J. Brown on problems in the pyrimidines, pteridines or other hetero-aromatic series, and take up duties in Canberra in 1961—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, November 30).

Biochemist (with an appropriate science degree or the A.R.I.C.) within the Nottingham No. 2 Group of Hospitals, to work under the direction of the Chemical Pathologist at the City Hospital, where there is a fully equipped biochemical laboratory—J. H. Hargreaves, Group Secretary, Nottingham No. 2 Hospital Management Committee, Sherwood Hospital, Hucknall Road, Nottingham.

Director of Research (with the highest administrative and negotiating ability, academic qualifications and technical experience) of the Machine Tool Industry Research Association—The Chairman of Council, Machine Tool Industry Research Association, Brettenham House, Lancaster Place, London, W.C.2, marking envelope "R.A. Application".

International Wool Secretariat Research Fellow (with a degree in physics or physical chemistry with some research experience, and able to undertake work on the structure of protein fibres generally and wool in particular), to work in conjunction with Dr. F. Happey, Head of the Department of Textile Industries—The Clerk to the Governors, Bradford Institute of Technology, Bradford.

Lecturer (with good academic qualifications in chemistry, together with industrial and/or research experience) in Surface Coatings; and an Assistant Lecturer, Grade B (with good academic qualifications, and preferably some teaching or industrial experience) in Organic Chemistry in the Department of Chemistry and Food Technology—Clerk to the Governing Body, Borough Polytechnic, Borough Road, London, S.E.1.

LECTURER (with qualifications in mineralogy and petrology and an active interest in Pre-Cambrian rocks and ore deposits) IN GEOLOGY at the University of Khartoum—The Registrar, University of Khartoum, c/o Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

MEDICAL RESEARCH OFFICER (with registrable medical qualifications and aptitude for research, and preferably postgraduate research experience in the epidemiology of insect-borne diseases) WITH THE EAST AFRICAN TRYPANOSOMIASIS ORGANIZATION, to undertake research on the epidemiology of human trypanosomiasis—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/198/02.

PATENT EXAMINERS and PATENT OFFICERS (age at least 21 and under 29 (30 for Examiners), with a first- or second-class honours degree in physics, chemistry, engineering or mathematics, or equivalent attainment, or professional qualification, for example, A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., or A.R.I.C.), for work on the examination of patent applications—Civil Service Commission, 17 North Audley Street, London, W.1, quoting S/128/60, and stating date of birth.

RESEARCH ASSISTANT (with a degree in chemistry, G.R.I.C. or Dip. Tech.) IN CHEMISTRY, for fundamental work on the measurement of pH values—The Head of the Department of Applied Chemistry, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

RESEARCH ASSISTANT (with graduate or equivalent qualifications and appropriate experience in electronic instrument design and construction) IN THE DEPARTMENT OF PHYSICS, to take part in a space research project under Dr. T. R. Kaiser. The work will involve the development of instruments for installation in rockets and satellites—The Registrar, The University, Sheffield.

RESEARCH FELLOW (Ph.D. standard in chemistry or physics and a sound knowledge of electronics), and a RESEARCH STUDENT, for research on new developments of nuclear magnetic resonance spectroscopy—The Secretary, Department of Chemistry, King's College, Strand, London, W.C.2.

SCIENTIFIC OFFICER (honours graduate in chemistry or biochemistry) IN THE RADIOBIOCHEMISTRY DEPARTMENT, for biochemical research involving the use of radioactive isotopes, and in particular C^{14} and tritium—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 60/T.

SENIOR LECTURER (with specialist knowledge of crop husbandry) IN AGRICULTURE—The Clerk to the Governors, Essex Institute of Agriculture, Writtle, near Chelmsford, Essex.

SENIOR TECHNICIAN I IN THE DEPARTMENT OF EXPERIMENTAL PATHOLOGY, to assist in the research programme (no routine work involved)—The House Governor, St. Mary's Hospital, Paddington, London, W.2.

SENIOR TECHNICIAN or TECHNICIAN (with experience and training in electronics) IN THE PHARMACOLOGY DEPARTMENT—The Secretary, Royal Free Hospital School of Medicine, Hunter Street, London, W.C.1.

TEMPORARY RESEARCH ASSISTANT (with a first- or second-class honours degree in zoology or botany) IN THE PLANT PATHOLOGY LABORATORY, Ministry of Agriculture, Fisheries and Food, Harpenden, for work on biology and control of Stem and Bulb Eelworm in Narcissus bulbs—The Ministry of Labour, Technical and Scientific Register, Almack House, 26 King Street, London, S.W.1, quoting G.245/0A.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Colonial Office. The Colonial Territories, 1959–1960. Pp. vi+147. (Cmnd. 1065). (London: H.M. Stationery Office, 1960.) 6s. 6d. net. [57

Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom. Second Report of an *ad hoc* Committee on Procedure for Admission of Students. Pp. vi+31. (London: Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom, 1960.) 2s. [57

Department of Scientific and Industrial Research: Laboratory of the Government Chemist. Report of the Government Chemist from 1st April, 1958 to 31st December, 1959. Pp. iv+56. (London: H.M. Stationery Office, 1960.) 2s. 6d. net. [57

Ministry of Education. 15 to 18: Report of the Central Advisory Council for Education—England. Part 2: Surveys. Pp. xviii+240. (London: H.M. Stationery Office, 1960.) 8s. 6d. net. [57

The Place of Physiology in University Education. By Prof. J. A. B. Gray. (An Inaugural Lecture delivered at University College, London, 23 February, 1960.) Pp. 16. (London: H. K. Lewis and Co., Ltd., 1960.) 2s. 6d. net. [57

Department of Scientific and Industrial Research: National Physical Laboratory. Mathematical Tables, Vol. 3: Tables of Generalized Exponential Integrals. By G. F. Miller. Pp. iii+43. (London: H.M. Stationery Office, 1960.) 7s. 6d. net. [57

Government Publications. Sectional List No. 1: Agriculture and Food—Publications prepared by the Ministry of Agriculture, Fisheries and Food. Pp. 36. (London: H.M. Stationery Office, 1960.) [67

Library Association. Library Telex Directory: a List of Libraries in the United Kingdom with access to Telex. Pp. ii+15. (London: Library Association, Reference, Special and Information Section, 1960.) [67

Department of Scientific and Industrial Research. Scientific Research in British Universities, 1959–60. Pp. xii+492. (London: H.M. Stationery Office, 1960.) 25s. net. [87

Russian Review of Biology, Vol. 48, No. 1 (July-August, 1959). Pp. 1–110. Translated from the Russian. Subscription rates: £9 or 30 dollars for the first nine issues (Vol. 48, Parts 1, 2 and 3 of 1959, and six issues of 1960.) Thereafter annual subscription will be £6 10s. or 20 dollars. Single issues 30s. or 5 dollars. Published six times a year. (Edinburgh and London: Oliver and Boyd, Ltd., 1959.) [87

Other Countries

European Organization for Nuclear Research, CERN. Annual Report, 1959. Pp. 102 (25 plates). Inauguration of the Proton Synchrotron, 5 February 1960. Pp. 22 (8 plates). (Geneva: CERN, European Organization for Nuclear Research, 1960.) [57

New Zealand Forest Service: Forest Research Institute. Research Notes. No. 13: Relations between Vertebrates and Forest after the 1955 Fire at Balmoral State Forest. By Thane Riney and C. L. Batcheler. Pp. 15. No. 19: Combined Taper and Volume Tables for *Pinus radiata*, New Zealand, 1957; Shelterbelts; and for *Pseudotsuga taxifolia*, New Zealand, 1958: All Stands. By S. W. Burstall. Pp. 63. (Wellington: Government Printer, 1959.) [57

Zoology Publications from Victoria University of Wellington, New Zealand. No. 26: Synoptic Keys to the Genera of Ophiuroidea. By H. Barraclough Fell. Pp. 44. (Wellington, New Zealand: Victoria University of Wellington, 1960.) [57

Association of Food Technologists, Mysore. Annual Review of Food Technology, Vol. 1, 1959. Pp. 155. (Mysore: Association of Food Technologists, Central Food Technological Research Institute, 1960.) Rs. 5; 10s. [57

On Quantum Mechanics in Acceleration Field. By Nagatoshi Tunasima. Pp. v+39. (Tokyo: The Sanshusha Press, 1960.) [57

Comptes Rendus des Travaux du Laboratoire Carlsberg. Vol. 31, No. 25: On the Kinetics of Protein Isomerization Processes: Mechanisms Providing for Rapid Approach to an Equilibrium between Slowly Interconverting Species. By Joseph F. Foster. Pp. 351–371. 3 kr. 85 øre. Vol. 31, No. 26: The *in vitro* Uptake of Fluorescein Labelled Plasma Proteins. 1. Mature Cells. By H. Holtzer and S. Holtzer. Pp. 373–408+8 plates. 4 kr. 50 øre. Vol. 31, No. 27: Observations on Yeast Protoplasts. By H. Holtzer and Paul Ottolenghi. Pp. 409–422+8 plates. 2 kr. 25 øre. (Copenhague: Danish Science Press, Ltd., 1960.) [57

Commonwealth Scientific and Industrial Research Organization, Australia. List of Publications. Pp. 46. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1960.) [57

Research Council of Alberta. Fortieth Annual Report, 1959. Pp. v+54. (Report No. 79). (Edmonton: Research Council of Alberta, 1960.) [57

Bulletin of the Madras Government Museum. New Series, General Section, Vol. 7, No. 5: The Gopuras of Tiruvannamalai. By F. H. Gravely. Pp. iii+8+13 plates. 5 rupees 90 naye Paise. Handbook of Museum Technique. Edited by Dr. A. Aiyappan and Dr. S. T. Satyamurti. Pp. xvii+228 (11 plates). 2 rupees 75 naye Paise. (Madras: Madras Government Museum, 1959 and 1960.) [57

Polish Academy of Sciences: Distribution Centre for Scientific Publications. Quarterly Review of Scientific Publications, Series A—Social Sciences, No. 1 (9), 1960. Pp. 41. (Warsaw: Polish Academy of Sciences, 1960.) [67

Regional Research Centre of the British Caribbean at the Imperial College of Tropical Agriculture, Trinidad, W.I. Soil and Land-Use Surveys No. 9: Grenada. By K. C. Vernon Hugh Payne, and J. Spector. Pp. 42 (2 plates). (St. Augustine, Trinidad: Imperial College of Tropical Agriculture, 1960.) 18s. [87

The Quantum Hypothesis: a Criticism and Emendation. By Prof. B. M. Sen. Pp. 13. (Calcutta: The University Press, 1960.) [87

National Research Council of Canada: Associate Committee on Geodesy and Geophysics. *Canadian Geophysical Bulletin*, Vol. 12. Pp. v+95. (Ottawa: National Research Council of Canada, 1959.) [87

Archives de l'Institut de Paléontologie Humaine. (Fondation Albert 1er, Prince de Monaco). Mémoire No. 30: La Grotte de Rochereil: Station Magdalénienne et Azilienne. Par Dr. P. E. Jude. Pp. 74. (Paris: Masson et Cie., 1960.) [87

Institut des Parcs Nationaux du Congo Belge. Exploration du Parc National Albert. Mission F. Bourlière et J. Verschuren. Fascicule 1: Introduction a l'Ecologie des Ongulés du Parc National Albert. Par Francois Bourlière et Jacques Verschuren. Pp. 158+planches 1–49. Exploration du Parc National Albert. Mission J. Lebrun (1937–1938). Fascicule 2: Etudes sur la Flore et la Végétation des Champs de Lave au Nord du Lac Kivu (Congo Belge). Par Jean Lebrun. Pp. 352+planches 1–13. (Bruxelles: Institut des Parcs Nationaux du Congo Belge, 1960.) [87

Program for Scientific Translations, Jerusalem. Soviet Science in English—Catalogue. Pp. 24. (Jerusalem: Program for Scientific Translations, 1960.) [87

Laboratoire d'Astronomie de Lille. Astronomical Newsletter, No. 100. Pp. ii+53. (Lille: Laboratoire d'Astronomie, 1960.) [87

National Science Foundation, Washington, D.C. Weather Modification: First Annual Report for Fiscal Year ended June 30, 1959. Pp. iii+16. (Washington, D.C.: Government Printing Office, 1960.) 35 cents. [117

Editorial and Publishing Offices of "NATURE"

MACMILLAN & CO., LTD.,

ST. MARTIN'S STREET, LONDON, W.C.2.

Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance, postage paid to any part of the world.

Advertisements only should be addressed to

T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2

Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office